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# CHEMISTRY

# Spectrum

**TARGET**  
**2017**

**Rapid**  
**Concept Revision**

Periodic Classification  
Hydrogen  
s-block Elements

FROM CLASS XIth SYLLABUS

p-block Elements  
Organic Compounds  
Containing Nitrogen  
d and f-block Elements

FROM CLASS XIIth SYLLABUS

TEST RIDER FOR JEE  
MEDI QUEST FOR NEET  
TEST DRIVE FOR BOARD

**JUVENILEZ**

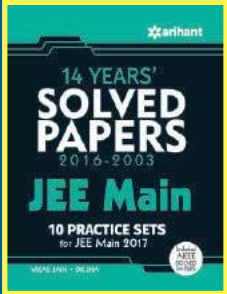

GOLDEN OLDIES *Aldehydes, Ketones & Carboxylic Acids*  
RAINBOW *Thermodynamics*  
FUN ARCADE

**MEGA**  
**ISSUE 4**

More Pages  
More Features  
More Practice...



# SOLVED PAPERS & PRACTICE SETS FOR JEE MAIN & ADVANCED

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			<h2>PRACTICE SETS FOR JEE MAIN &amp; ADVANCED</h2>
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# CHEMISTRY Spectrum

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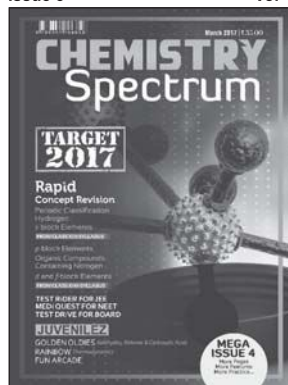
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Issue 3 Vol 4



## Dear Aspirants,

By now your studies would be in full swing as March is the month of examinations. New situations always pose new challenges and the same is applicable to March 2017. The difficulty level is a bit higher for aspirants this year due to elections. The decreased gap between JEE Mains/NEET and Board exams may dismantle your planning and affect your result.

Examinations are not only meant to test our knowledge and study skills. Rather, our personality as an individual is also tested through them. During an examination, our ability to do work, to deal with difficult situations, to withstand mental pressures and our thinking under stress are also tested. The day of examination is not at all a favourite for many among us, but nobody can avoid it. You may feel nervous, tense, scared, anxious or all on this particular day. But, remember! "Exams are not hurdles rather these are the stepping stones to success". So leave all your negative feeling, be relaxed and take it easy. Keep following points in mind to perform better in Boards:

- Careful reading of question paper is very important. In Boards, a proper time (e.g. half an hour in CBSE) is allotted for this task. Try to utilise this time properly. This will be the only procedure through which you can ignite your mind for the mammoth task ahead in next 3 hours.
- Prioritise and plan your paper also within this allotted time only i.e. don't waste this time in anything else.
- Try to convert those questions into flow charts or diagrams which are not clear to you. This will help in better visualisation of problems.
- Answer your best question first. Try to highlight the important parts of your answer. These will be helpful in catching the examiners attention at the time of checking of your response sheet.
- Try to be as neat and clean as possible. Start every new question from a fresh page.
- If you are short of time, avoid calculations and if there is some time left, check your answers again.
- Once your examination is over and you are out of the hall, avoid discussing the examination paper or questions with other candidates. This may create unnecessary tension.
- Last but not the least, "Try to stay positive and never let negative thoughts influence you at all".

Remember these beautiful lines of **Abraham Lincoln**

*"Always bear in mind that your resolution to succeed is more important than any other one thing"*

The spectrum team will be anxiously waiting for your feedbacks and comments.  
**Good luck**

*Sharma*

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@ CLASS XI SYLLABUS

# Rapid

## CONCEPT REVISION

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### PERIODIC CLASSIFICATION

#### Mendeleef's Periodic Table

- It is based on the principle that if elements are arranged in the increasing order of their atomic weight then after a regular interval, the periodic properties are repeated.
- It is made up of 63 elements. It contains 8 vertical columns, called **groups** and 12 horizontal rows, called **periods**. Zero group elements were not known at that time.

#### Modern Periodic Table

It is based on the principle that the physical and chemical properties of elements are periodic function of their atomic numbers.

- It consists of 9 groups and 7 periods.
- The groups are marked 0 to VIII out of which groups I to VII are sub-divided into subgroups A and B. VIII group has three vertical columns which are placed together in one place.

#### Long Form of Periodic Table

- Both modern and long form of periodic table were based on the same principle.
- It contains 7 periods, 18 groups (1 to 18) and 118 elements, which are classified as *s*-block, *p*-block, *d* and *f*-block elements, based on the orbital in which the last electron enters.
- *d* and *f*-block elements are called **transition** and **inner-transition** elements, respectively as they lie in between *s*-block (on extreme left) and *p*-block elements (on extreme right).

**Note** The difference between modern and long form of periodic table is only that in long form of periodic table older notations of groups IA ..... VIIA, VIII, IB ..... VIIB and 0 is removed and groups are numbered from 1 to 18.

#### Prediction of Group, Period and Block from Electronic Configuration

- In the electronic configuration of an atom, the principal quantum number of valence electron represents the period of the element.
- The orbital (either *s*, *p*, *d* or *f*) which receives the last electron, represents the block of the element.
- The group of the element is predicted from the block of the element as:
  - If the element belongs to *s*-block,  
Group number = number of valence electrons.
  - If the element belongs to *p*-block,  
Group number = 10 + number of valence electrons  
= 10 + *ns* electrons + *np* electrons
  - If the element belongs to *d*-block,  
Group number = number of electrons in  $(n - 1)d$  subshell + *ns* subshell.
  - If the element belongs to *f*-subshell, group number is always 3.

#### General Electronic Configuration of Different Blocks

- s*-block** (group 1 and 2): [Inert gas],  $ns^x$ ; ( $x = 1, 2$ )
  - For  $x = 1$ , elements constitute a group of alkali metals placed in group 1 (I A).

- For  $x = 2$ , elements constitute a group of alkaline earth metals placed in group 2 (II A).
- (ii) **p-block** (group 13 to 18): [Inert gas],  $ns^2np^x$ ; ( $x = 1$  to 6)  
Group number of an element of this block is
  - ( $2 + x$ ) A based on old system.
  - ( $12 + x$ ) based on new IUPAC system.
  - This is the only block that contains metals, semi-metals and non-metals.
- (iii) **d-block** (group 3 to 12): [Inert gas],  $(n-1)d^{1-10}, ns^{0-2}$ 
  - All elements of this group are metals.
  - They mostly form coloured ions, exhibit variable valencies (oxidation states), show paramagnetism and often used as catalysts.
  - Zn, Cd and Hg do not show most of the properties of transition elements because these have electronic configuration,  $(n-1)d^{10}ns^2$ .
- (iv) **f-block** Lanthanoids - [Xe],  $(n-2)f^{1-14}, (n-1)s^2, (n-1)p^6, (n-1)d^{0-1}, ns^2$ 
  - Actinoids - [Rn],  $(n-2)f^{1-14}, (n-1)s^2, (n-1)p^6, (n-1)d^{0-1}, ns^2$
  - The elements of both the series show striking resemblance in their properties due to almost similar electronic configurations of their two outer shells and same sizes.

## Nomenclature of the Elements having Atomic Number > 100

- For the elements having  $Z > 109$ , IUPAC recommended a nomenclature to be followed for naming these elements until their names are officially recognised.
- The names are derived by using roots for the three digits in the atomic number of the elements and adding the ending-ium. The roots for the numbers are given below:

Digit	0	1	2	3	4	5	6	7	8	9
Name	nil	un	bi	tri	quad	pent	hex	sept	oct	enn
Abbreviation	n	u	b	t	q	p	h	s	o	e

Atomic number	Name	Symbol	IUPAC official name	IUPAC symbol
101	Un-nil-unium	Unn	Mendelevium	Md
102	Un-nil-bium	Unb	Nobelium	No
103	Un-nil-trium	Unt	Lawrencium	Lr
104	Un-nil-quadium	Unq	Rutherfordium	Rf
105	Un-nil-pentium	Unp	Dubnium	Db
106	Un-nil-hexium	Unh	Seaborgium	Sg
107	Un-nil-septium	Uns	Bohrium	Bh



**WHY DO THE CUT APPLE BROWN?**  
The brown colour is because your apple has rusted! That's because apples are rich in iron, which is present in all their cells. When you cut an apple, the knife damages the cells. Oxygen from the air reacts with the iron in the apple cells, forming iron oxides. This is just like rust that forms on the surface of iron objects. An enzyme called polyphenol oxidase (that's present in these cells) helps make this reaction go faster.

108	Un-nil-octium	Uno	Hassium	Hs
109	Un-nil-ennium	Une	Meitnerium	Mt
110	Un-un-nillium	Uun	Darmstadtium	Ds
111	Un-un-unnium	Uuu	Roentgenium	Rg
112	Un-un-bium	Uub	—	—
113	Un-un-trium	Uut	Nihonium	Nh
114	Un-un-quadium	Uuq	Flerovium	Fl
115	Un-un-pentium	Uup	Moscovium	Mc
116	Un-un-hexium	Uuh	Livermorium	Lv
117	Un-un-septium	Uus	Tennesine	Ts
118	Un-un-octium	Uuo	Oganesson	Og

### Discovery of Elements having Atomic Numbers 113, 115, 117 and 118

- Elements having atomic numbers 113, 115, 117 and 118 have formally been recognised by the International Union of Pure and Applied Chemistry (IUPAC), the US based world authority on chemistry. On 30 Dec. 2015, IUPAC announced that the seventh row of the periodic table is completed.
- In 2011, the table had been updated, when elements flerovium (114) and livermorium (116) were added.
- These elements among the heaviest in the periodic table and does not exist in nature. They are highly unstable. When researchers crushed lighter nuclei into one another, the new elements existed for less than a second before breaking down into other elements.
- On 28 Nov. 2016, the IUPAC approved the names and symbols for four elements nihonium (Nh), moscovium (Mc), tennesine (Ts) and Oganesson (Og) for elements 113, 115, 117 and 118, respectively.

## Periodic Properties

The properties which are repeated at regular intervals are called **periodic properties**.

### Atomic Radius

- It is defined as the distance from the centre of the nucleus to the outermost shell of electrons. The definition is imaginary because according to quantum mechanics there is no certainty about the exact position of an electron in atom.
- Atomic radius of noble gas elements are highest in their respective period due to longest van der Waals' radius followed by alkali metals.
- Atomic radius  $\propto$  Screening effect

$$\propto \frac{1}{\text{Effective nuclear charge}} \propto \frac{1}{\text{Bond order}}$$

## RAPID CONCEPT REVISION

### Screening or Shielding Effect

The electrons present in inner orbital, decrease the force of attraction between nucleus and valence electron(s) and hence act as a shield for valence electrons. Hence, this effect is called **screening** or **shielding effect**.

- The screening effect of all the electrons are not equal and depends upon the subshell to which the electron belongs. The order of screening effect of electron(s) in different subshell is  $s > p > d > f$

- Screening effect ( $\sigma$ ) and effective nuclear charge ( $Z'$ ) are related as  $Z' = Z - \sigma$

where,  $Z$  is the atomic number of the element.

$\sigma = (0.35 \times \text{number of electrons in } n\text{th orbit} + 0.85 \times \text{number of electrons in } (n - 1)\text{th orbit} + 1 \times \text{rest of electrons})$

[Take 0.30 instead of 0.35 for 1st orbit (i.e.  $n = 1$ )].

### Comparison of Cationic and Anionic Radius

Cationic radius	Anionic radius
Smaller than the radius of corresponding neutral atom. e.g. $\text{Mg} > \text{Mg}^{2+}$	Larger than the radius of corresponding neutral atom. e.g. $\text{O}^{2-} > \text{O}$
For same atom, cationic radius is inversely proportional to the magnitude of positive charge. e.g. $\text{Fe} > \text{Fe}^{2+} > \text{Fe}^{3+}$	For same atom, anionic radius is directly proportional to the magnitude of negative charge. e.g. $\text{O}^{2-} > \text{O}^- > \text{O}$
For isoelectronic species, cationic radius $\propto \frac{1}{Z}$	For isoelectronic species, anionic radius $\propto \frac{1}{Z}$
e.g. $\text{Na}^+ > \text{Mg}^{2+} > \text{Al}^{3+}$	e.g. $\text{N}^{3-} > \text{O}^{2-} > \text{F}^-$

### REMEMBER

For a group of isoelectronic species involving cation, anion and neutral atom, radius is inversely proportional to nuclear charge.

e.g.  $\text{N}^{3-} > \text{O}^{2-} > \text{F}^- > \text{Na}^+ > \text{Mg}^{2+}$

(Order of radius)

## Trends in Atomic Radius

### (i) In the Group

Atomic radii of elements increases on moving down the group due to increase in the number of shells by a factor of 1 and increase in screening effect, which reduces effective nuclear charge.

### (ii) In the Period

- Across the period, atomic radius decreases due to increase in effective nuclear charge and the trend is regular till 3rd period.

- However in 4th, 5th and 6th period, trend is irregular.

**4th period**  $\text{Ni} < \text{Cu} < \text{Zn} \approx \text{Ga} > \text{Ge}$

**5th period**  $\text{Ru} < \text{Rh} < \text{Pd} < \text{Ag} < \text{Cd} < \text{In} > \text{Sn}$

**6th period**  $\text{Os} \approx \text{Ir} < \text{Pt} < \text{Au} < \text{Hg} < \text{Tl} > \text{Pb}$

### Lanthanide Contraction-An Exceptional Trend in Atomic Radius

Due to the addition of 14 extra  $f$ -block elements from Ce to Lu in 6th period, contraction in the size of transition elements takes place from Hf to Hg.

- As a result on descending from 5th to 6th period, a very small change in atomic radius (either increases, decreases or remains same) is observed. It is primarily due to poor screening or shielding effect of  $f$ -orbitals.
- This contraction in the size of atomic radius due to the addition of 14 lanthanide elements in 6th period is called lanthanide contraction.
- This decrease in size is extraordinary and against the trend as all the lanthanides are placed in 3rd group and 6th period.

## Ionisation Enthalpy (IE)

- It is the amount of energy required to remove an electron from the outermost orbit of an isolated gaseous atom.
- Its unit is  $\text{kJ mol}^{-1}$  (for 1 mole of element) or  $\text{eV atom}^{-1}$  (for a single atom).
- The value of 2nd IE is greater than 1st and that of 3rd is greater than 2nd and so on, because after removing an electron, effective nuclear charge increases and the electrons are more tightly bound to nucleus. Hence, the trend in IE is  $(\text{IE})_1 < (\text{IE})_2 < (\text{IE})_3 \dots$

## Factors Affecting Ionisation Enthalpy

$$(i) \text{IE} \propto \frac{1}{\text{Atomic/ionic radius}}$$

$$(ii) \text{IE} \propto \frac{1}{\text{Size of atom}}$$

(iii) Effective nuclear charge

(iv) Screening effect

(v) Half-filled or fully-filled electronic configuration

(vi) Type of subshell ( $s, p, d$  or  $f$ ) of the electron being removed.

## Dependence of IE on Subshell Type

Due to different shape of subshells ( $s, p, d$  and  $f$ ), they interact with the nucleus differently. Hence, IE depends on the type of subshell from which the electron is being removed.

- In  $s$ -orbital, electron penetrates nearer to the nucleus and hence, held more tightly than  $p$ -orbital electron and this trend decreases gradually from  $s$ -orbital to  $f$ -orbital.
- Hence, the order of IE of an electron in different subshell is  $s > p > d > f$

## Trends in Ionisation Enthalpy

### (i) In the Group

Ionisation energy, in general, decreases down the group with the following exceptions :

- In group-13, the 1st IE decreases from B to Al as expected, but the trend becomes irregular for rest of

the elements (Ga, In, Tl) due to the addition of extra electrons to *d* and *f*-orbitals.

	B	Al	Ga	In	Tl	(group-13)
(IE) <sub>1</sub>	801	577	579	558	589	(kJ mol <sup>-1</sup> )
			(Irregular)			

(b) Transition elements do not follow any regular trend in ionisation energy.

## (ii) In the Period

Ionisation enthalpy in general increases across a period, with the exception of those with either half-filled or fully-filled electronic configuration.

- It also follow an irregular trend in case of transition elements.
- Ionisation energy of noble gases (except Xe) is highest in their respective period due to stable fully-filled configuration.
- Ionisation enthalpy of alkali metals is lowest in their respective period because on the removal of one electron, nearest stable noble gas configuration is attained.

## REMEMBER

- The second ionisation energy of group 1 elements is much more than the first ionisation energy because the second electron is being removed from stable noble gas configuration.



- Similarly, third ionisation energy of group 2 elements is much more than second ionisation energy because the 3rd electron is being removed from stable noble gas configuration.



$$\text{In general, IE} \propto \frac{1}{\text{Metallic character}} \\ \propto \frac{1}{\text{Reactivity of metals}} \propto \frac{1}{\text{Reducing power}}$$

## Electron Gain Enthalpy ( $\Delta_{\text{eg}}H$ )

- It is the enthalpy change accompanying the reaction when an electron is added to a neutral gaseous atom.
- Its unit is eV/atom or kJ/g-atom.
- $\Delta_{\text{eg}}H$  value can be either positive (endothermic) or negative (exothermic).

## Factors Affecting Electron Gain Enthalpy

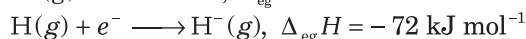
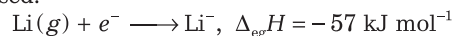
- Size of the element ( $\Delta_{\text{eg}}H \propto \frac{1}{\text{Atomic radius}}$ )
- Effective nuclear charge ( $\Delta_{\text{eg}}H \propto Z_{\text{eff}}$ )
- Electronic configuration of element ( $\Delta_{\text{eg}}H$  is usually positive for element with half-filled or fully-filled electronic configuration).
- Subshell to which the electron is being added (generally,  $\Delta_{\text{eg}}H$  of  $s > p > d > f$ ).

## Electron Affinity

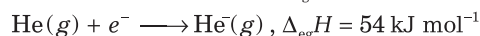
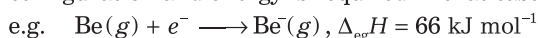
- The energy released when an extra electron is added to an isolated gaseous atom is called the **electron affinity** ( $A_e$ ) of that atom.
- It is defined at absolute zero and is related to electron gain enthalpy by  $\Delta_{\text{eg}}H = -A_e - 5/2 RT$
- At 298 K, however the value of  $5/2 RT$  is only 2.477 kJ mol<sup>-1</sup> and this small value can be ignored, thus, electron gain enthalpy and electron affinity have same magnitude but opposite sign.

## Electron Gain Enthalpy versus Electronic Configuration

- $\Delta_{\text{eg}}H$  value is negative, when the element attains a stable electronic configuration and energy is released. e.g. H-atom, when receives an electron attains nearest noble gas configuration and Li when receives an electron attains fully-filled 2s-orbital configuration and energy is released.



- However,  $\Delta_{\text{eg}}H$  value is positive, when an electron is added to an element with half-filled or fully-filled electronic configuration and energy is required in that case.



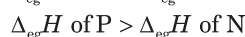
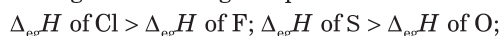
## Trends in Electron Gain Enthalpy

### (i) In the Period

- On moving across a period, the negative value of  $\Delta_{\text{eg}}H$  generally increases due to increase in effective nuclear charge.
- Half-filled or fully-filled electronic configuration have positive value of  $\Delta_{\text{eg}}H$ .

### (ii) In the Group

- On moving down a group, the  $\Delta_{\text{eg}}H$  value decreases due to decrease in effective nuclear charge. However, this is having the following exceptions.



- The reason is that due to smaller radius ( $n = 2$ ) of N, O and F, the added electron needs to overcome significant repulsion from other electrons releasing less energy. However, in case of P, S and Cl, due to larger radius ( $n = 3$ ), the electron needs to overcome lesser repulsion from other electron releasing more energy.

## REMEMBER

The first electron gain enthalpy of O and S are negative, whereas, the second electron gain enthalpy is positive. Despite of this fact,  $\text{O}^{2-}$  and  $\text{S}^{2-}$  are well known. Hence, it is obvious from the above fact that energy required to form ion depends not only on electron affinity but also depends on lattice energy, hydration energy, etc. that compensate each other to form the final stable ion.

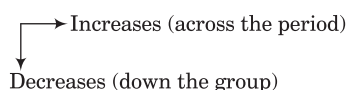
## RAPID CONCEPT REVISION

### Electronegativity

- It is the tendency of an atom to attract shared pair of electrons towards itself in a covalent bond.
- It is different from electronegative character of an atom which is the ability of an atom to gain electron.
- It is a qualitative value and hence, only approximate value of electronegativity can be determined.

### Trends in Electronegativity

The variation of electronegativity in the periodic table is



### Measurement of Electronegativity

The following scales are used to measure electronegativity.

- (i) **Pauling scale** Pauling considered F (the most electronegative element) as the standard element and arbitrarily assigned an electronegativity of 4. The electronegativity value for other elements are calculated as follows for a covalent bond between A and B.

$$\chi_A - \chi_B = 0.208\sqrt{\Delta}$$

$$\text{where, } \Delta = E_{A-B} - \sqrt{E_{A-A} \times E_{B-B}}$$

where,  $\chi_A$  and  $\chi_B$  are electronegativities of A and B, respectively.

- (ii) **Mulliken Scale** According to this scale, electronegativity,
- $$\chi = \frac{\text{Ionisation enthalpy} + \text{electron gain enthalpy}}{2}$$

- (iii) **Allred-Rochow's Scale** According to this scale, electronegativity is a measure of the force between the nucleus and electrons of outermost orbit. It is considered as a real scale. Hence,

$$\text{Electronegativity} = \frac{0.359 \times Z_{\text{eff}}}{r^2} + 0.744$$

where  $r$  = covalent radius

$Z_{\text{eff}}$  = effective nuclear charge

#### Applications of Electronegativity

- (i) To predict the nature of A—B bond : The elements with high electronegativity difference form ionic bond, whereas the elements of comparable or with small difference in electronegativity value form covalent bond.

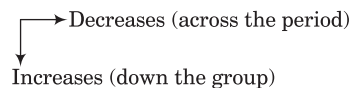
- (ii) Electronegativity difference

$$\propto \frac{1}{\text{Bond length}} \propto \text{Bond energy}$$

- (iii) It helps in predicting bond polarity.

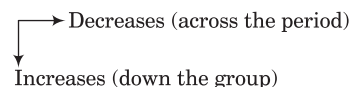
### Electropositive or Metallic Character

- It is the tendency of an element to form the cation by the loss of electron.
- The variation of electropositive or metallic character in the periodic table is

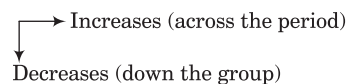


### Reducing and Oxidising Properties

- Reducing power of an element is the tendency to lose an electron.
- The variation of reducing power of elements in the periodic table is



- Oxidising power of an element is the tendency to gain electron and hence the trend is opposite to that of reducing power.



- Hence, alkali metals are strongest reducing agents and halogens are strongest oxidising agents in their respective period.

### Periodic Trends in Chemical Properties

#### Oxidation State

- The oxidation state of group 1 and group 2 are +1 and +2, respectively. The oxidation state of group 13 elements is +3.
- Group 14 elements show oxidation state of +4 and +2, where the stability of +4 and +2 oxidation state decreases and increases down the group, respectively.
- Group 15 elements show oxidation states from -3 to +5.
- Group 16 elements show oxidation states from -2 to +6, and halogens show oxidation states from -1 to +7.
- *d* and *f*-block elements show variable oxidation state.

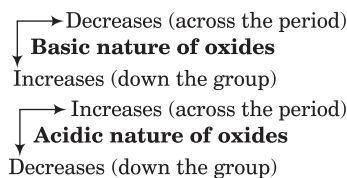
#### Chemical Reactivity

- It is highest at the two extremes of a period and lowest at the centre.
- This is because, the elements present at extreme left of a period have the lowest ionisation enthalpy and that present at the extreme right have the highest electron affinity.
- Highly reactive elements are always found in combined state.



## Nature of Oxides

- In general, metallic oxides are basic, non-metal oxides are acidic and metalloid oxides are usually amphoteric in nature.
- Basic and acidic nature of oxides show the following trends in the periodic table.

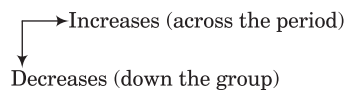


### REMEMBER

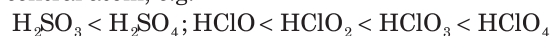
- The oxides  $\text{CO}$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}$  and  $\text{H}_2\text{O}$  are neutral in nature. The oxides of  $\text{Al}$ ,  $\text{Zn}$ ,  $\text{Sn}$ ,  $\text{As}$  and  $\text{Sb}$  alongwith metalloids are amphoteric in nature.
- The acidic nature of oxides of non-metals increases with oxidation state, e.g. the order of acidity of the following oxides are  $\text{N}_2\text{O}_3 < \text{N}_2\text{O}_5$ ,  $\text{SO}_2 < \text{SO}_3$ ,  $\text{Cl}_2\text{O} < \text{Cl}_2\text{O}_3 < \text{Cl}_2\text{O}_7$
- Non-metal oxides, when dissolved in water form oxyacids. Hence, the oxides are called anhydrides of the corresponding formed acids.

## Nature of Oxyacids

- Generally, non-metals which are less electronegative than oxygen form oxyacids.
- Only one oxyacid of fluorine has been prepared (HOF) which is unstable.
- The acidic nature of oxyacids show the following trends in periodic table.



- Acidic strength of oxyacids increases with oxidation state of central atom, e.g.



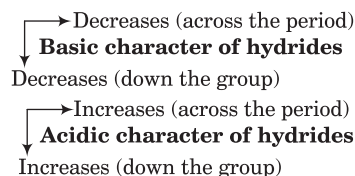
However, the following exception is also found in this rule.



- Basicity of an oxyacid is equal to the number of  $\text{—OH}$  groups present in the molecule.

## Nature of Hydrides

The basic and acidic nature of hydrides show the following trends in the periodic table.



### REMEMBER

Reducing power of hydrides increases down the group and stability decreases due to decrease in  $M\text{—H}$  bond strength. Hence, the order is

Reducing power ↓	$\text{CH}_4$	$\text{NH}_3$	$\text{H}_2\text{O}$	$\text{HF}$	↑ Stability
	$\text{SiH}_4$	$\text{PH}_3$	$\text{H}_2\text{S}$	$\text{HCl}$	
	$\text{SnH}_4$	$\text{AsH}_3$	$\text{H}_2\text{Se}$	$\text{HBr}$	
	$\text{PbH}_4$	$\text{SbH}_3$		$\text{HI}$	
		$\text{BiH}_3$			

### Elements Showing Highest and Lowest Properties

Highest melting point	C (diamond)
Highest electron affinity	Cl
Highest electronegativity	F
Highest ionisation potential	He
Lowest ionisation potential	Cs
Highest density	Os
Lowest melting point	He
Lowest density	$\text{H}_2$
Lowest density among metals	Li
Highest melting point among metals	Tungsten (W)
Smallest anion	$\text{H}^-$
Largest anion	$\text{I}^-$
Smallest cation	$\text{H}^+$
Largest cation	$\text{Cs}^+$

### Notice Board

#### JIPMER 2017

Events	Dates
Online application form starts	27th March 2017
Last date to submit the online application	3rd May 2017
Admit card release	Third week of May 2017
Exam date	4th June 2017
Result announcement	Third week of June 2017
Seat allotment starts	Fourth week of June 2017

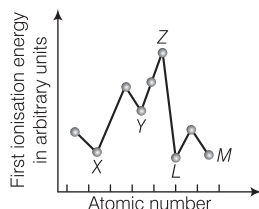
# MASTER STROKES

1. Which pair of atomic numbers represents s-block elements?  
(a) 3, 12 (b) 6, 12 (c) 7, 15 (d) 9, 17
2. The electronic configuration of four elements are  
I. [Xe]  $6s^1$  II. [Xe]  $4f^{14}, 5d^1, 6s^2$   
III. [Ar]  $4s^2, 4p^5$  IV. [Ar]  $3d^7, 4s^2$   
Which one of the following statements about these elements is not correct?  
(a) I is a strong reducing agent  
(b) II is a d-block element  
(c) III has high electron affinity  
(d) IV shows variable oxidation state
3. Which of the following statements is correct about lanthanides?  
(a) 14 elements in the seventh period (90-103) that are being filled into 5f-subshell.  
(b) 14 elements in the sixth period (58-71) that are being filled into 4f-subshell.  
(c) 14 elements in the seventh period (58-71) that are being filled into 4f-subshell.  
(d) 14 elements in the sixth period (90-103) that are being filled into 4f-subshell.
4. Out of BeO,  $Al_2O_3$ ,  $SnO_2$ ,  $PbO_2$  and ZnO, oxide(s) soluble in NaOH is  
(a)  $SnO_2$  and  $PbO_2$  (b) BeO,  $SnO_2$  and  $PbO_2$   
(c)  $PbO_2$  (d) None of these
5. Which of the following pairs has both members of the same period of the periodic table?  
(a) Na – Cl (b) Na – Ca (c) Ca – Cl (d) Cl – Br
6. Mendeleef's periodic table is upset by the fact that  
(a) many elements have several isotopes  
(b) noble gases do not form compounds  
(c) some groups divided into two subgroups A and B  
(d) atomic weights of elements are not always whole numbers
7. Which of the following electronic configurations in the outermost shell is characteristic of alkali metals?  
(a)  $ns^2p^6d^1$  (b)  $(n-1)s^2p^6, ns^1$   
(c)  $(n-1)s^2p^6, ns^2p^1$  (d)  $(n-1)s^2p^6d^{10}, ns^1$
8. The electronic configuration of four elements are given below. Which element does not belong to the same family?  
(a) [Xe]  $4f^{14}5d^{10}6s^2$  (b) [Kr]  $4d^{10}5s^2$   
(c) [Ne]  $3s^23p^5$  (d) [Ar]  $3d^{10}4s^2$
9. Which of the following pairs has both members from the same group of the periodic table?  
(a) Mg — Ba (b) Mg — Cu  
(c) Mg — K (d) Mg — Na
10. An atom has electronic configuration  $1s^2 2s^2, 2p^6, 3s^2, 3p^6, 3d^3, 4s^2$ , it is placed in  
(a) fifth group (b) fifteenth group  
(c) second group (d) third group
11. An element X belongs to fourth period and fifteenth group of the periodic table. Which one of the following is true regarding the outer electronic configuration of X?  
(a) It has partially filled d-orbitals and completely filled s-orbitals.  
(b) It has completely filled s-orbitals and completely filled p-orbitals.  
(c) It has completely filled s-orbitals and half-filled p-orbitals  
(d) It has half-filled d-orbitals and completely filled s-orbitals.
12. An element with atomic number 112 has been discovered recently. It should be  
(a) an actinide (b) a transition metal  
(c) a noble gas (d) a lanthanide
13. Which among the following is the most reactive?  
(a)  $Cl_2$  (b)  $Br_2$  (c)  $I_2$  (d) ICl  
[JEE Main 2015]
14. Which of the following statements is incorrect regarding modern periodic table?  
(a) The p-block has 6 columns because a maximum of 6 electrons can occupy all the orbitals in a p-subshell.  
(b) The d-block has 8 columns because a maximum of 8 electrons can be occupied by all the orbitals in a d-subshell.  
(c) Each block contains a number of columns equal to the number of electrons that can occupy that subshell.  
(d) The block indicates values of azimuthal quantum number (l) for the last subshell that received electrons in building up the electronic configuration
15. Match the Column I with Column II and choose the correct code.
- | Column I<br>(Atomic number) |     | Column II<br>(IUPAC nomenclature) |     |
|-----------------------------|-----|-----------------------------------|-----|
| i.                          | 105 | p.                                | Uub |
| ii.                         | 107 | q.                                | Uup |
| iii.                        | 110 | r.                                | Ubp |
| iv.                         | 112 | s.                                | Unp |
| v.                          | 115 | t.                                | Uns |
| vi.                         | 125 | u.                                | Uun |
- Codes**  
i ii iii iv v vi i ii iii iv v vi  
(a) s t u p q r (b) s t p u r q  
(c) t p s u q r (d) r q s p t u
16. The second ionisation energy is always higher than the first ionisation energy because the  
(a) ion becomes more stable attaining an octet or duplet configurations.  
(b) electron is more tightly bound to the nucleus in an ion.  
(c) electron is attracted more by the core electrons.  
(d) None of the above

17. Identify the correct order in which the ionic radius of the following ions increases

- I.  $F^-$                       II.  $Na^+$                       III.  $N^{3-}$   
 (a) III, I and II                      (b) I, II and III  
 (c) II, III and I                      (d) II, I and III

18. In the graph given below, the one which represents an alkali metal with the highest atomic number is



- (a) X                      (b) Y                      (c) Z                      (d) M

19. Which of the following is second most electronegative element?

- (a) Chlorine    (b) Oxygen    (c) Sulphur    (d) Fluorine

20. Electron affinity is positive when

- (a) O changes into  $O^-$   
 (b) O changes into  $O^+$   
 (c)  $O^-$  changes into  $O^{2-}$   
 (d) electron affinity is always negative

21. The negative ion (anion) is always larger than that of the corresponding atom. It is due to

- (a) increase in number of electrons and force of attraction which pulls valence shell outwards.  
 (b) decrease in nuclear charge per electron  
 (c) Both (a) and (b)  
 (d) None of the above

22. In the transition elements, Ga, In and Tl,  $(IE)_1$  changes abruptly. This is due to

- (a) decrease in effective nuclear charge  
 (b) increase in atomic radius  
 (c) removal of an electron from the singly occupied  $np$ -orbitals of higher energy than the  $ns$ -orbitals of Zn, Cd and Hg.  
 (d) None of the above

23. In which of the following arrangements, the order is not according to the property indicated after it in bracket?

- (a)  $Al^{3+} < Mg^{2+} < Na^+ < F^-$  (Increasing ionic size)  
 (b)  $B < C < N < O$  (Increasing first ionisation energy)  
 (c)  $I < Br < F < Cl$  (Increasing electron gain enthalpy)  
 (d)  $Li < Na < K < Rb$  (Increasing metallic radius)

24. The ionic radii (in Å) of  $N^{3-}$ ,  $O^{2-}$  and  $F^-$ , respectively are

- (a) 1.36, 1.40 and 1.71                      (b) 1.36, 1.71 and 1.40  
 (c) 1.71, 1.40 and 1.36                      (d) 1.71, 1.36 and 1.40

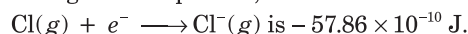
25. Which one of the following statements is incorrect in relation to ionisation enthalpy?

- (a) The greatest increase in ionisation enthalpy is experienced on removal of electron from core of noble gas configuration  
 (b) Ionisation enthalpy increases for each successive electron

(c) End of valence electron is marked by a large jump in ionisation enthalpy

(d) Removal of electron from orbitals bearing lower  $n$  value is easier than from orbitals having higher  $n$  value

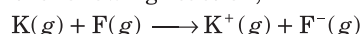
26. The amount of energy released when  $1 \times 10^{10}$  atoms of chlorine in vapour state are converted to  $Cl^-$  ions according to the equation,



The electron gain enthalpy of chlorine atom in terms of  $kJ \text{ mol}^{-1}$  is

- (a) + 3.61  $kJ \text{ mol}^{-1}$                       (b) - 3.61  $kJ \text{ mol}^{-1}$   
 (c) - 4.61  $kJ \text{ mol}^{-1}$                       (d) + 5.61  $kJ \text{ mol}^{-1}$

27. Consider the following reaction,



$\Delta H$  was calculated to be 19 kcal under condition where the cation and anion were prevented by electrostatic separation from combining with each other. The ionisation energy of potassium is 4.3 eV, the magnitude of  $\Delta_{eg}H$  of F is

- (a) - 7.9                      (b) - 0.82                      (c) + 4.3                      (d) + 3.48

28. Which one of the following alkaline earth metal sulphates has its hydration enthalpy greater than its lattice enthalpy?

[JEE Main 2015]

- (a)  $CaSO_4$                       (b)  $BeSO_4$                       (c)  $BaSO_4$                       (d)  $SrSO_4$

29. Which of the following pairs show reverse properties on moving along a period from left to right and from top to down in a group?

- (a) Nuclear charge and electron affinity  
 (b) Ionisation energy and electron affinity  
 (c) Atomic radius and electron affinity  
 (d) None of the above

30. The value of electronegativity of atoms A and B are 1.20 and 4.0, respectively. The percentage of ionic character at A—B bond is

- (a) 58.3%                      (b) 48.0%                      (c) 79.6%                      (d) 73.6%

31. The increasing order of atomic radii of the following group 13 elements is

- (a)  $Al < Ga < In < Tl$                       (b)  $Ga < Al < In < Tl$   
 (c)  $Al < In < Ga < Tl$                       (d)  $Al < Ga < Tl < In$

32. A sudden large jump between the values of second and third ionisation energies of an element would be associated with the electronic configuration

- (a)  $1s^2 2s^2, 2p^6, 3s^2$                       (b)  $1s^2 2s^2, 2p^6, 3s^1$   
 (c)  $1s^2 2s^2, 2p^6, 3s^2, 3p^1$                       (d)  $1s^2 2s^2, 2p^6, 3s^2, 3p^2$

33. Identify the wrong statement on moving horizontally from left to right across a period in the periodic table

- (a) metallic character decreases  
 (b) electronegativity increases  
 (c) reducing power decreases  
 (d) size of the atoms increases for normal elements.

34. The ionisation energy of nitrogen is larger than that of oxygen because of

- (a) greater attraction of electrons by the nucleus  
 (b) the size of nitrogen atom being smaller  
 (c) the half-filled  $p$ -orbitals possess extra stability  
 (d) greater penetration effect


**RAPID CONCEPT REVISION**

- 35.** Consider the following energy data ( $\text{kJ mol}^{-1}$ ),  $\text{IE}_1$  for Be = 899,  $\text{IE}_2$  for Be = 1757, EA for Cl = -348  
The energy deficit in the formation of  $\text{BeCl}_2$  is  
(a)  $1960 \text{ kJ mol}^{-1}$  (b)  $1780 \text{ kJ mol}^{-1}$   
(c)  $2000 \text{ kJ mol}^{-1}$  (d)  $1660 \text{ kJ mol}^{-1}$
- 36.** Match the correct ionisation enthalpies and electron gain enthalpies (in  $\text{kJ mol}^{-1}$ ) of the following elements.
- | Elements                       | $\Delta H_1$ | $\Delta H_2$ | $\Delta_{\text{eg}} H$ |
|--------------------------------|--------------|--------------|------------------------|
| A. Most reactive non-metal     | p.           | 419          | 3051 - 45              |
| B. Most reactive metal         | q.           | 1681         | 3374 - 328             |
| C. Least reactive element      | r.           | 738          | 1451 - 40              |
| D. Metal forming binary halide | s.           | 2372         | 5251 + 48              |
- Codes**
- | A   | B | C | D | A | B   | C | D |   |   |
|-----|---|---|---|---|-----|---|---|---|---|
| (a) | q | p | s | r | (b) | p | q | r | s |
| (c) | p | s | r | q | (d) | p | q | s | r |
- 37.** If  $r_{\text{H}}$  and  $r_{\text{F}}$  are  $0.37 \text{ \AA}$  and  $0.72 \text{ \AA}$ , respectively and electronegativities of F and H are 4.0 and 2.1, respectively. The theoretical value of bond length in  $\text{H}-\text{F}$  is  
(a)  $0.80 \text{ \AA}$  (b)  $1.1 \text{ \AA}$  (c)  $0.72 \text{ \AA}$  (d)  $0.92 \text{ \AA}$
- 38.** Which of the following is an incorrect statement?  
(a) Fluorine is more electronegative than chlorine  
(b) Nitrogen has greater  $\text{IE}_1$  than oxygen  
(c) Lithium is amphoteric  
(d) Chlorine is an oxidising agent
- 39.** Which is the correct order for ionic sizes (At. no. Ce = 58, Sn = 50, Yb = 70 and Lu = 71).  
(a)  $\text{Ce} > \text{Sn} > \text{Yb} > \text{Lu}$  (b)  $\text{Sn} > \text{Yb} > \text{Ce} > \text{Lu}$   
(c)  $\text{Sn} > \text{Ce} > \text{Yb} > \text{Lu}$  (d)  $\text{Lu} > \text{Yb} > \text{Sn} > \text{Ce}$
- 40.** Fluorine has low electron affinity than chlorine because of  
(a) bigger radius of fluorine, less density  
(b) smaller radius of fluorine, high density  
(c) smaller radius of chlorine, high density  
(d) smaller radius of chlorine, less density
- 41.** The correct increasing order of molecular character of oxides:  $\text{SO}_3$ ,  $\text{Cl}_2\text{O}_7$ ,  $\text{CaO}$  and  $\text{PbO}_2$  is  
(a)  $\text{CaO} < \text{PbO}_2 < \text{SO}_3 < \text{Cl}_2\text{O}_7$   
(b)  $\text{PbO}_2 < \text{SO}_3 < \text{CaO} < \text{Cl}_2\text{O}_7$   
(c)  $\text{PbO}_2 < \text{Cl}_2\text{O}_7 < \text{CaO} < \text{SO}_3$   
(d)  $\text{CaO} < \text{SO}_3 < \text{Cl}_2\text{O}_7 < \text{PbO}_2$
- 42.** Compounds that formally contains  $\text{Pb}^{4+}$  easily reduced to  $\text{Pb}^{2+}$ . The stability of the lower oxidation state is due to  
(a) inert pair effect (b) electronegativity  
(c) diagonal relationship (d) Both (b) and (c)
- 43.** Which of the following metal exhibits more than one oxidation state  
(a) Na (b) Mg (c) Al (d) Fe
- 44.** An element X which occurs in the first short period has an outer electronic structure,  $s^2p^1$ . What are the formula and acid-base character of its oxides?  
(a)  $\text{XO}_3$ , basic (b)  $\text{X}_2\text{O}_3$ , basic  
(c)  $\text{X}_2\text{O}_3$ , amphoteric (d)  $\text{XO}_2$ , acidic
- 45.** A trend common to both group I and VII elements in the periodic table as atomic number increases is  
(a) atomic radius increases  
(b) oxidising power increases  
(c) reactivity with water increases  
(d) maximum valency increases
- 46.** In periodic table, the basic character of oxides  
(a) increases from left to right and decrease from top to bottom  
(b) decreases from right to left and increases from top to bottom  
(c) decreases from left to right and increases from top to bottom  
(d) decreases from left to right and increases from bottom to top
- 47.** The following statements regarding the periodic trends of chemical reactivity of the alkali metals and the halogens are given. Which of these statements gives the correct explanation?  
(a) The reactivity decreases in the alkali metals but increases in the halogens with increase in atomic number down the group  
(b) In both the alkali metals and the halogens, the chemical reactivity decreases with increase in atomic number down the group.  
(c) In both the alkali metals and the halogens, the chemical reactivity increases with increase in atomic number down the group  
(d) In alkali metals the reactivity increases but in the halogens, it decreases with increase in atomic number down the group
- 48.** Which among the following factor is the most important in making fluorine the strongest oxidising halogen?  
(a) Hydration enthalpy (b) Electron gain enthalpy  
(c) Ionisation enthalpy (d) Bond dissociation enthalpy
- 49.** Among  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{P}_2\text{O}_3$  and  $\text{SO}_2$ , the correct order of acidic strength is  
(a)  $\text{SO}_2 < \text{P}_2\text{O}_3 < \text{SiO}_2 < \text{Al}_2\text{O}_3$   
(b)  $\text{SiO}_2 < \text{SO}_2 < \text{Al}_2\text{O}_3 < \text{P}_2\text{O}_3$   
(c)  $\text{Al}_2\text{O}_3 < \text{SiO}_2 < \text{SO}_2 < \text{P}_2\text{O}_3$   
(d)  $\text{Al}_2\text{O}_3 < \text{SiO}_2 < \text{P}_2\text{O}_3 < \text{SO}_2$
- 50.** The elements X, Y and Z form oxides which are acidic, basic and amphoteric, respectively. The correct order of their electronegativity is  
(a)  $X > Y > Z$  (b)  $Z > Y > X$  (c)  $X > Z > Y$  (d)  $Y > X > Z$

**Answers**

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (a)  | 2. (b)  | 3. (b)  | 4. (d)  | 5. (a)  |
| 6. (a)  | 7. (b)  | 8. (c)  | 9. (a)  | 10. (a) |
| 11. (c) | 12. (b) | 13. (d) | 14. (b) | 15. (a) |
| 16. (b) | 17. (d) | 18. (d) | 19. (b) | 20. (c) |
| 21. (c) | 22. (c) | 23. (b) | 24. (c) | 25. (d) |
| 26. (b) | 27. (d) | 28. (b) | 29. (c) | 30. (d) |
| 31. (b) | 32. (a) | 33. (d) | 34. (c) | 35. (a) |
| 36. (a) | 37. (d) | 38. (c) | 39. (c) | 40. (b) |
| 41. (a) | 42. (a) | 43. (d) | 44. (c) | 45. (a) |
| 46. (c) | 47. (d) | 48. (d) | 49. (c) | 50. (c) |

# HYDROGEN

- It is the first element in the periodic table with electronic configuration of  $1s^1$ .
- It is the simplest element known that contains 1 proton in its nucleus with 1 planetary electron present in the  $s$ -orbital of  $K$ -shell or 1st orbit.
- Neutron is absent in its nucleus.
- It is the most abundant element of the universe with 70% by mass. However, its occurrence is very less in the earth's atmosphere (0.15% by mass) due to its light nature.
- It exists as 3 different isotopes such as protium ( ${}_1\text{H}^1$ ), deuterium or heavy hydrogen ( ${}_1\text{H}^2$  or  $\text{D}$ ) and tritium ( ${}_1\text{H}^3$  or  $\text{T}$ ).

## REMEMBER

- Atomic mass, melting point, boiling point, density, enthalpy of fusion/vaporisation and bond dissociation enthalpy increases from protium to tritium due to increase in atomic mass.
- They have same chemical property but the rate of reaction decreases from protium to tritium due to increase in bond dissociation enthalpy.
- Hydrogen shows dual nature, i.e. it can behave like alkali metals as well as halogens.

## Resemblance with Alkali Metals

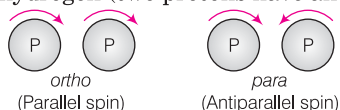
- All alkali metals and hydrogen have similar outermost electronic configuration, i.e.  $ns^1$ .
- All of them are strongly electropositive, i.e. have tendency to lose their outermost electron and change into unipositive ions.
- Normal valency of all alkali metals and hydrogen is 1.
- All form stable oxides (like  $\text{H}_2\text{O}$ ,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$  etc.) and peroxides (like  $\text{H}_2\text{O}_2$ ,  $\text{Na}_2\text{O}_2$ , etc.)
- All are good reducing agents due to their high electropositive character.

## Resemblance with Halogens

- Like halogens, hydrogen have the tendency to gain an electron, thus change into  $\text{H}^-$  ion and acquire the stable configuration ( $1s^2$ ).
- Hydrogen shows the ionisation energy of the same order as halogens.
- In its molecular state, hydrogen ( $\text{H}_2$ ) is a gas. Similarly, among halogens  $\text{F}_2$  and  $\text{Cl}_2$  are gases,  $\text{Br}_2$  is volatile liquid and  $\text{I}_2$  is volatile solid.

## Allotropes of Hydrogen

Hydrogen exists as *ortho*-hydrogen (two protons have parallel spin) and *para*-hydrogen (two protons have antiparallel spin).



- These two forms are interconvertible.
- At room temperature, hydrogen gas has 75% *ortho*- form and 25% *para*- form.

## REMEMBER

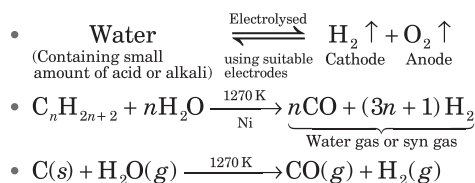
Since, *para*-form has lower energy, on decreasing temperature, *ortho*- form is continuously converted into *para*-form and becomes 100% *para*-form at absolute zero. The reverse process occurs when temperature is increased. Thus, *para* hydrogen is favoured at lower temperature.

- Both allotropes have same chemical properties but different physical properties like thermal conductivity, boiling point, specific heats, etc.

## Methods of Preparation of Dihydrogen

$\text{H}_2$  is prepared through the following methods:

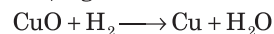
- $\text{Zn} + \text{H}_2\text{SO}_4 \longrightarrow \text{ZnSO}_4 + \text{H}_2 \uparrow$  (Lab method)



The above process is called **coal gasification**.

## Physical and Chemical Properties

- Hydrogen is colourless, odourless, tasteless diatomic gas. It is the lightest element known.
- On combination with non-metals it forms covalent compounds at higher temperatures.
- On combination with metals, electrovalent hydrides are formed.
- $\text{H}_2$  has the property to reduce the oxides of less electropositive element, e.g.



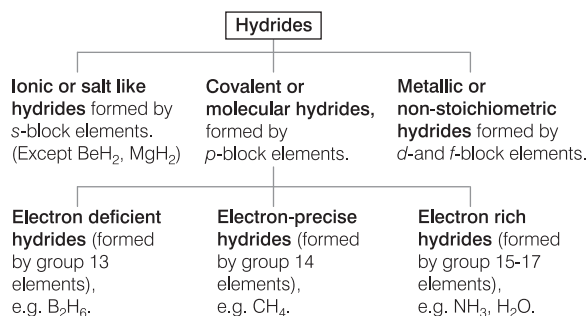
## Uses

$\text{H}_2$  is used in the synthesis of  $\text{NH}_3$  by Haber's process, organic compounds like  $\text{CH}_3\text{OH}$ , hydrogenation of vegetable oils, metal hydrides. It is also used as a rocket fuel and in fuel cells for generating electrical energy without causing pollution.

## Hydrides

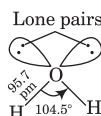
Hydrogen forms hydrides with most of the elements except noble gases, group VII, VIII and IX elements of  $d$ -block. Hydrides are classified as follows :

## RAPID CONCEPT REVISION



## Water

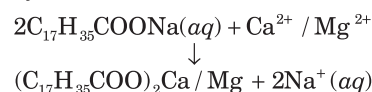
- It is the most important hydride and plays a vital role for the existence of life due to its ability to form hydrogen bonding and high specific heat capacity.
- It is polar and has two lone pairs of electrons and is a bent molecule in gas phase with bond angle of 104.5°.
- It behaves as an amphoteric substance and can be oxidised as well as reduced.



- Ice is the crystalline form of water which exists below melting point of water.
- It forms hcp crystals at atmospheric pressure but condenses to cubic form at low temperature.
- The crystalline structure has large voids that make ice less denser than water.
- In crystalline structure of ice, each O-atom is tetrahedrally surrounded by 4 other O-atoms. Hydrogen bonding is also found in ice.

## Hardness of Water

- It is due to the presence of calcium and magnesium salt of bicarbonates (temporary hardness), chlorides and sulphates (permanent hardness).
- Hard water forms precipitate with soap through the reaction given below and hence, not suitable for laundry.



The hardness of water is removed through the following methods:

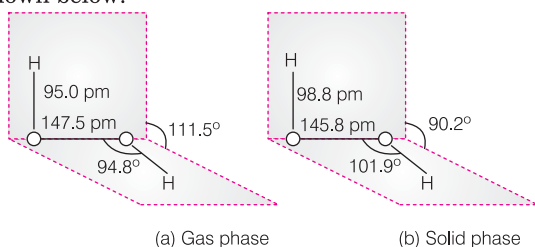
	Procedure	Chemical reaction
(a)	<b>Removal of temporary hardness</b>	
1.	<b>Boiling</b> $\text{Mg}(\text{HCO}_3)_2$ is precipitated as $\text{Mg}(\text{OH})_2$ , whereas $\text{Ca}(\text{HCO}_3)_2$ is precipitated as $\text{CaCO}_3$ .	$\text{Mg}(\text{HCO}_3)_2 \xrightarrow{\Delta} \text{Mg}(\text{OH})_2 \downarrow + 2\text{CO}_2$ $\text{Ca}(\text{HCO}_3)_2 \xrightarrow{\Delta} \text{CaCO}_3 \downarrow + \text{H}_2\text{O} + \text{CO}_2$ (Here, $\text{Mg}(\text{OH})_2$ is produced instead of $\text{MgCO}_3$ due to high solubility product of $\text{Mg}(\text{OH})_2$ )
2.	<b>Clark's method</b> Required amount of lime is added to hard water that precipitates hydrogen carbonates as carbonates.	$\text{Ca}(\text{HCO}_3)_2 + \text{Ca}(\text{OH})_2 \longrightarrow 2\text{CaCO}_3 \downarrow + 2\text{H}_2\text{O}$ $\text{Mg}(\text{HCO}_3)_2 + \text{Ca}(\text{OH})_2 \longrightarrow \text{Mg}(\text{OH})_2 + 2\text{CaCO}_3 \downarrow + 2\text{H}_2\text{O}$
(b)	<b>Removal of permanent hardness</b>	
1.	<b>Treatment with <math>\text{Na}_2\text{CO}_3</math></b>	$\text{MCl}_2 + \text{Na}_2\text{CO}_3 \longrightarrow \text{MCO}_3 \downarrow + 2\text{NaCl}$ $\text{MSO}_4 + \text{Na}_2\text{CO}_3 \longrightarrow \text{MCO}_3 \downarrow + \text{Na}_2\text{SO}_4 \quad (M = \text{Ca}, \text{Mg})$
2.	<b>Calgon's method</b> Calgon (sodium hexa metaphosphate) is added to hard water that removes chlorides and sulphates.	$\text{M}^{2+} + \text{Na}_4\text{P}_6\text{O}_{18}^{2-} \longrightarrow [\text{Na}_2\text{MP}_6\text{O}_{18}]^{2-} + 2\text{Na}^+(aq)$ (M = Ca, Mg)
3.	<b>Ion-exchange method</b> Hydrated sodium aluminium silicate or zeolite or permutit ( $\text{Na}_2 \cdot \text{Al}_2\text{Si}_2\text{O}_8 \cdot x\text{H}_2\text{O}$ ) is added to hard water that removes hardness through ion exchange reaction.	$\text{Na}_2(\text{AlSiO}_4)_2(s) + \text{M}^{2+}(aq) \longrightarrow \text{M}(\text{AlSiO}_4)_2 \downarrow + 2\text{Na}^+(aq)$ (M = Ca, Mg)
4.	<b>Synthetic resins method</b>	
(i)	<b>Cation exchange resins</b> These resins ( $\text{RNa}, \text{RH}$ etc.) exchange cations present in hard water.	$2\text{RNa}(s) + \text{M}^{2+}(aq), \quad 2\text{RH}(s) + \text{M}^{2+}(aq) \longrightarrow \text{R}_2\text{M}(s) + 2\text{H}^+(aq)$ $\text{R}_2\text{M}(s) + 2\text{Na}^+(aq) \quad (M = \text{Ca}^{2+}, \text{Mg}^{2+})$
(ii)	<b>Anion exchange resins</b> These resins exchange anions present in hard water.	$\text{RNH}_3^+ \text{OH}^- + \text{X}^-(aq) / \text{SO}_4^{2-}$ (Anion exchange resin) $\text{RNH}_3^+ \text{X}^-(s) / \text{R}(\text{NH}_3)_2\text{SO}_4 + \text{OH}^-(aq)$ (X <sup>-</sup> = Cl <sup>-</sup> , HCO <sub>3</sub> <sup>-</sup> , etc.)

## Heavy Water (D<sub>2</sub>O)

- It is obtained by rigorous electrolysis of water.
- D<sub>2</sub>O gives all reactions that are given by ordinary water but at a slower rate due to high bond energy.
- It is used as a moderator in nuclear reactors, in the study of mechanisms of chemical reactions involving hydrogen and its compound, etc.

## Hydrogen Peroxide (H<sub>2</sub>O<sub>2</sub>)

- It is one of the most important compound of hydrogen.
- It has an open book type structure (non-planar) having different bond parameters in solid and gaseous phase as shown below:



## Preparations

It is prepared through the following chemical reactions.

- $\text{BaO}_2 \cdot 8\text{H}_2\text{O}(s) + \text{H}_2\text{SO}_4(aq) \longrightarrow \text{BaSO}_4(s) + \text{H}_2\text{O}_2 + 8\text{H}_2\text{O}$
- $\text{H}_2\text{SO}_4 \rightleftharpoons \text{H}^+ + \text{HSO}_4^-$

**At cathode**  $2\text{H}^+ + 2e^- \longrightarrow 2\text{H} \longrightarrow \text{H}_2$

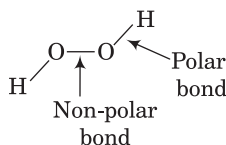
**At anode**  $2\text{HSO}_4^- \longrightarrow \text{H}_2\text{S}_2\text{O}_8 + 2e^-$

The  $\text{H}_2\text{S}_2\text{O}_8$  on hydrolysis gives  $\text{H}_2\text{O}_2$ .

- 2-alkyl anthraquinol  $\xrightleftharpoons[\text{R}]{\text{O}}$   $\text{H}_2\text{O}_2 + \text{Oxidised product}$

## Physical Properties

- Pure  $\text{H}_2\text{O}_2$  is odourless and pale-blue in colour.
- It exists as liquid at normal temperature and pressure due to hydrogen bonding.
- It is diamagnetic having both polar and non-polar bond.



- Some of the important physical properties of  $\text{H}_2\text{O}$ ,  $\text{D}_2\text{O}$  and  $\text{H}_2\text{O}_2$  are given in the table below:

Name of physical property	H <sub>2</sub> O	D <sub>2</sub> O	H <sub>2</sub> O <sub>2</sub>
Melting point (K)	273	276.8	272.4
Boiling point (K)	373	374.4	423
Density (298 K, gcm <sup>-3</sup> )	1.000	1.106	1.440
Viscosity (298 K, centipoise)	0.89	1.11	1.25
Dielectric constant (298 K, C <sup>2</sup> N <sup>-1</sup> m <sup>-2</sup> )	78.39	78.06	70.7

## Chemical Properties

- It acts as both oxidising and reducing agent in acidic as well as alkaline medium, as O-atom in  $\text{H}_2\text{O}_2$  is in intermediate oxidation state (-1).
- In acidic medium, it is reduced to water whereas in alkaline medium, it is reduced to  $\text{OH}^-$ .
- Some of the important reactions are given in the below table.

Reaction condition	Chemical reaction
<b>(a) Oxidising property</b>	
(i) In acidic medium (Reduced to $\text{H}_2\text{O}$ )	$\text{Fe}^{2+}$ to $\text{Fe}^{3+}$ , $\text{PbS}$ to $\text{PbSO}_4$ , $\text{I}^-$ to $\text{I}_2$ , $\text{K}_4[\text{Fe}(\text{CN})_6]$ to $\text{K}_3[\text{Fe}(\text{CN})_6]$ , $\text{Hg}$ to $\text{HgO}$ , $\text{H}_2\text{S}$ to $\text{S}$ , etc.
(ii) In basic medium (Reduced to $\text{OH}^-$ )	$\text{Fe}^{2+}$ to $\text{Fe}^{3+}$ , $\text{Mn}^{2+}$ to $\text{Mn}^{4+}$ , etc.
<b>(b) Reducing property</b>	
(i) In acidic medium (oxidised to $\text{O}_2$ )	$\text{Ag}_2\text{O}$ to $\text{Ag}$ , $\text{PbO}_2$ to $\text{PbO}$ , $\text{MnO}_4^-$ to $\text{Mn}^{2+}$ , $\text{OCl}^-$ to $\text{Cl}^-$ , $\text{MnO}_2$ to $\text{Mn}^{2+}$ , etc.
(ii) In basic medium (oxidised to $\text{O}_2$ )	$\text{I}_2$ to $\text{I}^-$ , $\text{MnO}_4^-$ to $\text{MnO}_2$ , $\text{K}_3[\text{Fe}(\text{CN})_6]$ to $\text{K}_4[\text{Fe}(\text{CN})_6]$ , etc.

## REMEMBER

- When  $\text{H}_2\text{O}_2$  is added to a cold mixture of  $\text{K}_2\text{Cr}_2\text{O}_7$  and concentrated  $\text{H}_2\text{SO}_4$ , a blue coloured solution is obtained due to the formation of perchromate ( $\text{CrO}_5$ ).  

$$\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{SO}_4 + 4\text{H}_2\text{O}_2 \longrightarrow \text{K}_2\text{SO}_4 + 2\text{CrO}_5 + 5\text{H}_2\text{O}$$

(Blue colour)
- $\text{H}_2\text{O}_2$  is stored in plastic vessels because metal surface or glass (alkali) catalyse the decomposition of  $\text{H}_2\text{O}_2$  to  $\text{H}_2\text{O}$  and  $\text{O}_2$ .

## Uses

- It is germicide and antiseptic. It is used for washing cuts, wounds, teeth under the name perhydrol.
- Old oil paintings turn black with time due to the formation of black  $\text{PbS}$ .  $\text{H}_2\text{O}_2$  oxidises black  $\text{PbS}$  into white  $\text{PbSO}_4$  and thus, restore their colour.
- It is used as antichlor to remove  $\text{Cl}_2$  etc., present in a solution.

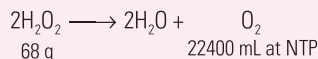
## Strength of $\text{H}_2\text{O}_2$

- It is expressed in terms of 'volume of  $\text{O}_2$ '.
- Commercially,  $\text{H}_2\text{O}_2$  is available as '10 volume of  $\text{H}_2\text{O}_2$ ' which means 1 mL of  $\text{H}_2\text{O}_2$  at NTP gives 10 mL of  $\text{O}_2$  gas."
- The strength of 10 volume of  $\text{H}_2\text{O}_2$  solution is 3%  $\text{H}_2\text{O}_2$  by weight. This expression can be converted into strength ( $\text{g L}^{-1}$ ), normality, density, etc., by applying stoichiometry.


**RAPID CONCEPT REVISION**
**Trick to Solve Problems Based on Finding Strength, Normality and Density of H<sub>2</sub>O<sub>2</sub> Solution**

Volume strength of H<sub>2</sub>O<sub>2</sub> can be converted to strength (g L<sup>-1</sup>), normality, density, etc., through the following steps:

**Step 1** Write the balanced equation for the decomposition of H<sub>2</sub>O<sub>2</sub> and apply laws of stoichiometry.



**Step 2** For a given 'x' volume of H<sub>2</sub>O<sub>2</sub> solution, calculate the weight of H<sub>2</sub>O<sub>2</sub> giving x mL of O<sub>2</sub> gas.

22400 mL O<sub>2</sub> is produced by 68 g of H<sub>2</sub>O<sub>2</sub>

∴ x mL O<sub>2</sub> will be produced by

$$= \frac{68 \text{ g}}{22400 \text{ mL}} \times x \text{ mL (at NTP)} = \frac{68x}{22400} \text{ g H}_2\text{O}_2$$

Since, according to definition, 1 mL of H<sub>2</sub>O<sub>2</sub> gives x mL O<sub>2</sub> gas,

hence,  $\frac{68x}{22400}$  g will be the weight of 1 mL H<sub>2</sub>O<sub>2</sub>.

**Step 3** From step 2, it is clear that density of H<sub>2</sub>O<sub>2</sub> solution

$$= \frac{68x}{22400} \text{ g mL}^{-1}$$

**Step 4** Calculate strength (g L<sup>-1</sup>)

$$\begin{aligned} \text{Strength (g L}^{-1}\text{)} &= \frac{68x}{22400} \times 1000 \text{ g L}^{-1} \\ &= \frac{680x}{224} \text{ g L}^{-1} \end{aligned}$$

**Step 5** Calculate normality (N)/molarity (M).

$$\begin{aligned} N &= \frac{\text{Strength (g L}^{-1}\text{)}}{\text{Equivalent weight of H}_2\text{O}_2} \\ &= \frac{680x}{224} \times \frac{1}{17} = \frac{x}{5.6} \text{ N} \\ M &= \frac{x}{11.2} \text{ M} \end{aligned}$$

# MASTER STROKES

- Ortho* and *para* hydrogen differs in
  - nuclear charge
  - nuclear reaction
  - electron spin
  - proton spin
- Which of the following is poorest reducing agent?
  - Atomic hydrogen
  - Nascent hydrogen
  - Dihydrogen
  - All have same reducing strength
- Hydrogen resembles halogens in many respects for which several factors are responsible. From the following factors, which one is most important in this respect?
  - Its tendency to lose an electron to form a cation
  - Its tendency to gain a single electron in its valence shell to attain stable electronic configuration
  - Its low negative electron gain enthalpy value
  - Its small size
- Very pure hydrogen (99.9%) can be made by which of the following processes?
  - Reaction of methane with steam
  - Mixing natural hydrocarbons of high molecular weight
  - Electrolysis of water
  - Reaction of salts like hydrides with water
- Under what conditions of temperature and pressure, the formation of atomic hydrogen from molecular hydrogen will be favoured more?
  - High temperature and low pressure
  - Low temperature and low pressure
  - High temperature and high pressure
  - Low temperature and high pressure
- Which of the following metals evolve hydrogen on reacting with cold dilute HNO<sub>3</sub>?
  - Fe
  - Cu
  - Al
  - Mg
- High purity H<sub>2</sub> is formed by
  - electrolysis of acidified water using platinum electrodes
  - electrolysis of warm aqueous Ba(OH)<sub>2</sub> solution between nickel electrodes
  - electrolysis of brine solution using amalgam electrodes
  - reaction of steam on hydrocarbon or coke
- In water-gas shift reaction, H<sub>2</sub> is formed in excess and CO is oxidised to CO<sub>2</sub>

$$\text{CO} + \text{H}_2 + \text{H}_2\text{O} \xrightarrow[450-550 \text{ K}]{\text{Fe}_2\text{O}_3} \text{CO}_2 + 2\text{H}_2$$

Mixture of CO<sub>2</sub> and H<sub>2</sub> can be separated by

  - dissolving into water
  - dissolving into lime water
  - diffusion
  - All of the above
- Atomic hydrogen is formed in the following reaction,
 
$$\text{H}_2(\text{g}) \xrightarrow{\text{Tungsten}} 2\text{H}(\text{g})$$

It is a powerful reducing agent. Which of the following reaction does not show the reducing nature of hydrogen?

  - HgO + 2H → Hg + H<sub>2</sub>O
  - CuO + 2H → Cu + H<sub>2</sub>O
  - AgNO<sub>3</sub> + H → Ag + HNO<sub>3</sub>
  - Na + H → NaH



- 10.** Which of the following process is used for the manufacture of  $H_2$ ?
- Hoope's process
  - Le-Blanc process
  - Lane's process
  - Carter's process
- 11.** Which one of the following is correct order?
- $T_2 > D_2 > P_2$  (order of boiling point)
  - $T_2 > D_2 > P_2$  (order of bond enthalpy)
  - $T_2 = D_2 = P_2$  (order of bond length)
  - $T_2 < D_2 < P_2$  (order of reactivity with  $Cl_2$ )
- I, II and III
  - Both I and II
  - I, II, III and IV
  - II, III and IV
- 12.** In context with the industrial preparation of hydrogen from water gas ( $CO + H_2$ ), which of the following is the correct statement?
- $CO$  and  $H_2$  are fractionally separated using difference in their densities
  - $CO$  is removed by the absorption in aqueous  $Cu_2Cl_2$  solution
  - $H_2$  is removed through occlusion with Pd
  - $CO$  is oxidised to  $CO_2$  with steam in the presence of a catalyst followed by absorption of  $CO_2$  in alkali
- 13.** Polyphosphates are used as water softening agents because they
- form soluble complexes with anionic species
  - precipitate anionic species
  - precipitate cationic species
  - form soluble complexes with cationic species
- 14.**  $H_2O_2$  is manufactured these days by
- burning hydrogen in excess of oxygen
  - the action of  $H_2O_2$  on  $BaO_2$
  - the action of  $H_2SO_4$  on  $Na_2O_2$
  - electrolysis of 50%  $H_2SO_4$
- 15.** In Calgon's method of removing permanent hardness,  $Ca^{2+}$  and  $Mg^{2+}$  remain soluble due to the formation of complex,
- $Na_2[Na_2CaP_6O_{18}]$
  - $Na_4[CaP_6O_{18}]$
  - $Ca[NaPO_3]_4$
  - None of these
- 16.** De-ionised water is obtained by passing hard water through
- anion exchanger
  - zeolite
  - cation exchanger
  - Both anion and cation exchanger
- 17.** What mass of  $CaO$  will be required to remove the hardness of 1000L of water containing 1.62g of calcium bicarbonate per litre?
- 560 g
  - 660 g
  - 720 g
  - 220 g
- 18.** When hard water is passed through ion exchange resin of type  $R'COOH$ , then the ion released is
- $Mg^{2+}$
  - $H_3O^+$
  - $SO_4^{2-}$
  - $Ca^{2+}$
- 19.** Identify the incorrect statement from the following regarding heavy water. [JEE Main 2016]
- It reacts with  $CaC_2$  to produce  $C_2D_2$  and  $Ca(OD)_2$
  - It is used as a coolant in nuclear reactors
  - It reacts with  $Al_4C_3$  to produce  $CD_4$  and  $Al(OD)_3$
  - It reacts with  $SO_3$  to form deuterated sulphuric acid ( $D_2SO_4$ )
- 20.** Which one of the following statements about water is false? [JEE Main 2016]
- Water can act both as an acid and as a base
  - There is extensive intramolecular hydrogen bonding in the condensed phase
  - Ice formed by heavy water sinks in normal water
  - Water is oxidised to oxygen during photosynthesis
- 21.** Saline hydrides are known to react with water violently producing fire. The fire cannot be extinguished by  $CO_2$  because
- $CO_2$  is lighter than the gas evolved
  - $CO_2$  is heavier than the gas evolved
  - $CO_2$  gets reduced by the gas evolved
  - $CO_2$  gets oxidised by the gas evolved
- 22.** Given sample of matter has degree of hardness equal to 40 ppm. If the entire hardness is due to  $MgSO_4$ , the amount of  $MgSO_4$  present per kg of water is
- 24 g
  - 48 g
  - 24 mg
  - 48 mg
- 23.** Which of the following processes will produce hard water?
- Saturation of water with  $CaCO_3$
  - Saturation of water with  $MgCO_3$
  - Saturation of water with  $CaSO_4$
  - Addition of  $Na_2SO_4$  to water
- 24.** Saline hydrides are known to react with water violently producing fire which can be put off by
- $CO_2$
  - $H_2O$
  - sand
  - None of these
- 25.** Electron-rich hydrides have excess of electrons which are present as lone pairs. Number of lone pairs are incorrectly matched in
- $PH_3 - 1$
  - $HF - 3$
  - $H_2O - 2$
  - $CH_4 - 4$
- 26.** Which of the following is not correct regarding the electrolytic preparation of  $H_2O_2$ .
- Lead is used as cathode
  - Hydrogen is liberated at anode
  - 50%  $H_2SO_4$  is used
  - Sulphuric acid undergoes oxidation
- 27.** The degree of hardness of water is usually expressed in terms of
- ppm weight of  $MgSO_4$
  - g/L of  $CaCO_3$  and  $MgCO_3$  present
  - ppm by weight of  $CaCO_3$  irrespective of whether it is actually present
  - ppm of  $CaCO_3$  actually present in water

## RAPID CONCEPT REVISION

- 28.** Hydrogen sulphide is acidic while water is neutral. The reason is  
 (a) molecular weight of  $\text{H}_2\text{S}$  is more than  $\text{H}_2\text{O}$   
 (b) water molecules associate, while  $\text{H}_2\text{S}$  molecules does not  
 (c)  $\text{H}-\text{S}$  bond is weaker than  $\text{H}-\text{O}$  bond due to the bigger size of S-atom  
 (d) S-atoms has less affinity for hydrogen atom than O-atom
- 29.** Steam is passed over red hot carbon and the gaseous products cooled and passed first through a solution of alkali then through ammoniacal cuprous chloride and then through water. What is finally collected?  
 (a)  $\text{CO}_2$   
 (b) A mixture of hydrocarbon  
 (c)  $\text{CO} + \text{H}_2$   
 (d)  $\text{H}_2$
- 30.** The strength in volumes of a solution containing 30.36 g/L of  $\text{H}_2\text{O}_2$  is  
 (a) 10V (b) 5V  
 (c) 20V (d) None of these
- 31.** Select the correct statement about the reaction of  $\text{MnO}_4^-$  with  $\text{H}_2\text{O}_2$ . It is reduced to  
 (a)  $\text{Mn}^{2+}$  in acidic medium and  $\text{MnO}_2$  in basic medium  
 (b)  $\text{MnO}_2$  in acidic medium  $\text{Mn}^{2+}$  in basic medium  
 (c)  $\text{Mn}^{2+}$  in acidic as well as in basic medium  
 (d)  $\text{MnO}_2$  in acidic as well as in basic medium
- 32.** When  $\text{CO}_2$  is bubbled through a solution of barium peroxide in water  
 (a)  $\text{O}_2$  is released  
 (b) carbonic acid is formed  
 (c)  $\text{H}_2\text{O}_2$  is formed  
 (d) no reaction occurs
- 33.** How many millilitre of perhydrol is required to produce sufficient oxygen which can be used to completely convert 2L of  $\text{SO}_2$  gas  
 (a) 10 mL (b) 5 mL  
 (c) 20 mL (d) 30 mL
- 34.** From the following statements regarding  $\text{H}_2\text{O}_2$ , choose the incorrect statement. [JEE Main 2015]  
 (a) It can act only as an oxidising agent  
 (b) It decomposed on exposure to light  
 (c) It has to be stored in plastic or wax lined glass bottles in dark  
 (d) It has to be kept away from dust
- 35.** Which of the following reactions is accompanied by the emission of light in the dark (chemiluminesens)?  
 (a)  $2\text{HCO} + \text{H}_2\text{O}_2 \longrightarrow 2\text{HCOOH} + \text{H}_2$   
 (b)  $\text{Na}_2\text{CO}_3 + \text{H}_2\text{O}_2 \longrightarrow \text{Na}_2\text{O}_2 + \text{H}_2\text{O} + \text{CO}_2$   
 (c)  $\text{AsO}_3^{3-} + \text{H}_2\text{O}_2 \longrightarrow \text{AsO}_4^{3-} + \text{H}_2\text{O}$   
 (d)  $\text{NO}_2^- + \text{H}_2\text{O}_2 \longrightarrow \text{NO}_3^- + \text{H}_2\text{O}$
- 36.** Hydrogen peroxide when added to a solution of potassium permanganate acidified with sulphuric acid  
 (a) forms water  
 (b) acts as an oxidising agent  
 (c) acts as a reducing agent  
 (d) reduced sulphuric acid
- 37.** The hardness of water is estimated by  
 (a) EDTA method (b) titrimetric method  
 (c) conductivity method (d) distillation method
- 38.** The laboratory method for the preparation of  $\text{H}_2\text{O}_2$  is by  
 (a)  $\text{H}_2\text{SO}_4$  (b)  $\text{NH}_4\text{HSO}_4$   
 (c)  $\text{Na}_2\text{O}_2 + \text{H}_2\text{SO}_4$  (d) All of these
- 39.** Phosphoric acid is preferred over sulphuric acid in preparing hydrogen peroxide from peroxides because  
 (a)  $\text{H}_2\text{SO}_4$  acts as a reducing agent  
 (b)  $\text{H}_2\text{SO}_4$  gives  $\text{BaSO}_4$  which is difficult to separate  
 (c)  $\text{H}_2\text{SO}_4$  acts as catalyst  
 (d) Both (a) and (c)
- 40.** Which of the following equations depicts the oxidising nature of  $\text{H}_2\text{O}_2$ ?  
 (a)  $2\text{MnO}_4^- + 6\text{H}^+ + \text{H}_2\text{O}_2 \longrightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{O}_2$   
 (b)  $2\text{Fe}^{3+} + 2\text{OH}^- + \text{H}_2\text{O}_2 \longrightarrow 2\text{Fe}^{2+} + 2\text{H}_2\text{O} + \text{O}_2$   
 (c)  $2\text{I}^- + 2\text{H}^+ + \text{H}_2\text{O}_2 \longrightarrow \text{I}_2 + 2\text{H}_2\text{O}$   
 (d)  $\text{PbS} + 4\text{H}_2\text{O}_2 \longrightarrow \text{PbSO}_4 + 4\text{H}_2\text{O}$

### Answers

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (d)  | 2. (c)  | 3. (b)  | 4. (d)  | 5. (a)  |
| 6. (d)  | 7. (b)  | 8. (d)  | 9. (d)  | 10. (c) |
| 11. (b) | 12. (d) | 13. (d) | 14. (d) | 15. (a) |
| 16. (d) | 17. (a) | 18. (b) | 19. (b) | 20. (b) |
| 21. (c) | 22. (c) | 23. (c) | 24. (b) | 25. (d) |
| 26. (c) | 27. (c) | 28. (c) | 29. (d) | 30. (a) |
| 31. (a) | 32. (c) | 33. (a) | 34. (a) | 35. (a) |
| 36. (c) | 37. (a) | 38. (c) | 39. (c) | 40. (c) |

## THE SECRET BEHIND ELECTION INK MARK

Whenever an election comes round, you'll see that people who voted have an ink mark on their fingers. Silver nitrate is just the chemical we need. It is soluble in water, so you can make an inky black solution. When it is put on skin, it reacts with the salt present on it to form silver chloride. Silver chloride is not soluble in water, and clings to your skin. It cannot be washed off with soap and water. Not even hot water. Not even if you use alcohol, nail polish remover, or bleach. (But please don't try these things, they are dangerous.) But as new skin grows and the old skin sloughs off, the ink stain will disappear. The ink on the skin goes off in a week. The ink on the nail takes longer, as the nail grows out.



## **s-BLOCK ELEMENTS**

- s-block elements constitute two groups which are present at the extreme left of periodic table.
- The first group is called **alkali metals**. It contains Li, Na, K, Rb, Cs, Fr having general electronic configuration of [inert gas]  $ns^1$ .
- The second group is called **alkaline earth metals**. It contains Be, Mg, Ca, Sr, Ba, Ra having general electronic configuration of [inert gas]  $ns^2$ .

### I. Physical Properties

	Properties	Alkali metals	Alkaline earth metals
(i)	Ionisation enthalpy (1st)	Sharply decreases down the group. It is less than the corresponding alkaline earth metals and also the least in the corresponding period.	Sharply decreases upto Ba and then increases slightly from Ba to Ra.
(ii)	Hydration enthalpy	Sharply decreases down the group (due to increase in ionic radius).	Sharply decreases down the group (due to increase in ionic radius).
(iii)	Density	Irregular (usually increases on moving down the group but K has slightly lower density than Na)	Irregular (but higher than the corresponding alkali metal).
(iv)	Melting and boiling points	Decreases sharply down the group	Irregular (but higher than the corresponding alkali metal).
(v)	Colour to oxidising flame	Li-crimson red, Na-yellow, K-violet, Rb-red violet, Cs-blue.	Ca-brick red, Sr-crimson red, Ba- apple green, Ra-crimson (Be and Mg do not impart any colour).

### II. Chemical Properties

(i)	Reactivity	Highly reactive	Reactive (but less than the corresponding alkali metal).
(ii)	Reaction with air	Li forms oxide ( $\text{Li}_2\text{O}$ ), Na forms $\text{Na}_2\text{O}$ on limited supply of oxygen and peroxide ( $\text{Na}_2\text{O}_2$ ) in excess of $\text{O}_2$ and other metals form superoxide ( $\text{MO}_2$ ). Only lithium reacts with $\text{N}_2$ to form nitride. $6\text{Li} + \text{N}_2 \longrightarrow 2\text{Li}_3\text{N}$	React with $\text{O}_2$ and $\text{N}_2$ to form oxides and nitrides, respectively. Be and Mg are quite inert to $\text{O}_2$ due to the formation of oxide layer.
(iii)	Reaction with $\text{H}_2\text{O}$	Form hydroxide and $\text{H}_2$ gas.	Form hydroxides and $\text{H}_2$ gas (Be and Mg are less reactive due to the formation of the oxide layer).
(iv)	Reaction with $\text{H}_2$	Form ionic hydrides with high melting point.	All except, Be form ionic hydrides ( $\text{MH}_2$ ). $\text{BeH}_2$ can be prepared by the reaction of $\text{BeCl}_2$ with $\text{LiAlH}_4$ .
(v)	Reaction with halogens	All form ionic halides except, $\text{LiX}$ which is covalent.	All form ionic halides ( $\text{MX}_2$ ) except, $\text{BeX}_2$ and $\text{MgX}_2$ which is covalent.
(vi)	Reducing nature	These are strong reducing agents (Li is the strongest one due to high hydration enthalpy).	Their reducing power is less than the corresponding alkali metal.
(vii)	Solution in liquid $\text{NH}_3$	$M + (x + y) \text{NH}_3$ $\downarrow$ $[M(\text{NH}_3)_x]^+ + [e(\text{NH}_3)_y]^-$ (blue colour, paramagnetic). On long standing, the solution slowly converts to $\text{MNH}_2$ liberating $\text{H}_2$ gas. ( $M$ =alkali metals)	$M + (x + y) \text{NH}_3$ $\downarrow$ $[M(\text{NH}_3)_x]^{2+} + 2[e(\text{NH}_3)_y]^-$ (deep blue-black, paramagnetic). ( $M$ = alkaline earth metals)

## RAPID CONCEPT REVISION

A comparison of the characteristics of compounds of alkali and alkaline earth metals are shown in the table below:

	Metal compounds	Alkali metals	Alkaline earth metals
(a)	Oxides	Stability of peroxides and superoxides increases down the group (due to stabilisation of larger anion by larger cation). All react with water to form hydroxide.	BeO is amphoteric, while the rest are ionic. The basic strength of oxides increases down the group.
(b)	Hydroxides	Solubility, thermal stability and basic character increases down the group.	Solubility, thermal stability and basic character of hydroxides increases down the group (less basic and stable than the corresponding alkali metal hydroxide).
(c)	Halides	All halides have negative $\Delta_f H^\circ$ value and the order of the magnitude of $\Delta_f H^\circ$ is $\text{LiF} > \text{NaF} > \text{KF} > \text{RbF} > \text{CsF}$ The order of $\Delta_f H^\circ$ for chlorides, bromides and iodides is $\text{FrX} > \text{CsX} > \text{RbX} > \text{KX} > \text{NaX} > \text{LiX}$ ( $X = \text{Cl}^-, \text{Br}^-, \text{I}^-$ ) Order of melting and boiling points is $MF > MCl > MBr > MI$	All are ionic except beryllium halides which are covalent. The tendency of formation of halide hydrates decrease down the group. The fluorides are less soluble than the corresponding chlorides due to high lattice enthalpies.
(d)	Salts of oxoacids		
(i)	Carbonates and hydrogen carbonates	Their stability increases down the group. These are soluble in water.	These are very less soluble and their solubility decrease down the group. Thermal stability increases down the group.
(ii)	Sulphates	The stability of sulphates increases down the group. These are soluble in water.	Sulphates of Be and Mg are readily soluble in water due to higher hydration enthalpy. However, solubility decreases from $\text{CaSO}_4$ to $\text{BaSO}_4$ .
(iii)	Nitrates	The stability of nitrates increases down the group. These are all soluble in water. $\text{LiNO}_3$ on heating gives $\text{Li}_2\text{O}$ , $\text{NO}_2$ and $\text{O}_2$ , whereas other alkali metal nitrates give corresponding nitrite on heating.	The tendency of nitrates to form hydrates decrease down the group (due to decrease in hydration enthalpy). They decompose to give corresponding oxide, $\text{NO}_2$ and $\text{O}_2$ gas. Thermal stability increases down the group.

### Anomalous Behaviour of Li

Li, due to small size, high polarising power and absence of *d*-orbitals, shows the following anomalous properties:

- It is the hardest metal having boiling and melting points highest among the group.
- It is the strongest reducing agent among alkali metals and unlike other alkali metals, it forms  $\text{Li}_2\text{O}$  and  $\text{Li}_3\text{N}$  with oxygen and nitrogen, respectively.
- It does not form acetylide on reaction with  $\text{CH}\equiv\text{CH}$ .
- Only LiCl forms  $\text{LiCl} \cdot 2\text{H}_2\text{O}$  with water.
- $\text{LiHCO}_3$  is not obtained in solid or whereas other alkali metals form solid metal hydrogen carbonates.

### Diagonal Relationship of Li with Mg

Li and Mg shows diagonal relationship with each other due to their small size and high polarising power. Both have the following common properties:

- Both form covalent compounds that are soluble in organic solvents like ethanol.

- Both  $\text{LiCl}$  and  $\text{MgCl}_2$  crystallise in aqueous solution to form  $\text{LiCl}_2 \cdot 2\text{H}_2\text{O}$  and  $\text{MgCl}_2 \cdot 8\text{H}_2\text{O}$ , respectively.
- Both Li and Mg do not form solid hydrogen carbonates and their carbonates decompose easily on heating.
- Their oxides do not combine with excess of oxygen to give only superoxides.
- Their oxides and hydroxides are very less soluble in water.
- Both react with  $\text{N}_2$  to form  $\text{Li}_3\text{N}$  and  $\text{Mg}_3\text{N}_2$ .
- Both are lighter and harder than other elements in their respective groups.

### Anomalous Behaviour of Be

Be shows anomalous behaviour due to its small size, high ionisation energy and absence of *d*-orbitals.

- It has higher melting and boiling points.
- It does not react with water even at higher temperature.
- It forms covalent compounds. Its oxides and hydroxides are amphoteric in nature rather than basic.
- It does not exhibit coordination number more than 4 due to the absence of vacant *d*-orbital.

## Diagonal Relationship of Be with Al

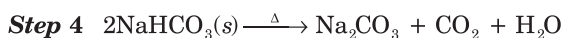
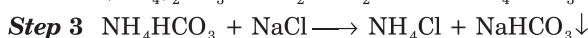
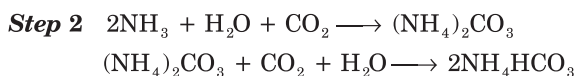
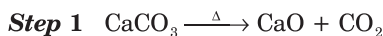
Be shows diagonal relationship with Al having the following common properties:

- Both are not easily attacked by acids due to the formation of oxide layer.
- Beryllium and aluminium hydroxides dissolve in excess of alkali to give a beryllate ion,  $[\text{Be}(\text{OH})_4]^{2-}$  and aluminate ion,  $[\text{Al}(\text{OH})_4]^-$ , respectively.
- Both have bridged chloride structure in vapour phase. Chlorides of both can be used in Friedel-Crafts reaction, as they act as strong Lewis acid and are soluble in organic solvents.

## Some Important Compounds of Alkali Metals

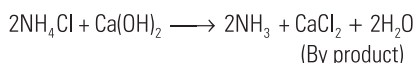
### Soda Ash (Sodium Carbonate, $\text{Na}_2\text{CO}_3$ )

- It is a white crystalline solid and exists as decahydrate (sodium carbonate decahydrate,  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$  is also known as **washing soda**).
- It is manufactured by **Solvay-ammonia process** through the following steps:

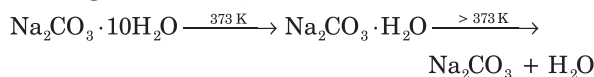


### REMEMBER

In the above process,  $\text{NH}_4\text{Cl}$  formed is separated by treating it with  $\text{Ca}(\text{OH})_2$ .

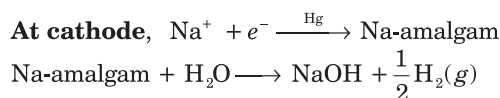


- It gives alkaline solution with  $\text{H}_2\text{O}$ .  
 $\text{CO}_3^{2-} + \text{H}_2\text{O} \longrightarrow \text{HCO}_3^- + \text{OH}^-$
- On heating above 373 K, it loses all water molecules.

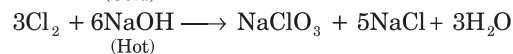
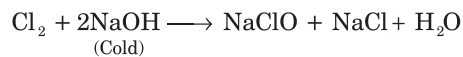


### Caustic Soda (Sodium Hydroxide, $\text{NaOH}$ )

- It is a white, translucent crystalline solid and completely dissolved in water to give strong alkaline solution.
- It is prepared by the electrolysis of brine ( $\text{NaCl}$ ) in Castner-Kellner cell.



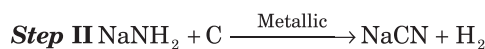
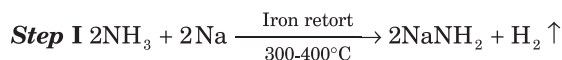
- Some of its important reactions are



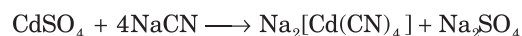
- It reacts with non-metals to give their corresponding sodium salt of oxyacid and  $\text{H}_2$  gas.

### Sodium Cyanide ( $\text{NaCN}$ )

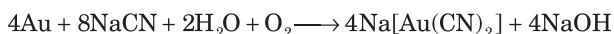
- It is a highly poisonous and colourless solid with a smell of bitter almond. It is highly soluble in water forming alkaline solution.
- It is prepared from Na by the following steps:



- It forms soluble complex cyanides with salt of transition metals like Cu, Au, Ag, Cd, Zn, etc.

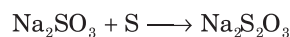


- It is used in the extraction of Au, Ag etc. It is also used for the electroplating of Au and Ag.

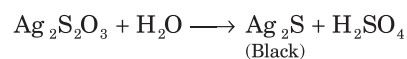
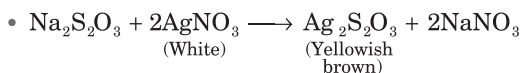
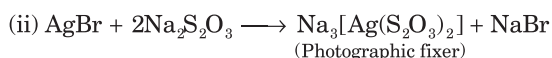
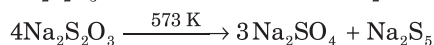
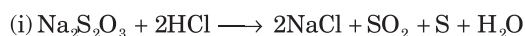


### Sodium Thiosulphate or Hypo ( $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ )

- It is a colourless, efflorescent and crystalline substance.
- It is highly soluble in water.
- It is prepared by boiling sodium sulphate solution with sulphur and stir till the alkaline reaction is disappeared.



- Some of the important reactions of hypo are

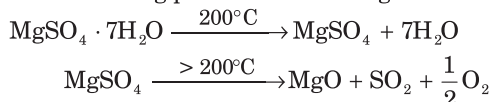


## RAPID CONCEPT REVISION

### Some Important Compounds of Alkaline Earth Metals

#### Epsom Salt ( $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ )

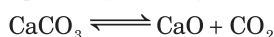
- It is a colourless, efflorescent solid having bitter taste.
- Commercially, it is prepared by dissolving mineral Kieserite ( $\text{MgSO}_4 \cdot \text{H}_2\text{O}$ ) in boiling water followed by crystallisation.
- It gives the following products on heating.



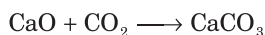
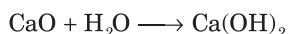
- It is used as fertiliser to treat magnesium deficiency in plants.

#### Quick Lime (Calcium Oxide, $\text{CaO}$ )

- It is prepared by heating limestone to  $1000^\circ\text{C}$ .



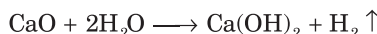
- It is an amorphous white solid with high melting point.
- It absorbs moisture and reacts with  $\text{CO}_2$



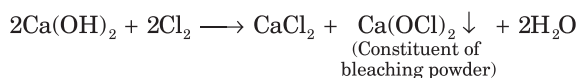
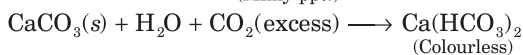
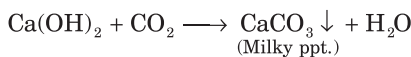
- It is used in the manufacturing of cement, sodium carbonate, dye stuffs and in the purification of sugar etc.

#### Slaked Lime (Calcium Hydroxide, $\text{Ca(OH)}_2$ )

- It is prepared by adding water to quick lime



- It is a white amorphous powder and is sparingly soluble in water and the aqueous solution is called **lime water**.
- It shows the following chemical reactions :



- It is used in mortar production, disinfectant, bleaching powder production, etc.

#### Lime Stone (Calcium Carbonate, $\text{CaCO}_3$ )

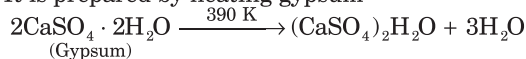
- It is found in marble, chalk, calcite, coral, etc.
- It is prepared by



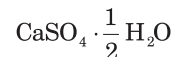
- It is insoluble in water and decomposes to  $\text{CaO}$  and  $\text{CO}_2$  when heated to 1200 K.

#### Plaster of Paris ( $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ )

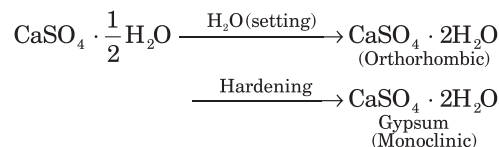
- It is prepared by heating gypsum



or

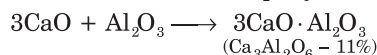
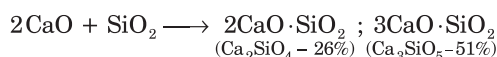


- It is a white solid and used in the preparation of pottery, ceramics, moulds and in construction work, etc.
- When mixed with water, it form a hard mass by absorbing water.

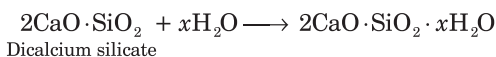
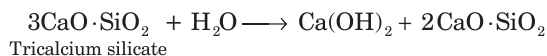
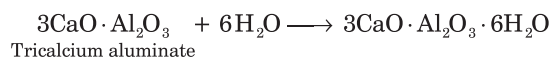


#### Portland Cement

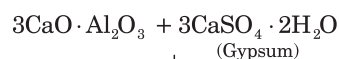
- Chemical composition**  $\text{CaO}$  (50 – 60%),  $\text{SiO}_2$  (20-25%),  $\text{Al}_2\text{O}_3$  (5-10%),  $\text{MgO}$  (2-3%),  $\text{Fe}_2\text{O}_3$  (1-2%),  $\text{SO}_3$  (1-2%).
- Essential raw materials** Limestone for  $\text{CaO}$  etc., clay for  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$  etc.
  - If lime is excess  $\rightarrow$  Cement cracks during settings
  - If lime is less  $\rightarrow$  Cement with weak strength.
- The following reactions are involved during the production of the constituents of cement.



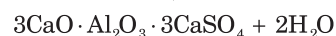
- Setting of cement** involves the following reactions: When water is added to cement, setting of cement takes place due to hydration and rearrangement of the constituents of cement. The chemical reactions are given below:



Gypsum is added to cement to slow down the process of setting so that the cement gets sufficiently hardened.



$\downarrow$



# MASTER STROKES

- The metallic luster exhibited by sodium metal is explained by
  - diffusion of sodium ions
  - oscillation of loose electron
  - excitation of free protons
  - existence of body centred cubic lattice
- The correct order of the solubility of alkaline earth metal sulphates in water is [JEE Main 2016]
  - $\text{Mg} < \text{Sr} < \text{Ca} < \text{Ba}$
  - $\text{Mg} > \text{Ca} > \text{Sr} > \text{Ba}$
  - $\text{Mg} > \text{Sr} > \text{Ca} > \text{Ba}$
  - $\text{Mg} < \text{Ca} < \text{Sr} < \text{Ba}$
- The main oxides formed on combustion of Li, Na and K in excess of air respectively are [JEE Main 2016]
  - $\text{Li}_2\text{O}_2$ ,  $\text{Na}_2\text{O}_2$  and  $\text{K}_2\text{O}$
  - $\text{Li}_2\text{O}$ ,  $\text{Na}_2\text{O}_2$  and  $\text{KO}_2$
  - $\text{Li}_2\text{O}$ ,  $\text{Na}_2\text{O}_2$  and  $\text{KO}_2$
  - $\text{Li}_2\text{O}$ ,  $\text{Na}_2\text{O}$  and  $\text{KO}_2$
- Which one of the following does not react with water even under hot condition?
  - Na
  - Be
  - Ca
  - K
- Which physical property of the alkali metal group increases with atomic number?
  - Melting point
  - Electronegativity
  - Hydration enthalpy
  - Density
- Compared with the alkaline earth metals, the alkali metals exhibit
  - Greater hardness
  - Smaller ionic radii
  - Lower ionisation energies
  - Highest boiling points
- Which one of the following alkaline earth metal sulphates has its hydration enthalpy greater than its lattice enthalpy? [JEE Main 2015]
  - $\text{CaSO}_4$
  - $\text{BeSO}_4$
  - $\text{BaSO}_4$
  - $\text{SrSO}_4$
- Which of the following does not illustrate the anomalous properties of lithium unlike other alkali metals?
  - Lithium is much softer
  - The melting and boiling points of Li are higher
  - Lithium forms nitride,  $\text{Li}_3\text{N}$
  - The positive ion of lithium get more hydrated
- Among the alkali metals, caesium is the most reactive because
  - its incomplete shell is nearest to the nucleus
  - it has a single electron in the valence shell
  - it is the heaviest alkali metal
  - the outermost electron is more loosely bound than the outermost electron of the other alkali metals
- Calcium, strontium and barium impart characteristics brick red, crimson red and apple green colours, respectively to the flame. In flame, the electrons are excited to higher energy levels and when they drop back to the ground state, energy is emitted in the form of
  - visible light
  - heat
  - UV light
  - IR light
- Which of the following statements is/are true regarding diagonal relationship between beryllium and aluminium?
  - The chlorides of both beryllium and aluminium have  $\text{Cl}^-$  bridged chloride structure in vapour phase.
  - Beryllium and aluminium hydroxides dissolve in excess of alkali to give a beryllate ion  $[\text{Be}(\text{OH})_4]^{2-}$  and aluminate ion  $[\text{Al}(\text{OH})_4]^-$ , respectively.
    - Only I
    - Only II
    - Both I and II
    - Neither I or II
- Conducting power of  $\text{Be}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$  and  $\text{Ba}^{2+}$  is in the order
  - $\text{Be}^{2+} > \text{Mg}^{2+} > \text{Ca}^{2+} < \text{Sr}^{2+} < \text{Ba}^{2+}$
  - $\text{Be}^{2+} > \text{Mg}^{2+} > \text{Ca}^{2+} > \text{Sr}^{2+} > \text{Ba}^{2+}$
  - $\text{Be}^{2+} < \text{Mg}^{2+} < \text{Ca}^{2+} < \text{Sr}^{2+} < \text{Ba}^{2+}$
  - All have equal conducting power
- Group 2 (alkaline earth elements) and group 12 (zinc family) have  $ns^2$ -configuration of valence shell. Thus,
  - both form  $M^{2+}$  ions with inert gas configuration
  - $\text{BeO}$  and  $\text{ZnO}$  are amphoteric
  - sulphides of both groups are soluble
  - solubility of hydroxide increases as we go down the group
- Which oxide undergoes redox reaction to  $M_2O_2$  and metal  $M$  on heating?
  - $\text{Li}_2\text{O}$
  - $\text{Na}_2\text{O}$
  - Both (a) and (b)
  - None of these
- Which is the bridge element of group 1 (alkali metals) and group 11 (coinage metals)?
  - Li
  - Na
  - Cu
  - Ag
- The following compounds have been arranged in order of their increasing thermal stabilities.  $\text{K}_2\text{CO}_3$  (I),  $\text{MgCO}_3$  (II),  $\text{CaCO}_3$  (III),  $\text{BeCO}_3$  (IV) Identify the correct order.
  - $\text{I} < \text{II} < \text{III} < \text{IV}$
  - $\text{IV} < \text{II} < \text{III} < \text{I}$
  - $\text{IV} < \text{II} < \text{I} < \text{III}$
  - $\text{II} < \text{IV} < \text{III} < \text{I}$
- $\text{Be}(\text{OH})_2$  is insoluble in water while  $\text{Ba}(\text{OH})_2$  is highly soluble due to
  - lattice energy difference
  - common ion effect
  - bond order
  - hard acid
- Which of the following metal hydroxides does not dissolve in sodium hydroxide solution?
  - $\text{Zn}(\text{OH})_2$
  - $\text{Al}(\text{OH})_3$
  - $\text{Fe}(\text{OH})_3$
  - $\text{Pb}(\text{OH})_2$
- The reaction between sodium and water can be made less vigorous by
  - adding a little alcohol
  - amalgamated sodium
  - adding a little acetic acid
  - lowering the temperature


**RAPID CONCEPT REVISION**

- 20.** Which of the following oxides is formed when potassium metal is burnt in excess of air?  
 (a)  $\text{KO}_2$  (b)  $\text{K}_2\text{O}_2$  (c)  $\text{KO}$  (d)  $\text{K}_2\text{O}$
- 21.** Generally, it is found that gun powder spontaneously reacts when ignited. The reaction involved is/are  
 (a)  $2\text{KNO}_3(\text{s}) + 4\text{C}(\text{s}) \longrightarrow \text{K}_2\text{CO}_3(\text{s}) + 3\text{CO}(\text{g}) + \text{N}_2(\text{g})$   
 (b)  $2\text{KNO}_3(\text{s}) + 2\text{S}(\text{s}) \longrightarrow \text{K}_2\text{SO}_4(\text{s}) + \text{SO}_2(\text{g}) + \text{N}_2(\text{g})$   
 (c) Both (a) and (b)  
 (d) None of the above
- 22.** Sodium thiosulphate is used in photography  
 (a) as  $\text{AgBr}$  is reduced to non-metallic silver  
 (b) to convert metallic silver into silver salt  
 (c) to remove undecomposed  $\text{AgBr}$  in the form of  $\text{Na}_3[\text{Ag}(\text{S}_2\text{O}_3)_2]$   
 (d) to remove reduced silver
- 23.**  $\text{Na}_2\text{CO}_3$  can be manufactured by Solvay process but  $\text{K}_2\text{CO}_3$  cannot be prepared because  
 (a)  $\text{K}_2\text{CO}_3$  is more soluble  
 (b)  $\text{KHCO}_3$  is more soluble than  $\text{NaHCO}_3$   
 (c)  $\text{K}_2\text{CO}_3$  is less soluble  
 (d)  $\text{KHCO}_3$  is less soluble than  $\text{NaHCO}_3$
- 24.** Lithium hydride can be used to prepare other useful hydrides. Beryllium hydride is one of them. The reagents that are required to prepare  $\text{BeH}_2$  from lithium hydride is/are  
 (a)  $\text{BeCl}_2$  (b)  $\text{Al}_2\text{Cl}_6, \text{BeCl}_2$   
 (c)  $\text{AlH}_3, \text{CH}_4$  (d)  $\text{AlH}_3, \text{BeCl}_2$
- 25.** Match the following columns and choose the correct option.
- | Column I<br>(Compound)                                 | Column II<br>(Use)         |
|--|----------------------------|
| A. $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ | p. Common salt             |
| B. $\text{NaCl}$                                       | q. Purification of bauxite |
| C. $\text{NaOH}$                                       | r. Water softening         |
| D. $\text{NaHCO}_3$                                    | s. Antiseptic              |
- Codes**
- |             |             |
|-------------|-------------|
| A B C D     | A B C D     |
| (a) p r s q | (b) q s p r |
| (c) r p q s | (d) p q r s |
- 26.** In which of the following processes, fused sodium hydroxide is electrolysed at  $330^\circ\text{C}$  temperature for extraction of sodium?  
 (a) Castner's process (b) Cyanide process  
 (c) Down's process (d) Both (b) and (c)
- 27.** When sodium chloride solution is electrolysed, the gas that is liberated at the cathode is  
 (a) oxygen (b) chlorine  
 (c) hydrogen (d) air
- 28.** Sodium thiosulphate is prepared by  
 (a) boiling  $\text{Na}_2\text{SO}_3$  solution with  $\text{S}$  in alkaline medium  
 (b) reducing  $\text{Na}_2\text{SO}_4$  solution with  $\text{H}_2\text{S}$   
 (c) boiling  $\text{Na}_2\text{SO}_3$  solution with  $\text{S}$  in acidic medium  
 (d) neutralising  $\text{H}_2\text{S}_2\text{O}_3$  solution with  $\text{NaOH}$
- 29.** Which of the following effloresces and gives white precipitate with  $\text{BaCl}_2$  solution?  
 (a)  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$   
 (b)  $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$   
 (c) Both (a) and (b)  
 (d) None of the above
- 30.** A sodium salt of an unknown anion when treated with  $\text{MgCl}_2$  gives white precipitate only on boiling. The anion is  
 (a)  $\text{SO}_4^{2-}$  (b)  $\text{HCO}_3^-$   
 (c)  $\text{CO}_3^{2-}$  (d)  $\text{NO}_3^-$
- 31.**  $\text{CaCl}_2$  is used as  
 (a) disinfectant (b) desiccating agent  
 (c) medicine (d) None of these
- 32.** Which of the following is the main process for the manufacture of sodium carbonate?  
 (a) Nelson process  
 (b) Down's process  
 (c) Castner process  
 (d) Solvay process
- 33.** Consider the following reactions to prepare  $\text{K}_2\text{CO}_3$ ,
- $$\text{KCl} + \text{H}_2\text{SO}_4 \longrightarrow \text{KHSO}_4 + \text{HCl}$$
- $$\text{KHSO}_4 + \text{KCl} \longrightarrow \text{K}_2\text{SO}_4 + \text{HCl}$$
- Select the correct statement(s).  
 (a) Reactions are part of Le-Blanc process to prepare  $\text{K}_2\text{CO}_3$   
 (b)  $\text{K}_2\text{SO}_4$  is converted to  $\text{K}_2\text{CO}_3$  by heating with  $\text{CaCO}_3$  and carbon  
 (c) Both (a) and (b)  
 (d) None of the above
- 34.** The pair whose both species are used in antacid medicines, is  
 (a)  $\text{NaHCO}_3$  and  $\text{Mg}(\text{OH})_2$   
 (b)  $\text{Na}_2\text{CO}_3$  and  $\text{Ca}(\text{HCO}_3)_2$   
 (c)  $\text{Ca}(\text{HCO}_3)_2$  and  $\text{Mg}(\text{OH})_2$   
 (d)  $\text{Ca}(\text{OH})_2$  and  $\text{NaHCO}_3$
- 35.** The impurity (as a salt) associated with table salt obtained from sea water is  
 (a)  $\text{NaHCO}_3$  (b)  $\text{MgCO}_3$   
 (c)  $\text{MgCl}_2$  (d)  $\text{NaI}$
- 36.** Initial setting of cement is mainly due to  
 (a) hydration and gel formation  
 (b) dehydration and gel formation  
 (c) hydration and hydrolysis  
 (d) dehydration and dehydrolysis
- 37.** Dead burnt plaster is  
 (a)  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$  (b)  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$   
 (c)  $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$  (d)  $\text{CaSO}_4$
- 38.** If strongly ignited magnesium oxide is added to a concentrated solution of magnesium chloride, the slurry so obtained solidifies to a solid mass after some time. Solid mass so obtained is called  
 (a) Sorel cement (b) Portland cement  
 (c) Plaster of Paris (d) None of these



39. Which of the following substances is used in the laboratory for fast drying of neutral gases?

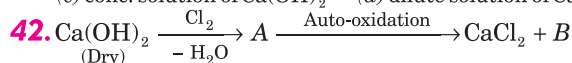
- (a) Sodium sulphate  
(b) Phosphorus pentoxide  
(c) Sodium phosphate  
(d) Anhydrous calcium chloride

40. Slaked lime  $[\text{Ca}(\text{OH})_2]$  is used in the manufacture of

- (a) fire bricks (b) cement  
(c) medicine (d) pigment

41. Bleaching powder is obtained by the interaction of chlorine and

- (a) dry calcium oxide (b) dry slaked lime  
(c) conc. solution of  $\text{Ca}(\text{OH})_2$  (d) dilute solution of  $\text{Ca}(\text{OH})_2$



Identify B in the above reaction.

- (a)  $\text{CaOCl}_2$  (b)  $\text{Ca}(\text{ClO}_3)_2$   
(c)  $\text{Ca}(\text{OH})_2$  (d)  $\text{Ca}(\text{ClO}_2)_2$

43. Gypsum,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$  on heating to about  $120^\circ\text{C}$  forms a compound which has the chemical composition represented by

- (a)  $\text{CaSO}_4 \cdot \text{H}_2\text{O}$  (b)  $2\text{CaSO}_4 \cdot 3\text{H}_2\text{O}$   
(c)  $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$  (d)  $\text{CaSO}_4$

44. Which of the following is the correct increasing order of solubilities?

- (a)  $\text{CaCO}_3 < \text{KHCO}_3 < \text{NaHCO}_3$   
(b)  $\text{NaHCO}_3 < \text{KHCO}_3 < \text{CaCO}_3$   
(c)  $\text{KHCO}_3 < \text{NaHCO}_3 < \text{CaCO}_3$   
(d)  $\text{CaCO}_3 < \text{NaHCO}_3 < \text{KHCO}_3$

45. Match the following columns and choose the correct option.

Column I (Compound)	Column II (Property)
A. $\text{BeCO}_3$	p. Temporary hardness
B. $\text{BaCl}_2$	q. Permanent hardness
C. $\text{MgSO}_4$	r. Decomposes readily
D. $\text{Ca}(\text{HCO}_3)_2$	s. Gives green edged flame

Codes

- A B C D  
(a) r s q p  
(b) p q r s  
(c) r p q s  
(d) q p s r

46. Match the different forms of calcium sulphate in Column I with their names in Column II and mark the correct option from the codes given below.

Column I	Column II
A. $\text{CaSO}_4$	p. Alabaster
B. $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$	q. Gypsum
C. $\text{CaSO}_4 \cdot \text{H}_2\text{O}$	r. Plaster of Paris
D. $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$	s. Anhydrite
E. $2\text{CaSO}_4 \cdot \text{H}_2\text{O}$	

Codes

- A B C D E  
(a) q r p s s  
(b) s r p q r  
(c) s r p q q  
(d) p r s q r

47. A metal M readily forms water soluble,  $\text{MSO}_4$ . It also forms oxide, MO which becomes inert on heating. MO is insoluble in water but soluble in dil. HCl as well as in NaOH solution. Thus, metal M is

- (a) Mg (b) Ca (c) Ba (d) Be

48. Which of the following reactions give gaseous product?

- (a)  $\text{Al} + \text{NaOH} + \text{H}_2\text{O} \xrightarrow{\Delta}$   
(b)  $\text{F}_2 + \text{NaOH} (\text{conc.}) \longrightarrow$   
(c)  $\text{NaOH} + \text{P}(\text{white}) + \text{H}_2\text{O} \longrightarrow$   
(d) All of the above

49. Chemical 'A' is used for water softening to remove temporary hardness. 'A' reacts with sodium carbonate to form caustic soda. When  $\text{CO}_2$  is bubbled through a solution of 'A', it turns cloudy. What is the chemical formula of 'A'?

- (a) CaO (b)  $\text{Ca}(\text{OH})_2$  (c)  $\text{CaCO}_3$  (d)  $\text{Ca}(\text{HCO}_3)_2$

50. Which one of the following is present as an active ingredient in bleaching powder for bleaching action?

- (a)  $\text{CaCl}_2$  (b)  $\text{CaOCl}_2$  (c)  $\text{Ca}(\text{OCl})_2$  (d)  $\text{CaO}_2\text{Cl}_2$

### Answers

1. (b) 2. (b) 3. (c) 4. (b) 5. (d)  
6. (c) 7. (b) 8. (a) 9. (d) 10. (a)  
11. (c) 12. (c) 13. (b) 14. (b) 15. (b)  
16. (b) 17. (a) 18. (c) 19. (b) 20. (a)  
21. (c) 22. (c) 23. (b) 24. (b) 25. (c)  
26. (a) 27. (c) 28. (a) 29. (c) 30. (b)  
31. (b) 32. (d) 33. (c) 34. (a) 35. (c)  
36. (a) 37. (d) 38. (a) 39. (d) 40. (a)  
41. (b) 42. (b) 43. (c) 44. (d) 45. (a)  
46. (b) 47. (d) 48. (d) 49. (b) 50. (c)



### WHY DO OLD BOOKS BECOME YELLOW?

Walk into a big library, and you'll see many old books that have become yellow and brittle. It is because paper is made from wood. Wood is in turn made of carbohydrates like cellulose and lignin. Lignin is a very complicated molecule that adds hardness to wood. More the lignin, harder is the wood. However, in paper it is a problem. Over time, lignin breaks down to form many phenolic acids, which are yellow in colour. These acids then react with cellulose. This causes the paper to become very brittle.


**TARGET JEE 2017**

# TEST RIDER

Comprehensive Simulator Test Series for JEE Main & Advanced

# JEE MAIN

## (PAPER ONE PREP UP)

**FULL  
TEST**

# 5

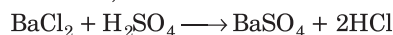
**(COMPLETE SYLLABUS)  
FULLY SOLVED**

Mock Questions from complete Syllabus with Complete Solutions

### INSTRUCTIONS

- This test consists of 30 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

1. For the reaction,



Molar mass of Ba = 137, Cl = 35.5, S = 32 and O = 16.

If 2.08g of BaCl<sub>2</sub> reacts with 9.8 g of H<sub>2</sub>SO<sub>4</sub>, the mass of BaSO<sub>4</sub> produce will be

(a) 11.68 g (b) 23.33 g (c) 2.33 g (d) 1.168 g

2. A gas is kept under two different pressures  $p_1$  and  $p_2$  having densities in the ratio of 2 : 1, respectively. At constant temperature, the ratio  $p_1$  to that of  $p_2$  will be

(a) 1 : 2 (b) 2 : 1 (c) 1 : 4 (d) 4 : 1

3. When an electron in a hydrogen atom, jumps from  $n = 6$  to  $n = 2$  energy level, the all possible spectral lines are equal to

(a) 20 (b) 15 (c) 10 (d) 4

4. Which of the following is most reactive towards anionic polymerisation?

(a) CH<sub>2</sub>=CH · C<sub>2</sub>H<sub>5</sub> (b) CH<sub>2</sub>=CH · CH<sub>3</sub>

(c) CH<sub>2</sub>=CH · Cl (d) CH<sub>2</sub>=C  $\begin{matrix} \text{CH}_3 \\ \diagup \\ \text{C} \\ \diagdown \\ \text{CH}_3 \end{matrix}$

5. The molecular shapes of SF<sub>4</sub>, SiF<sub>4</sub> and ICl<sub>4</sub><sup>-</sup> are

- (a) same with 1, 1 and 1 lone pair of electrons on the central atoms, respectively
- (b) same with 2, 0 and 1 lone pairs of electrons on the central atom, respectively
- (c) different with 1, 0 and 2 lone pairs of electrons on the central atoms, respectively
- (d) different with 0, 1 and 2 lone pairs of electrons on the central atoms, respectively

6. The correct increasing bond order of the following species O<sub>2</sub>(A), O<sub>2</sub><sup>2-</sup>(B), CO(C), NO(D) will be

(a) (A) < (B) < (D) < (C) (b) (A) < (B) < (C) < (D)

(c) (D) < (C) < (B) < (A) (d) (B) < (A) < (D) < (C)

7. H<sub>2</sub>SO<sub>4</sub> can act as

- I. dehydrating agent  
II. acid  
III. oxidising agent  
IV. bleaching agent

(a) Both I and II (b) Both II and III  
(c) II, III and IV (d) I, II and III

8. 0.81 g of metal carbonate react with nitrate to give 1.0 g of metal nitrate. The equivalent mass of metal will be

(a) 53.0 (b) 106.0 (c) 212.0 (d) 80.0

9. In which of the following species, central atom contain three lone pair of electrons?

- I. SF<sub>6</sub> II. I<sub>3</sub><sup>-</sup>  
III. [ClO<sub>3</sub>]<sup>-</sup> IV. XeF<sub>2</sub>

(a) Only III (b) Only IV  
(c) Both I and IV (d) Both II and IV

10. The correct increasing order of acidic strength for the following oxides P<sub>2</sub>O<sub>5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, SO<sub>3</sub> is

- (a) SO<sub>2</sub> < NO<sub>2</sub> < P<sub>2</sub>O<sub>5</sub> < SO<sub>3</sub>  
(b) P<sub>2</sub>O<sub>5</sub> < SO<sub>3</sub> < NO<sub>2</sub> < SO<sub>2</sub>  
(c) SO<sub>3</sub> < P<sub>2</sub>O<sub>5</sub> < SO<sub>2</sub> < NO<sub>2</sub>  
(d) NO<sub>2</sub> < SO<sub>2</sub> < P<sub>2</sub>O<sub>5</sub> < SO<sub>3</sub>

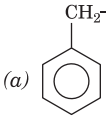
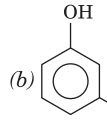
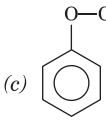
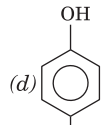
11. The enthalpy of hydrogenation of cyclohexene is  $-119.5 \text{ kJ mol}^{-1}$ . If resonance energy of benzene is  $-150.4 \text{ kJ mol}^{-1}$ , its enthalpy of hydrogenation would be  
 (a)  $-208.1 \text{ kJ mol}^{-1}$  (b)  $-269.9 \text{ kJ mol}^{-1}$   
 (c)  $-358.5 \text{ kJ mol}^{-1}$  (d)  $-508.9 \text{ kJ mol}^{-1}$
12. Enthalpy of vaporisation of a liquid is  $40 \text{ kJ mol}^{-1}$  and its entropy of vaporisation is  $80 \text{ J mol}^{-1}$ . The boiling point of the liquid at 1 atm is  
 (a) 400 K (b) 320 K  
 (c) 500 K (d) 600 K
13. For the reaction(s), value of equilibrium constant ( $K$ ) are as follows  

$$P \rightleftharpoons Q, K_1 = 3.0, Q \rightleftharpoons R, K_2 = 4.0$$

$$R \rightleftharpoons S, K_3 = 5.0$$
 The equilibrium constant for the reaction  $P \rightleftharpoons S$  will be  
 (a) 12 (b) 50  
 (c) 60 (d) 24
14. At constant temperature, the value of  $K_p$  for the decomposition of  $\text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g)$  is  $Z$ . If  $(x)$  is the extent of decomposition at pressure  $p$ , the correct statement about  $K_p$  is  
 (a)  $K_p$  increases with the increase in value of  $(x)$   
 (b)  $K_p$  increases with the increase in value of ' $p$ '  
 (c)  $K_p$  decreases with the increase in value of  $(x)$   
 (d)  $K_p$  remains constant with change in values of  $(x)$  and ' $p$ '
15. Which of the following pair is isoelectronic as well as isostructural?  
 (a)  $\text{CO}_2$  and  $\text{SO}_2$  (b)  $\text{SO}_3$  and  $\text{NO}_3^-$   
 (c)  $\text{NO}_3^-$  and  $\text{CO}_3^{2-}$  (d)  $\text{SO}_3$  and  $\text{CO}_3^{2-}$
16. If the solubility of  $\text{AgBr}$  in  $\text{H}_2\text{O}$ ,  $\text{CaBr}_2(0.01 \text{ M})$ ,  $\text{NaBr}(0.01 \text{ M})$  and  $\text{AgNO}_3(0.05 \text{ M})$  are  $S_1, S_2, S_3$  and  $S_4$ , respectively. The correct increasing order for solubility is  
 (a)  $S_4 < S_2 < S_3 < S_1$  (b)  $S_4 < S_3 < S_2 < S_1$   
 (c)  $S_1 < S_2 < S_3 < S_4$  (d)  $S_3 < S_2 < S_1 < S_4$
17. A substance  $A_xB_y$  crystallises in fcc-packing. Atoms of (A) occupy all cubic corners and atoms of (B) are present at alternate center of opposite face. The correct formula of the substance  $A_xB_y$  is  
 (a)  $AB_4$  (b)  $AB_2$  (c)  $A_2B$  (d)  $AB$
18. Osmotic pressure of blood is 7.70 atm at  $40^\circ\text{C}$ . How much glucose should be taken per litre for an intravenous injection that have same osmotic pressure as that of blood  
 (a) 4.47 g (b) 54.50 g (c) 12.10 g (d) 25.26 g
19. Consider the half-cell reaction(s),  

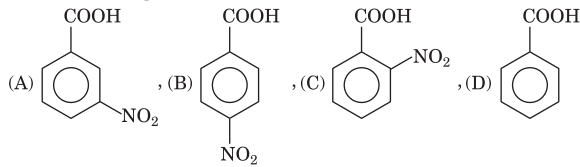
$$\text{Cu}^{2+} + e^- \longrightarrow \text{Cu}^+; E^\circ = 0.15 \text{ V}$$

$$\text{Cu}^{2+} + 2e^- \longrightarrow \text{Cu}; E^\circ = 0.33 \text{ V}$$

$$E^\circ \text{ for the half-cell reaction: } \text{Cu}^+ + e^- \longrightarrow \text{Cu}, \text{ will be}$$
 (a) 0.48 V (b) 0.18 V (c) 0.31 V (d) 0.51 V
20. For a reaction at 287 K, rate constant and activation energy are respectively,  $4 \times 10^{-4} \text{ s}^{-1}$  and  $110 \text{ kJ mol}^{-1}$ . Also, value of pre-exponential factor is  $4 \times 10^{16} \text{ s}^{-1}$ . The value of rate constant at  $T \rightarrow \infty$  is  
 (a)  $2.0 \times 10^{18}$   
 (b) infinity  
 (c)  $3.6 \times 10^{12}$   
 (d) equal to pre-exponential factor
21. Which of the following reaction(s) is/are example(s) of smelting?  
 I.  $\text{SnO}_2 + 2\text{C} \xrightarrow{\Delta} \text{Sn} + 2\text{CO}$   
 II.  $2\text{PbO} + \text{PbS} \xrightarrow{\Delta} 3\text{Pb} + \text{SO}_2$   
 III.  $\text{FeO} + \text{CO} \xrightarrow{\Delta} \text{Fe} + \text{CO}_2$   
 IV.  $\text{ZnCO}_3 \xrightarrow{\Delta} \text{ZnO} + \text{CO}_2$   
 (a) Only I (b) Both II and IV  
 (c) Only III (d) Both I and III
22. A yellowish white halide of phosphorus (A), on complete hydrolysis gives an oxoacid (B) having oxidation number +5 of phosphorus. (A) and (B) are respectively  
 (a)  $\text{PCl}_3, \text{H}_3\text{PO}_3$  (b)  $\text{PCl}_5, \text{H}_3\text{PO}_4$   
 (c)  $\text{PCl}_5, \text{H}_3\text{PO}_5$  (d)  $\text{PCl}_3, \text{H}_3\text{PO}_4$
23. Which of the following properties decreases with the increase in number of shells of the noble gases?  
 (a) Atomic radius (b) Boiling point  
 (c) Volatile nature (d) Ionisation energy
24. Among the following, the compound which show a decrease in its weight when kept in a magnetic field is  
 (a)  $\text{ScCl}_3$  (b)  $\text{TiCl}_3$  (c)  $\text{VCl}_3$  (d)  $\text{FeCl}_3$
25. Which of the following options are correct for  $[\text{Fe}(\text{CN})_6]^{3-}$  complex?  
 I.  $d^2sp^3$ -hybridisation II.  $sp^3d^2$ -hybridisation  
 III. paramagnetic IV. diamagnetic  
 (a) Both I and III (b) Both I and IV  
 (c) Both II and III (d) Both II and IV
26. A compound (Z) having molecular formula,  $\text{C}_7\text{H}_8\text{O}$  is insoluble in  $\text{NaHCO}_3$  but soluble in  $\text{NaOH}$ . (Z) on bromination gives an *ortho-para* directive tribromo compound. (Z) gives a coloured solution with  $\text{FeCl}_3$ . Compound (Z) is  
 (a)  (b)   
 (c)  (d) 

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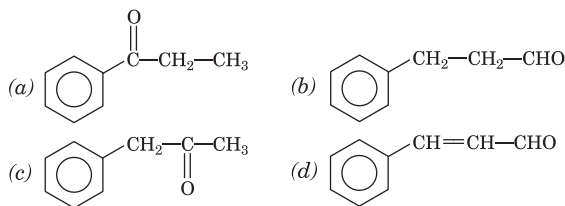
27. The correct increasing order of acidic strength for the following acids is



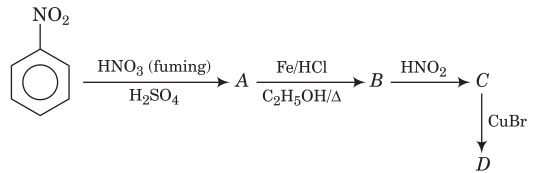
- (a)  $A < B < C < D$                       (b)  $D < C < B < A$   
(c)  $D < A < B < C$                       (d)  $D < C < A < B$

28. An organic compound (A) with molecular formula,  $C_9H_{10}O$  gives the following results  
I. (A) forms an orange red precipitate with 2,4-DNP.  
II. (A) gives a yellow ppt on heating with iodine and NaOH.  
III. (A) does not reduce Tollen's reagent.  
IV. (A) on drastic oxidation with chromic acid gives two acids having molecular formula,  $C_7H_6O_2$  and  $C_2H_4O_2$ .

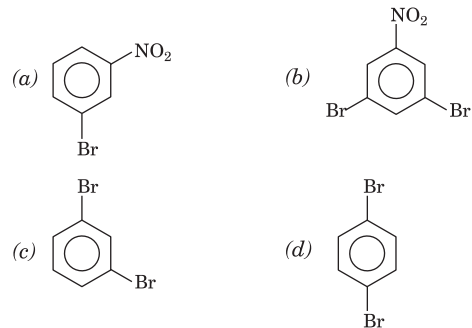
Compound (A) is



29. In the following reaction,



Final product D is



30. The sequence of nitrogen bases in one of the DNA-strand is as follows, A T T C T C G G A T. The sequence of complementary (counter) part of DNA strand will be  
(a) C A A G A G A T C G  
(b) T A A G A G C C T A  
(c) G C C T T G A T T G C  
(d) C G G A G A T T C G

## Answers with Explanation

1. (c) Moles of  $BaCl_2$  in 2.08 g =  $\frac{2.08}{208} = 0.01$  mol  
[∵ Molar mass of  $BaCl_2 = (137 + 2 \times 35.5) = 208$ ]  
Moles of  $H_2SO_4$  in 9.8 g =  $\frac{9.8}{98} = 0.1$  mol  
[∵ Molar mass of  $H_2SO_4 = 2 + 32 + (4 \times 16) = 98$ ]  
Thus,  $BaCl_2$  acts as limiting reagent and only 0.01 mole of  $BaSO_4$  is formed.  
Mass of 0.01 moles of  $BaSO_4$   
[Molar mass of  $BaSO_4 = 137 + 32 + (4 \times 16) = 233$ ]  
Moles ( $n$ ) =  $\frac{\text{Weight}(w)}{\text{Molar mass}(M)}$   
∴  $w(BaSO_4) = n \times M = 0.01 \times 233$   
Mass of  $BaSO_4 = 2.33$  g

2. (b) **Key Concept** The relation between pressure ( $p$ ) and density ( $d$ ) is  
[For  $n$  moles of gas]  
 $pV = nRT$   
or  $p = \frac{w}{M} \times \frac{RT}{V}$   
 $= \frac{dRT}{M}$                       [∵ Density =  $\frac{\text{Mass}}{\text{Volume}}$ ]

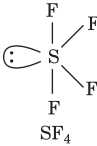
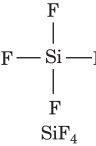
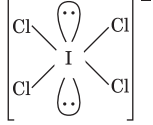
Gas is same, thus  $M$  is constant along with  $R$  and  $T$ .  
∴  $p \propto d$   
Hence, the ratio of pressure will be same as that of densities, i.e. 2 : 1.

3. (c) **Key Concept** All possible spectral lines can be calculated as  $\frac{\Delta n(\Delta n + 1)}{2}$

where,  $\Delta n$  = difference of highest and lowest energy level.  
Here,  $\Delta n = 6 - 2 = 4$

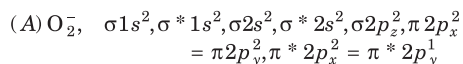
$$\therefore \text{Number of spectral lines} = \frac{4 \times 5}{2} = 10$$

4. (c) Electron withdrawing groups makes the monomer more reactive towards anionic polymerisation.  
Thus,  $CH_2 = CH \cdot Cl$  is most reactive.

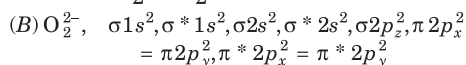
5. (c)                                               
( $sp^3d$ , lone pair = 1)                      ( $sp^3$ , lone pair = 0)                      ( $sp^3d^2$ , lone pairs = 2)

6. (d) **Key Concept** Bond order (BO) can be calculated by the following formula,  
 $BO = \frac{N_b - N_a}{2}$

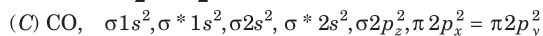
where,  $N_b$  = Number of bonding electrons  
 $N_a$  = Number of anti-bonding electrons



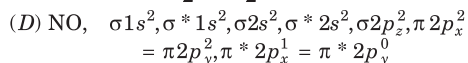
$$BO = \frac{10-7}{2} = \frac{3}{2} = 1.5$$



$$BO = \frac{10-8}{2} = \frac{2}{2} = 1$$

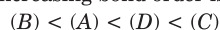


$$BO = \frac{10-4}{2} = \frac{6}{2} = 3$$



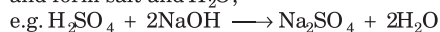
$$BO = \frac{10-5}{2} = \frac{5}{2} = 2.5$$

Thus, correct increasing bond order is

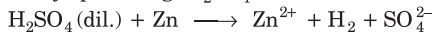


7. (d) I.  $H_2SO_4$  can act as dehydrating agent as it removes water in many reactions, e.g.  $H_2SO_4$  removes water from glucose.

II.  $H_2SO_4$  can act as an acid, as it react with the base and form salt and  $H_2O$ ,



III.  $H_2SO_4$  can act as an oxidising agent as it oxidise many species e.g.  $H_2SO_4$  oxidise Zn to  $Zn^{2+}$



IV.  $H_2SO_4$  will not act as a bleaching agent as it does not provide nascent oxygen for bleaching.

8. (b) Let, equivalent mass of metal =  $E_{(m)}$

Therefore,

Equivalent mass of metal carbonate ( $MCO_3$ )

$$= E_{(m)} + E_{(CO_3^{2-})} = E_{(m)} + \frac{(12 + 3 \times 16)}{2} = E_{(m)} + 30$$

Equivalent mass of metal nitrate ( $MNO_3$ )

$$= E_{(m)} + E_{(NO_3)} = E_{(m)} + [14 + (3 \times 16)] = E_{(m)} + 62$$

$$\frac{\text{Equivalent weight of metal carbonate}}{\text{Equivalent weight of metal nitrate}} = \frac{\text{Mass of } MCO_3}{\text{Mass of } MNO_3}$$

$$\text{or, } \frac{E_{(m)} + 30}{E_{(m)} + 62} = \frac{0.81}{1}$$

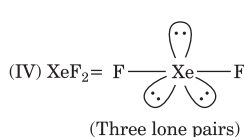
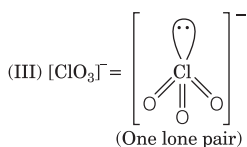
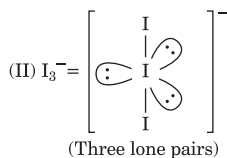
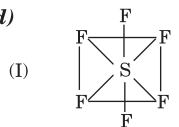
$$\text{or, } [E_{(m)} + 30] = [E_{(m)} + 62] \cdot 0.81$$

$$\text{or, } E_{(m)} + 30 = 0.81 E_{(m)} + 50.22$$

$$0.19 E_{(m)} = 20.22$$

$$\therefore E_{(m)} = \frac{20.22}{0.19} = 106.4 \approx 106$$

9. (d)



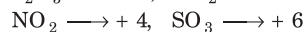
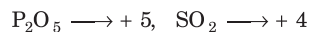
### 10. (a) Thinking Process

(i) Oxides of non-metals are acidic in nature.

(ii) Higher the positive oxidation number, more will be the acidic nature of the oxide.

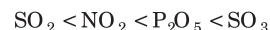
(iii) For same oxidation numbers, more the electronegativity of the central atom, more will be its acidic nature.

Oxidation number of central atom is as follows



$\therefore$  Sulphur is less electronegative than nitrogen.

Hence, order of acidic nature is



11. (a) The enthalpy of hydrogenation of cyclohexene (having one double bond) is  $-119.5 \text{ kJ mol}^{-1}$ . Hence, theoretically enthalpy of hydrogenation of Kekule's structure of benzene should be  $3 \times (-119.5) \text{ kJ mol}^{-1}$ . Since, the resonance energy of benzene is  $-150.4 \text{ kJ mol}^{-1}$ , the actual enthalpy of hydrogenation of benzene will be

$$= [3 \times (-119.5) - (-150.4)] = -208.1 \text{ kJ mol}^{-1}$$

12. (c) Given,  $\Delta H = 40 \text{ kJ mol}^{-1} = 40 \times 10^3 \text{ J mol}^{-1}$

$$\Delta S = 80 \text{ J mol}^{-1}$$

Gibb's free energy change ( $\Delta G$ ) is given by

$$\Delta G = \Delta H - T\Delta S$$

At equilibrium,  $\Delta G = 0$ , i.e.  $\Delta H = T\Delta S$

Therefore,  $40 \times 10^3 = T \cdot 80$

$$T(\text{bp}) = \frac{40 \times 1000}{80} = 500 \text{ K}$$

13. (c)  $K_1 = \frac{[Q]}{[P]} = 3.0, \quad K_2 = \frac{[R]}{[Q]} = 4.0$

$$K_3 = \frac{[S]}{[R]} = 5.0$$

$$\therefore K \text{ for } \frac{[S]}{[P]} \Rightarrow \frac{[Q]}{[P]} \times \frac{[R]}{[Q]} \times \frac{[S]}{[R]} = \frac{[S]}{[P]}$$

$$K = 3 \times 4 \times 5 = 60$$

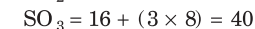
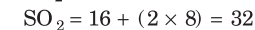
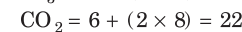
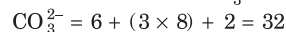
14. (d)  $K_p$  remains constant with the change in value of (x) or p. It only changes with the change in temperature.

### 15. (c) Key Concept

(i) The species which contain equal number of electrons are called isoelectronic species.

(ii) The species having same number of lone pair and hybridisation for the central atom are isostructural.

Number of electrons in  $NO_3^- = 7 + (3 \times 8) + 1 = 32$



	Lone pair	Hybridisation
$NO_3^-$	zero	$sp^2$
$CO_3^{2-}$	zero	$sp^2$
$CO_2$	zero	$sp$
$SO_2$	one	$sp$
$SO_3$	zero	$sp^2$

Hence, only  $NO_3^-$  and  $CO_3^{2-}$  are isoelectronic as well as isostructural.

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16. (a)  $\text{AgBr}$  dissociates as  $\text{AgBr} \rightleftharpoons \text{Ag}^+ + \text{Br}^-$

The common ion ( $\text{Ag}^+$  or  $\text{Br}^-$ ) will shift the equilibrium in backward direction such that solubility decreases. More be the concentration of common ion lesser will be the solubility.

Now, In  $\text{H}_2\text{O} \rightarrow$  No common ion ( $S_1$ )

In  $\text{CaBr}_2$  (0.01 M) has  $[\text{Br}^-] = 0.02 \text{ M}$  ( $S_2$ )

In  $\text{NaBr}$  (0.01 M) has  $[\text{Br}^-] = 0.01 \text{ M}$  ( $S_3$ )

In  $\text{AgNO}_3$  (0.05 M) has  $[\text{Ag}^+] = 0.05 \text{ M}$  ( $S_4$ )

Hence, increasing order of solubility will be

$$S_4 < S_2 < S_3 < S_1$$

17. (d) (A) is present at all corners of the cubic structure,

$$\therefore \text{Contribution of (A)} = \frac{1}{8} \times 8 = 1$$

$\therefore$  (B) is present at alternate center of opposite face,

$$\therefore \text{Contribution of (B)} = \frac{1}{2} \times 2 = 1$$

Hence, formula of  $A_xB_y = A_1B_1 = AB$

18. (b) **Key Concept** Osmotic pressure ( $\pi$ ) =  $\frac{n}{V} RT = \frac{w}{MV} \cdot RT$

$$\text{or, } w = \frac{\pi \cdot MV}{RT}$$

Given,  $\pi_{\text{glucose}} = \pi_{\text{blood}}$

$$M_{\text{C}_6\text{H}_{12}\text{O}_6} = M_{\text{glucose}} = 180 \text{ g mol}^{-1}$$

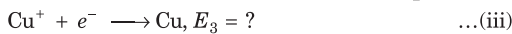
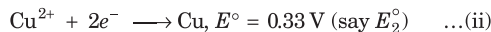
$R$  (Gas constant) =  $0.082 \text{ L atm mol}^{-1} \text{ K}^{-1}$

$$T = 37^\circ \text{C} = 310 \text{ K}$$

$$V = 1 \text{ L}$$

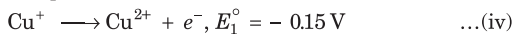
$$\therefore w \text{ (mass of glucose taken)} = \frac{7.7 \times 180 \times 1}{0.0821 \times 310} = 54.50 \text{ g}$$

19. (d) Given,  $\text{Cu}^{2+} + e^- \rightarrow \text{Cu}^+, E^\circ = 0.15 \text{ V}$  (say  $E_1^\circ$ ) ... (i)



$$\therefore \Delta G^\circ = -nFE^\circ$$

Reverse Eq. (i)



Now, add Eqs. (iv) and (ii) to get Eq. (iii)

$$\Delta G_3^\circ = \Delta G_1^\circ + \Delta G_2^\circ$$

$$-nFE_3^\circ = (-nFE_1^\circ) + (-nFE_2^\circ)$$

$$-E_3^\circ = +0.15 + (-2 \times 0.33)$$

$$(\because n = 1 \text{ for } G_1 \text{ and } n = 2 \text{ for } G_2)$$

$$-E_3^\circ = -0.51 \text{ V}$$

$$\therefore E_3^\circ = +0.51 \text{ V}$$

20. (d) Given,  $K_1 = 4 \times 10^{-4} \text{ s}^{-1}, E_a = 110 \times 10^3 \text{ J} \cdot \text{mol}^{-1}$

$$T_1 = 287 \text{ K}, T_2 = \infty$$

$$\therefore \log \frac{K_2}{K_1} = \frac{E_a}{2.303R} \left[ \frac{1}{T_1} - \frac{1}{T_2} \right]$$

$$\log \frac{K_2}{4 \times 10^{-4}} = \frac{110 \times 1000}{2.303 \times 8.314} \left[ \frac{1}{287} - 0 \right] \quad \left( \because \frac{1}{T_2} = \frac{1}{\infty} = 0 \right)$$

$$\log \frac{K_2}{4 \times 10^{-4}} = \frac{110,000}{2.303 \times 8.314 \times 287} = 20$$

Taking antilog of both sides,

$$K_2 = 4 \times 10^{-4} \times 10^{20} = 4 \times 10^{16} = A$$

(pre-exponential factor)

**Short trick**

$$\therefore \log K = \log A - \frac{E_a}{2.303 RT}$$

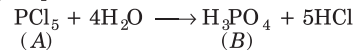
$$\text{At } T \rightarrow \infty, \quad \log K = \log A \quad \left( \because \frac{1}{\infty} = 0 \right)$$

$$\text{or } K = A = 4 \times 10^{16} \text{ (pre-exponential factor).}$$

21. (d) Reduction of metal oxide to metal at suitable temperature, using carbon (such as coal, coke, charcoal, CO etc.) is known as smelting.

Therefore, I and III are examples of smelting.

22. (b) Yellowish white halide of phosphorus is  $\text{PCl}_5$  (A) which on complete hydrolysis give  $\text{H}_3\text{PO}_4$  having oxidation number +5 of phosphorus.



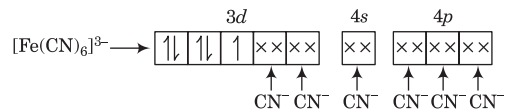
23. (d) As number of shells increase, effective nuclear charge on the outermost electron decreases, as a result ionisation energy decreases.

24. (a) Diamagnetic ions (i.e. which does not contain unpaired electrons) of transition metals, when kept in the magnetic field exhibit less weight.

Hence, option (a) is the correct because all other ions have unpaired electrons.

25. (a)
- $$\text{Fe}^{3+} = [\text{Ar}]_{18} \quad \begin{array}{c} 3d^5 \\ \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \boxed{\uparrow} \end{array} \quad \begin{array}{c} 4s^0 \\ \boxed{\phantom{\uparrow}} \end{array}$$

$\therefore \text{CN}^-$  is a strong field ligand, therefore electrons of  $\text{Fe}^{3+}$  pair up.



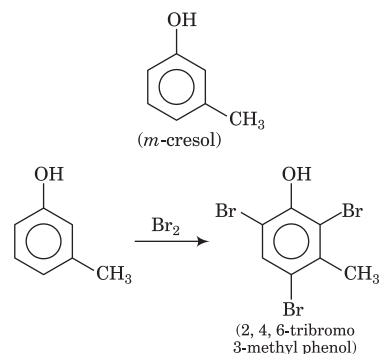
$\therefore$  Hybridisation =  $d^2sp^3$

Due to presence of one unpaired electron, complex show paramagnetic nature.

26. (b) (i) Degree of unsaturation = 4, thus the compound must contain sum of  $\pi$ -bond and ring = 4.

(ii) (Z) is insoluble in  $\text{NaHCO}_3$  but soluble in  $\text{NaOH}$  thus, it is not an alcohol.

(iii) (Z) gives *ortho-para* directive tribromo compound and gives a coloured solution with  $\text{FeCl}_3$ , therefore (Z) is a phenol with  $-\text{CH}_3$  group at *meta*-position, i.e.



27. (c) The presence of  $-\text{NO}_2$  group increases the acidic strength and its effect is maximum at *ortho*-position and minimum at *meta*-position.

To be Continued at Page 31


**TARGET JEE 2017**

# TEST RIDER

Comprehensive Simulator Test Series for JEE Main & Advanced

# JEE MAIN

## (PAPER TWO SCALE UP)

FULL  
TEST

6

(COMPLETE SYLLABUS)  
WITH ANSWER KEY

Mock Questions from complete syllabus to enhance Your Problem Solving Skills

### INSTRUCTIONS

- This test consists of 30 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

- What volume of oxygen, entering the engine at 0.950 atm and 20°C, is required to burn 1.00 g of benzene?  
(a) 2.4 L (b) 4.2 L (c) 3.2 L (d) 2.3 L
- Surface tension of water is 73 dyne cm<sup>-1</sup> at 20°C. If surface area is increased by 0.10 m<sup>2</sup>, work done is  
(a) 7.3 erg (b) 7.3 × 10<sup>4</sup> erg  
(c) 73 J (d) 0.73 J
- If the activation energy for a reaction is 65 kJ, how faster would a reaction proceed at 25°C than 0°C?  
(a) 11.05 (b) 22.05 (c) 10.1 (d) 7.9
- Water contains some dissolved oxygen but in limited amount. The optimum value of dissolved oxygen in water for good quality is  
(a) 10 ppm (b) 8 ppm (c) 6 ppm (d) 7 ppm
- If the pressure on a NaCl structure is increased, then its coordination number will  
(a) increase (b) decrease  
(c) Either (a) or (b) (d) remain the same
- Which of the following antibiotic was first discovered.  
(a) Ampicillin (b) Amoxycillin  
(c) Penicillin (d) Chloramphenicol
- Lead pipes are not suitable in the supply of drinking water because  
(a) a layer of lead dioxide is deposited over pipes  
(b) lead form basic lead carbonate

- (c) lead reacts with water containing air to form Pb(OH)<sub>2</sub>  
(d) lead reacts with air to form litharge

- Which of the following can exist both as diastereoisomer and enantiomer  
(a) [Pt(en)<sub>3</sub>]<sup>4+</sup> (b) [Pt(en)<sub>2</sub>ClBr]<sup>2+</sup>  
(c) [Ru(NH<sub>3</sub>)<sub>4</sub>Cl<sub>2</sub>] (d) [PtCl<sub>2</sub>Br<sub>2</sub>]
- 2-methyl propene is isomeric with but-1-ene. They can be distinguished by  
(a) Baeyer's reagent (b) ammonical AgNO<sub>3</sub>  
(c) Br<sub>2</sub> solution (d) O<sub>3</sub>, Zn/H<sub>2</sub>O
- Match the following and choose the correct option.

	Column I	Column II
(P)	$\left( \text{CH}_2 - \underset{\text{COOCH}_3}{\overset{\text{CH}_3}{\text{C}}} \right)_n$	(I) Addition homopolymer
(Q)	$\left( \text{OC} - \text{C}_6\text{H}_4 - \text{COO} - \text{CH}_2\text{CH}_2 - \text{O} \right)_n$	(II) Addition copolymer
(R)	$\left( \text{CH}_2 - \text{CH} = \text{CHCH}_2 - \underset{\text{CN}}{\text{CH}} - \text{CH}_2 \right)_n$	(III) Condensation copolymer
(S)	$\left( \text{NH} - (\text{CH}_2)_5 - \overset{\text{O}}{\parallel}{\text{C}} \right)_n$	(IV) Condensation homopolymer

 TARGET JEE 2017

- |         |     |    |    |        |     |     |    |
|---------|-----|----|----|--------|-----|-----|----|
| P       | Q   | R  | S  | P      | Q   | R   | S  |
| (a) I   | III | II | IV | (b) I  | II  | III | IV |
| (c) III | IV  | II | I  | (d) IV | III | I   | II |

17. In a mixture of A and B, components show negative deviation when

- (a) A—B interaction is stronger than A—A and B—B interaction  
 (b) A—B interaction is weaker than A—A and B—B interaction  
 (c)  $\Delta V_{\text{mix}} > 0$ ,  $\Delta S_{\text{mix}} > 0$   
 (d)  $\Delta V_{\text{mix}} = 0$ ,  $\Delta S_{\text{mix}} > 0$

12. Which of the following statement(s) is/are not correct?

- (a) Brownian motion and Tyndall effect are shown by true solutions  
 (b) Sorption process is combinations of absorption and adsorption process  
 (c) Higher is the gold number greater will be the protective power of a lyophilic colloid  
 (d) Both (a) and (c)

13. The ionic radius (Å) of  $\text{C}^{4-}$  and  $\text{O}^{2-}$ , respectively are 2.60 and 1.40. The ionic radius of the isoelectronic ion  $\text{N}^{3-}$  would be

- (a) 2.6 (b) 1.71 (c) 1.4 (d) 0.95

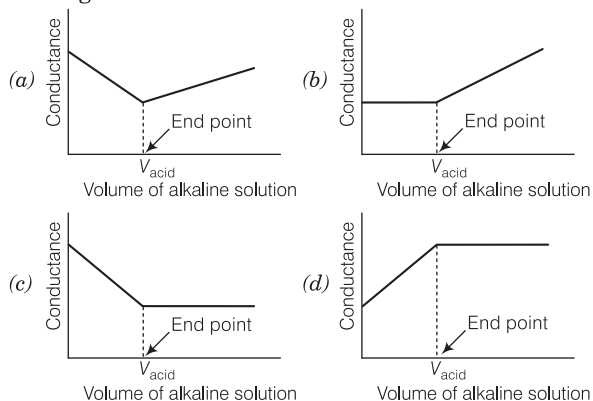
14. Which one of the following is correct statement?

- (a) Boric acid is a protonic acid  
 (b) Beryllium exhibits coordination number of six  
 (c) Chlorides of both beryllium and aluminium have bridged chloride structures in solid phase  
 (d)  $\text{B}_2\text{H}_6 \cdot 2\text{NH}_3$  is known as inorganic benzene

15. The number of peroxide bonds in perxenate ion  $[\text{XeO}_6]^{4-}$  is

- (a) 0 (b) 2 (c) 3 (d) 1

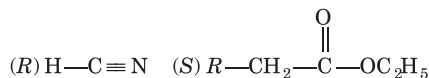
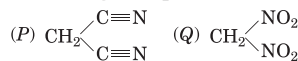
16. Which of the following plots will be obtained for a conductometric titration of strong acid against a strong base?



17. Among the following substituted silanes the one which will give rise to cross linked silicon polymer on hydrolysis is

- (a)  $\text{R}_4\text{Si}$  (b)  $\text{R Si Cl}_3$   
 (c)  $\text{R}_2\text{Si Cl}_2$  (d)  $\text{R}_3\text{SiCl}$

18. The correct decreasing order of acidity for the following compounds is



- (a)  $P > Q > R > S$  (b)  $Q > P > R > S$   
 (c)  $Q > R > P > S$  (d)  $S > Q > P > R$

19. A  $2.00 \times 10^{-3} \text{ mol dm}^{-3}$  solution of a compound absorbs 50% of the light of a certain wavelength passing through 1.00 cm of a sample. The molar absorption coefficient at this wavelength is

(a)  $15.1 \text{ m}^2 \text{mol}^{-1}$  (b)  $17.2 \text{ m}^2 \text{mol}^{-1}$   
 (c)  $10.2 \text{ m}^2 \text{mol}^{-1}$  (d)  $9.2 \text{ m}^2 \text{mol}^{-1}$

20. For the gas phase decomposition of phosphorus pentachloride,



The equilibrium constant is 1.7 at 500 K. 1 mole of  $\text{PCl}_5$  is placed in a sealed container and allowed to come to equilibrium at 500 K. At equilibrium the total pressure in the container is 0.2 bar. The amount of  $\text{Cl}_2$  present at equilibrium is

(a) 0.95 mol (b) 0.75 mol (c) 0.65 mol (d) 10 mol

21. The main form of sugar in your diet is probably sucrose ( $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ ). Its combustion at 1 bar and 298 K releases  $5647 \text{ kJ mol}^{-1}$  of heat. The standard enthalpy change of formation for sucrose is

[Given,  $\Delta_f H_{298}^\circ \{\text{CO}_2(g)\} = -393.5 \text{ kJ mol}^{-1}$  and  $\Delta_f H_{298}^\circ \{\text{H}_2\text{O}(l)\} = -285.8 \text{ kJ mol}^{-1}$ ]

- (a)  $-2219 \text{ kJ mol}^{-1}$   
 (b)  $-3322 \text{ kJ mol}^{-1}$   
 (c)  $-2110 \text{ kJ mol}^{-1}$   
 (d)  $-1125 \text{ kJ mol}^{-1}$

22. Which of the following compounds are coloured due to charge transfer spectra?

- (a)  $\text{K}_2\text{Cr}_2\text{O}_7$   
 (b)  $\text{KMnO}_4$   
 (c)  $\text{AgBr}$   
 (d) Both (a) and (b)

23. Gas 'A' bleaches the coloured matter temporary by reduction while other gas 'B' permanently by oxidation. The gases 'A' and 'B' are respectively

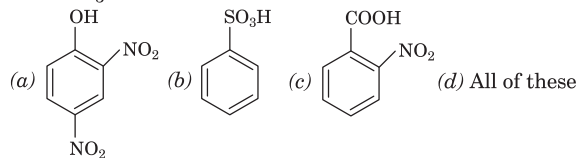
- (a)  $\text{SO}_2$  and  $\text{Cl}_2$  (b)  $\text{O}_3$  and  $\text{Cl}_2$   
 (c)  $\text{H}_2\text{S}$  and  $\text{CO}_2$  (d)  $\text{Cl}_2$  and  $\text{CO}_2$

24. The methods chiefly used for the extraction of lead and tin from their ores are respectively

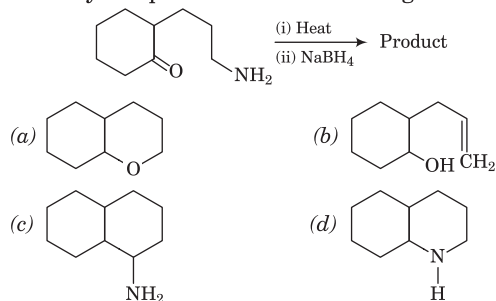
- (a) self-reduction and carbon reduction  
 (b) self-reduction and electrolytic reduction  
 (c) carbon reduction and self-reduction  
 (d) cyanide process and carbon reduction



25. Which of the following compound is soluble in  $\text{NaHCO}_3$ ?



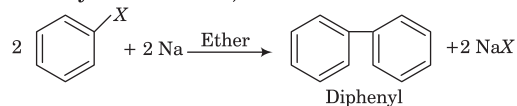
26. Identify the product in the following reaction,



27.  $P \xrightarrow{\text{PCl}_5} Q \xrightarrow{\text{Alc. KOH}} R \xrightarrow[\text{2H}_2\text{O}/\Delta]{\text{conc. H}_2\text{SO}_4} P$ . P is

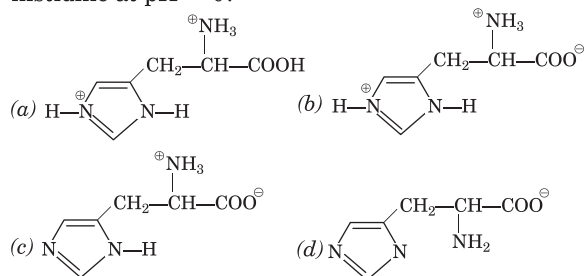
- (a)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$   
(b)  $(\text{CH}_3)_3\text{COH}$   
(c)  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$   
(d) None of the above

28. Identify the reaction,



- (a) Cannizzaro reaction (b) Sandmeyer reaction  
(c) Fittig reaction (d) Ullmann reaction

29. Which of the following is correct structure of histidine at  $\text{pH} = 0$ ?



30. Compared with the alkaline earth metals, the alkali metals exhibit

- (a) greater hardness (b) smaller ionic radii  
(c) lower ionisation potential (d) higher boiling points

### Answers

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (a)  | 2. (b)  | 3. (a)  | 4. (c)  | 5. (a)  |
| 6. (c)  | 7. (c)  | 8. (b)  | 9. (d)  | 10. (a) |
| 11. (a) | 12. (d) | 13. (b) | 14. (c) | 15. (a) |
| 16. (b) | 17. (b) | 18. (b) | 19. (a) | 20. (a) |
| 21. (a) | 22. (d) | 23. (a) | 24. (a) | 25. (d) |
| 26. (d) | 27. (c) | 28. (c) | 29. (a) | 30. (c) |

### Continued from Page 28

Thus, the correct order is

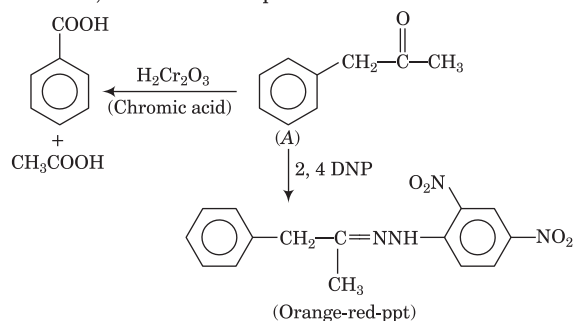
$$(D) < (A) < (B) < (C)$$

28. (c) I. (A) forms an orange-red ppt with 2, 4-DNP. Thus, (A) can be an aldehyde or ketone.  
II. (A) gives a yellow ppt. with  $\text{I}_2$  and  $\text{NaOH}$ . Thus, (A) must contain a methyl group next to carbonyl group.  
III. (A) does not reduce Tollen's reagent; thus, (A) must be a ketone.  
IV. Degree of unsaturation for,

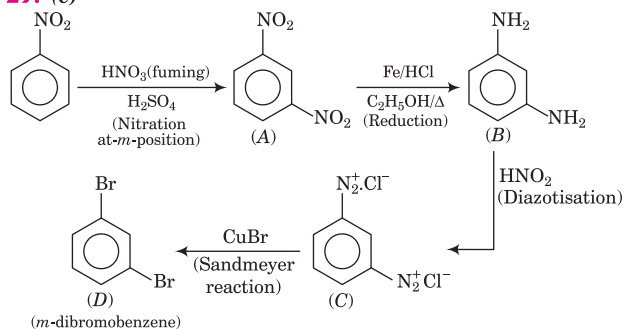
$$\text{C}_9\text{H}_{10}\text{O} = 5, \text{C}_2\text{H}_4\text{O}_2 = 1 \text{ and } \text{C}_7\text{H}_6\text{O}_2 = 5$$

Thus, (A) is an aromatic ring with  $-\text{CH}_3$  group attached next to carbonyl group.

Thus, reactions takes place as follows

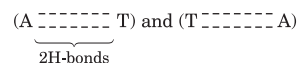


29. (c)

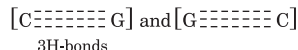


30. (b) In double helix of DNA,

- (i) Nitrogen base A is bonded through 2 H-bonds with its counter part (complementary strand) T and vice-versa



- (ii) Nitrogen base C is bonded through 3 H-bonds with its complementary strand (counter part) and vice-versa.



The correct sequence is T A A G A G C C T A

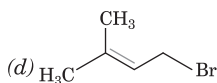
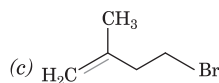
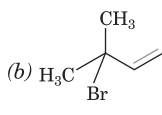
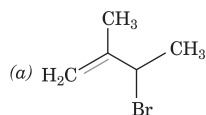
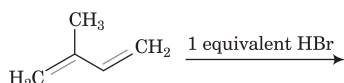
# JEE ADVANCED

# DRILL

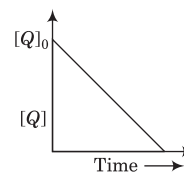
A collection of 30 innovative problems on JEE Advanced pattern from complete syllabus.

### Single Answer Correct Type

- The  $K_{sp}$  of  $\text{Ag}_2\text{CrO}_4$  is  $1.1 \times 10^{-12}$  at 298 K. The solubility (in mol/L) of  $\text{Ag}_2\text{CrO}_4$  in 0.1 M  $\text{AgNO}_3$  solution is  $1.1 \times 10^{-P}$ . The value of  $P$  is  
(a) 11 (b) 10 (c) 12 (d) 9
- Which of the following statement is correct?  
(a) Hydrated  $\text{FeCl}_3$  forms anhy.  $\text{FeCl}_3$  on heating  
(b) Solution of  $\text{Hg}_2\text{Cl}_2$  turns black, when  $\text{NH}_3$  is added in it  
(c) Aqueous solutions of  $\text{HgCl}_2$  and  $\text{SnCl}_2$  can co-exist  
(d)  $\text{CuCl}$  is soluble in water while  $\text{CuCl}_2$  is insoluble
- In the following reaction, the major product is  
[JEE Adv. 2015]



- Which pair of compounds is expected to show similar colour in aqueous medium?  
(a)  $\text{FeCl}_2$  and  $\text{CuCl}_2$  (b)  $\text{VOCl}_2$  and  $\text{CuCl}_2$   
(c)  $\text{VOCl}_2$  and  $\text{FeCl}_2$  (d)  $\text{FeCl}_2$  and  $\text{MnCl}_2$
- In the reaction,  $P + Q \longrightarrow R + S$ , the time taken for 75% reaction of  $P$  is twice the time taken for 50% reaction of  $P$ . The concentration of  $Q$  varies with reaction time as shown in the figure. The overall order of the reaction is



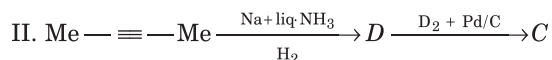
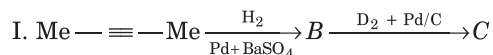
- (a) 3 (b) 2 (c) 1 (d) 0

### Multiple Answer Correct Type

- Which of the following pairs are correctly matched?  
(a) Terylene  $\rightarrow$  Condensation polymer of terephthalic acid and ethylene glycol  
(b) Perspex  $\rightarrow$  A homopolymer of methyl methacrylate  
(c) Teflon  $\rightarrow$  Thermally stable cross linked polymer of phenol and formaldehyde  
(d) Synthetic rubber  $\rightarrow$  A copolymer of butadiene and styrene
- The nitrogen containing compound produced in the reaction of  $\text{HNO}_3$  with  $\text{P}_4\text{O}_{10}$  [JEE Advanced 2016]  
(a) can also be prepared by reaction of  $\text{P}_4$  and  $\text{HNO}_3$   
(b) is diamagnetic  
(c) contains one N—N bond  
(d) reacts with Na metal producing a brown gas.
- Assuming  $2s$ - $2p$  mixing is not operative, the diamagnetic species among the following is [JEE Advanced 2014]  
(a)  $\text{Be}_2$  (b)  $\text{B}_2$  (c)  $\text{C}_2$  (d)  $\text{N}_2$
- Which of the following statements are correct?  
(a) In the extraction of Ag from  $[\text{Ag}(\text{CN})_2]^-$ , Zn is used in place of Cu  
(b) When,  $\text{NH}_4\text{OH}$  is added to copper sulphate solution, a deep blue colour appears  
(c)  $\text{AgNO}_3$  is called lunar caustic  
(d)  $\text{AgNO}_3$  gives white precipitate with  $\text{NaCl}$  but not with  $\text{CCl}_4$

10. Which of the following statements are incorrect?  
 (a) Benzoic acid is a stronger acid than formic acid  
 (b) Benzoic acid is a weaker acid than peroxy benzoic acid  
 (c) Acetic acid is a weaker acid than *p*-nitrophenol  
 (d)  $\alpha$ -methyl butyric acid is a stronger acid than  $\beta$ -methyl butyric acid

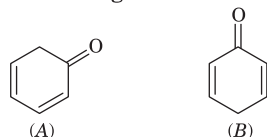
11. Consider the following reactions,



Which of the following statements are correct?

- (a) *B* is *cis* but-2-ene and *D* is *trans*-but-2-ene  
 (b) *B* is *trans* but-2-ene and *D* is *cis*-but-2-ene  
 (c) *C* is *meso*-form and *E* is racemic-form  
 (d) *C* is racemic-form and *E* is *meso*-form
12. The  $E^\circ_{\text{red}}$  of Sn, Fe and Zn are  $-0.14\text{V}$ ,  $-0.44\text{V}$  and  $-0.76\text{V}$ , respectively. Which of the following statements are incorrect?  
 (a) Corrosion of zinc can be prevented by coating with iron  
 (b) Corrosion of zinc can be prevented by coating with tin  
 (c) Corrosion of tin can be prevented by coating with zinc  
 (d) Corrosion of iron can be prevented by coating with tin

13. Consider the following two structures *A* and *B*



and choose the correct options.

- (a) *A* is more stable than *B*  
 (b) Both *A* and *B* shows keto-enol tautomerism  
 (c) *A* has acidic hydrogen whereas *B* has not  
 (d) The enol-form of *A* and *B* are more stable than keto-form

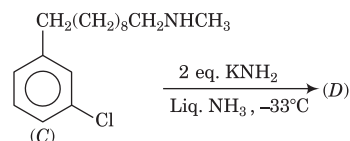
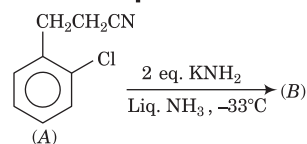
### Integer Type

14. A compound forms hexagonal close-packed structure. If the total number of voids in 0.5 mole of it is  $x \times 10^{23}$ , find the value of  $x$ .
15. The compound,  $\text{HOOC} - (\text{CHOH})_2 - \text{COOH}$  is a chiral compound. Calculate the number of optical isomers exhibited by this compound.
16. A closed vessel with rigid walls contains 1 mole of  $^{238}_{92}\text{U}$  and 1 mole of air at 298K. Considering complete decay of  $^{238}_{92}\text{U}$  to  $^{206}_{82}\text{Pb}$ , the ratio of the final pressure to the initial pressure of the system at 298 K is  
 [JEE Advanced 2015]
17. A 0.001 molal solution of  $[\text{Pt}(\text{NH}_3)_4\text{Cl}_n]\text{Cl}_{4-n}$  in water had a freezing point depression of  $0.0054^\circ\text{C}$ . Assuming 100% ionisation of the complex. Find the value of  $n$  [ $K_f(\text{H}_2\text{O}) = 1.86\text{kg mol}^{-1}\text{K}^{-1}$ ].
18. The atomic masses of He and Ne are 4 and 20 amu, respectively. The value of the de-Broglie wavelength of He gas at  $-73^\circ\text{C}$  is  $M$  times of the de-Broglie wavelength of Ne at  $727^\circ\text{C}$ .  $M$  is [JEE Advanced 2013]

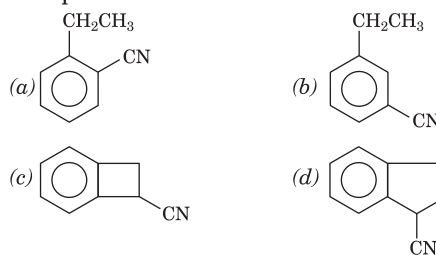
19. An alkane has a molecular mass of 72. The possible number of chain isomers for this molecule are
20. 50cc of 0.04 M  $\text{K}_2\text{Cr}_2\text{O}_7$  in acidic medium oxidises a sample of  $\text{H}_2\text{S}$  gas to sulphur. Volume of 0.03 M  $\text{KMnO}_4$  required to oxidise the same amount of  $\text{H}_2\text{S}$  gas to sulphur in acidic medium is  $10 \times x$  mL. The value of  $x$  is
21. In  $\text{Mn}_2(\text{CO})_{10}$ , the number of CO molecules in between the metal atoms are

### Paragraph Type

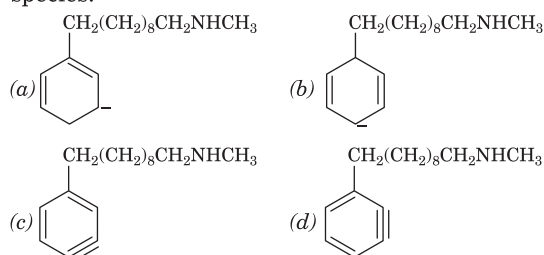
#### Comprehension I



22. The product *B* of the reaction would be



23. The formation of *D* from *C* proceeds *via*, the formation of which of the following intermediate species.



#### Comprehension II

When 100 mL of 1.0 M HCl was mixed with 100 mL of 1.0 M NaOH in an insulated beaker at constant pressure, a temperature increase of  $5.7^\circ\text{C}$  was measured for the beaker and its contents (Expt.1). Because the enthalpy of neutralisation of a strong acid with a strong base is constant ( $-57.0\text{kJ mol}^{-1}$ ), this experiment could be used to measure the calorimeter constant. In a second experiment (Expt.2), 100 mL of 2.0 M acetic acid ( $K_a = 2.0 \times 10^{-5}$ ) was mixed with 100 mL of 1.0 M NaOH (under identical conditions to Expt.1) where a temperature rise of  $5.6^\circ\text{C}$  was measured.

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24. Enthalpy of dissociation (in  $\text{kJ mol}^{-1}$ ) of acetic acid obtained from the Expt.2 is  
 (a) 1.0 (b) 10.0 (c) 24.5 (d) 51.4
25. The pH of the solution after Expt.2 is  
 (a) 2.8 (b) 4.7 (c) 5.0 (d) 7.0

### Comprehension III

The reactions of  $\text{Cl}_2$  gas with cold dilute and hot concentrated  $\text{NaOH}$  in water give sodium salts of two different oxoacids of chlorine,  $P$  and  $Q$ , respectively. The  $\text{Cl}_2$  gas reacts with  $\text{SO}_2$  gas in the presence of charcoal, to give a product  $R$ .  $R$  reacts with white phosphorus to give a compound  $S$ . On hydrolysis,  $S$  gives an oxoacid of phosphorus  $T$ .

26.  $P$  and  $Q$  respectively, are the sodium salts of  
 (a) hypochlorous and chloric acids  
 (b) hypochlorous and chlorous acids  
 (c) chloric and perchloric acids  
 (d) chloric and hypochlorous acids
27.  $R$ ,  $S$  and  $T$ , respectively are  
 (a)  $\text{SO}_2\text{Cl}_2$ ,  $\text{PCl}_5$  and  $\text{H}_3\text{PO}_4$   
 (b)  $\text{SO}_2\text{Cl}_2$ ,  $\text{PCl}_3$  and  $\text{H}_3\text{PO}_3$   
 (c)  $\text{SOCl}_2$ ,  $\text{PCl}_3$  and  $\text{H}_3\text{PO}_2$   
 (d)  $\text{SOCl}_2$ ,  $\text{PCl}_5$  and  $\text{H}_3\text{PO}_4$

### Matching Type

28. Match the Column I with Column II and select the correct code.

Column I (Reaction)	Column II (Mass of product)
A. $\text{N}_2 + 3\text{H}_2 \longrightarrow 2\text{NH}_3$ <small>1g      1g                  ?</small>	1. 1.214 g
B. $\text{CaCO}_3 \xrightarrow{\Delta} \text{CaO} + \text{CO}_2$ <small>1g                          ?</small>	2. 1.125 g
C. $2\text{H}_2 + \text{O}_2 \longrightarrow 2\text{H}_2\text{O}$ <small>1g      1g                  ?</small>	3. 1.333 g
D. $\text{C} + 2\text{H}_2 \longrightarrow \text{CH}_4$ <small>1g      1g                  ?</small>	4. 0.560 g

### Codes

	A	B	C	D
(a)	1	2	3	4
(b)	2	1	4	3
(c)	1	4	2	3
(d)	3	4	2	1

29. Match the Column I with Column II and select the correct code ( $M$  = central metal atom of molecule).

Column I (Molecule)	Column II (Property)
A. $\text{H}_2\text{O}$	1. Largest $M$ —H bond length
B. $\text{H}_2\text{S}$	2. Largest H— $M$ —H bond angle
C. $\text{H}_2\text{Se}$	3. Lowest boiling point
D. $\text{H}_2\text{Te}$	4. Two lone pairs

### Codes

	A	B	C	D
(a)	3	2	4	1
(b)	2	3	4	1
(c)	1	2	3	4
(d)	2	4	3	1

30. Match the chemical substance in Column I with type of polymer/type of bond in Column II.

Column I	Column II
A. Cellulose	1. Natural polymer
B. Nylon-6, 6	2. Synthetic polymer
C. Protein	3. Amide linkage
D. Sucrose	4. Glycoside linkage

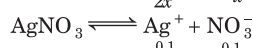
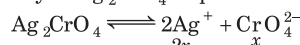
[IIT JEE 2007]

### Codes

	A	B	C	D
(a)	1,4	1,3	2,4	2,3
(b)	4	2	3,4	1,3
(c)	1,4	2,3	1,3	4
(d)	1	2,3	1,4	3

## Answers with Explanation

1. (b) **Key Concept** In presence of common ion (in this case  $\text{Ag}^+$  ion), solubility of sparingly soluble salt is decreased. Let, solubility of  $\text{Ag}_2\text{CrO}_4$  in presence of  $0.1\text{M AgNO}_3 = x$



Total  $[\text{Ag}^+] = (2x + 0.1)\text{M} \approx 0.1\text{M}$

As,  $x \ll 0.1\text{M}$

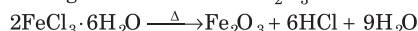
$$[\text{CrO}_4^{2-}] = x\text{M}$$

Thus,  $[\text{Ag}^+]^2[\text{CrO}_4^{2-}] = K_{\text{sp}}$

$$(0.1)^2(x) = 1.1 \times 10^{-12}$$

$\therefore x = 1.1 \times 10^{-10}\text{M}$

2. (b) (a) Hydrated  $\text{FeCl}_3$  does not form anhyd.  $\text{FeCl}_3$ , on heating because it forms  $\text{Fe}_2\text{O}_3$ .

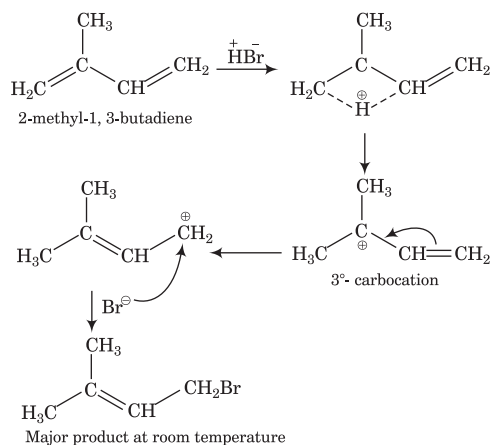


(b) Solution of  $\text{Hg}_2\text{Cl}_2$  turns black, when  $\text{NH}_3$  is added in it this is due to formation of  $\text{HgNH}_2\text{Cl}$  (black).

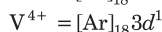
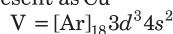
(c) Aqueous solution of  $\text{HgCl}_2$  and  $\text{SnCl}_2$  cannot co-exist because  $\text{SnCl}_2$  reduces  $\text{HgCl}_2$  to  $\text{Hg}$ .

(d)  $\text{CuCl}$  is insoluble in water while  $\text{CuCl}_2$  is soluble because according to Fajan's rule  $\text{CuCl}$  is preferably covalent in nature.

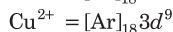
3. (d) When 2-methyl-1, 3 butadiene reacts with 1 equivalent of  $\text{HBr}$ , it undergoes Markownikoff's addition forming a  $\pi$ -bond lesser compound than the standing compound. Reaction looks like,



4. (b) Colour of transition metal ion salt is due to  $d-d$  transition of unpaired electrons of  $d$ -orbital. Metal ion salt having similar number of unpaired electrons in  $d$ -orbitals shows similar colour in aqueous medium. In  $\text{VOCl}_2$ , vanadium is present as  $\text{V}^{4+}$  and in  $\text{CuCl}_2$ , copper is present as  $\text{Cu}^{2+}$



$\therefore$  Number of unpaired electron = 1



$\therefore$  Number of unpaired electron = 1

Hence,  $\text{VOCl}_2$  and  $\text{CuCl}_2$  show similar colour.

5. (c) **Thinking Process** Time for 75% reaction is twice the time taken for 50% reaction if it is first order reaction wrt  $P$ . From graph,  $[Q]$  decreases linearly with time, thus it is zeroth order reaction wrt  $Q$ .

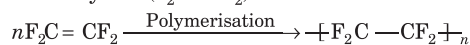
$$\frac{dx}{dt} = K [P]^a [Q]^b$$

Order wrt  $P = a = 1$

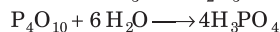
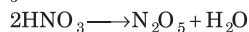
Order wrt  $Q = b = 0$

Thus, overall order of the reaction =  $1 + 0 = 1$ .

6. (a, b, d) Teflon is thermally stable polymer of tetrafluoroethylene ( $\text{F}_2\text{C}=\text{CF}_2$ ).

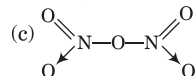


7. (b, d)  $\text{P}_4\text{O}_{10}$  is a dehydrating agent and converts  $\text{HNO}_3$  into  $\text{N}_2\text{O}_5$ .



Thus, (a) is incorrect.

- (b)  $\text{N}_2\text{O}_5$  has no unpaired electron and is thus, diamagnetic thus, (b) is correct.



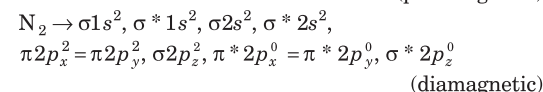
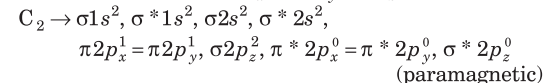
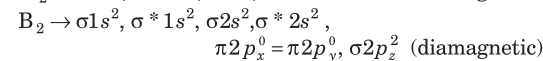
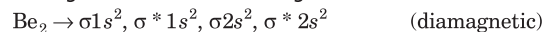
There is no  $\text{N}-\text{N}$  bond, thus, (c) incorrect.



$\text{NO}_2$  vapour are of brownish colour.

Thus, (d) is correct.

8. (a, b, d) **Thinking Process** This problem can be solved by using the concept involved in molecular orbital theory. Write the molecular orbital electronic configuration keeping in mind that there is no  $2s-2p$  mixing then, if highest occupied molecular orbital contain unpaired electron then molecule is paramagnetic otherwise diamagnetic.



9. (a, b, c, d)

- (a) Zn is stronger reducing agent than Cu and cheaper than Cu also.

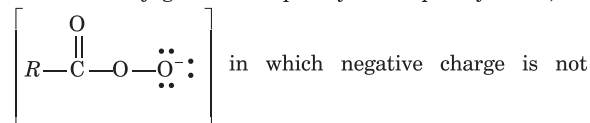


- (b) Due to the formation of blue copper tetraammine sulphate,  $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$  complex.

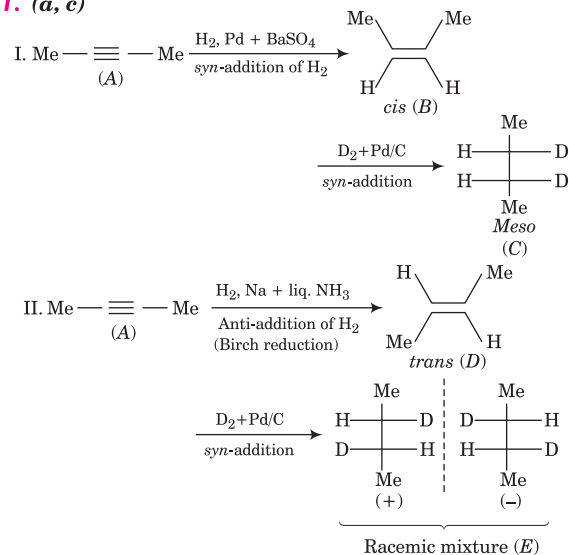
- (c) When bought in contact with skin, it leans black stain as present on moon.

- (d)  $\text{NaCl}$  is ionic compound and  $\text{Cl}^-$  ions obtained from it reacts with  $\text{Ag}^+$  to form white  $\text{AgCl}$ .  $\text{CCl}_4$  is covalent compound so it does not give  $\text{Cl}^-$  and hence, white precipitate of  $\text{AgCl}$ .

10. (a, c, d) Benzoic acid is a weaker acid than peroxy benzoic acid. The conjugate base of peroxy acid is peroxy anion,



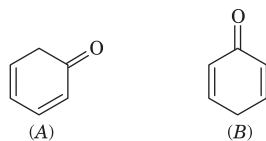
11. (a, c)



12. (a, b, d)  $E_{\text{red}}^\circ$  values can be used in protecting the corroded metal by plating the metal with a thin layer of a less easily oxidised metal. So, corrosion of tin (Sn) can be easily prevented by coating with zinc (Zn).

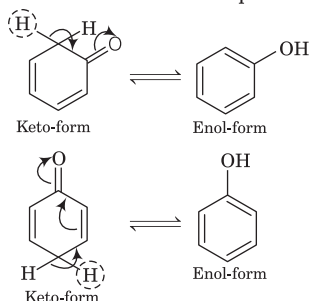
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13. (a, d)



Due to the presence of  $\alpha$ -hydrogen, they show tautomerism, i.e. shows keto-enol tautomerism.

Enol form of both A and B have an aromatic ring. So, they are more stable than their respective keto-forms.

14. (9) Total number of atoms ( $N$ ) in a closed packed structure (0.5 mol).

$$= 0.5 \times 6.023 \times 10^{23} = 3.011 \times 10^{23}$$

Number of octahedral voids ( $N$ ) =  $3.011 \times 10^{23}$ Number of tetrahedral voids ( $2N$ )

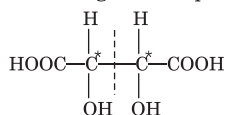
$$= 2 \times 3.011 \times 10^{23} = 6.022 \times 10^{23}$$

Total number of voids

$$= 3.011 \times 10^{23} + 6.022 \times 10^{23} = 9.033 \times 10^{23}$$

$$x \approx 9$$

15. (3) The structure of the given compound can be drawn as,



There are two asymmetric atoms present in this compound.

$$\therefore n = 2$$

If the molecule can be divided into two equal halves which are mirror images of each other and if  $n$  is even, then number of optically active isomers ( $a$ ) is

$$a = 2^{n-1} = 2^{2-1} = 2$$

Number of meso-isomers ( $m$ ) =  $2^{n/2-1}$ 

$$= 2^{\frac{2}{2}-1} = 1$$

$$\therefore \text{Total number of optical isomers} = a + m = 2 + 1 = 3$$

16. (9) **Key Concept** At constant volume and temperature, pressure is directly proportional to the number of moles of gas. For solving this problem, we shall first find total number of gaseous moles of products and reactants. Finally, we can easily find out ratio of final pressure ( $p_f$ ) to initial pressure ( $p_i$ ) as

$$\frac{p_f}{p_i} = \frac{n_f}{n_i}$$

Given, initial moles of gases = 1 mole

Consider the following reaction setup,



Initial moles

1 mol

Moles after decomposition

8 mol

$\therefore$  Total gaseous moles after decomposition

$$= 1 + 8 = 9 \text{ mol}$$

Therefore, ratio of pressures.

$$\frac{p_f}{p_i} = \frac{n_f}{n_i} = \frac{9}{1} = 9$$

17. (2) **Key Concept** In the given complex, there are four  $\text{NH}_3$  (which are the ligands only) and four  $\text{Cl}$  (which can be either ligands or ionisable ions or both). If there are  $n\text{Cl}$  ligands then ionisable  $\text{Cl}$  ligands will be  $(4-n)$ . Knowing van't Hoff factor ( $i$ ) for  $[\text{Pt}(\text{NH}_3)_4\text{Cl}_n] \text{Cl}_{4-n}$ ,  $n$  can be calculated.



Total number of ions after dissociation,

$$n' = (4-n) + 1 = 5-n$$

Hence, van't Hoff factor

$$i = 1 + (n'-1) = 1 + (5-n-1) = 5-n$$

where,  $n'$  = number of ions from one mole complex.

$$\Delta T_f = K_f m i$$

$$0.0054 = 1.86 \times 0.001 (5-n)$$

$$n = 2.1 \approx 2 \text{ (n is whole number)}$$

Hence, complex is  $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2] \text{Cl}_2$ 

18. (5) **Key Concept** In the given problem, we have provided atomic masses and temperature of helium and neon. For calculating the value of  $M$ , we shall use relationship between temperature ( $T$ ), mass ( $m$ ) and wavelength ( $\lambda$ ). This relation may be derived from kinetic energy and de-Broglie wavelength formulae.

As we know,

$$\text{Kinetic energy (KE)} = \frac{1}{2} m v^2 = \frac{3}{2} RT \quad \dots (i)$$

$$\therefore m^2 v^2 = 2m \text{KE} \Rightarrow m v = \sqrt{2m \text{KE}}$$

$$\text{de-Broglie wavelength } (\lambda) = \frac{h}{m v} = \frac{h}{\sqrt{2m \text{KE}}} \propto \frac{h}{\sqrt{2m(T)}}$$

[As from (i)]

$$\text{Now, } \lambda \text{ for He at } -73^\circ\text{C} = \frac{h}{\sqrt{2 \times 4 \times 200}}$$

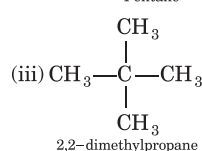
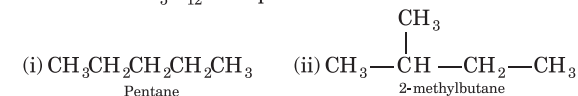
$$\lambda \text{ for Ne at } 727^\circ\text{C} = \frac{h}{\sqrt{2 \times 20 \times 1000}}$$

$$\text{Given, } \lambda_{\text{He}} = M \lambda_{\text{Ne}}$$

$$\therefore \frac{\lambda_{\text{He}}}{\lambda_{\text{Ne}}} = M = \sqrt{\frac{2 \times 20 \times 1000}{2 \times 4 \times 200}} = 5$$

19. (3) General molecular formula of alkane is  $\text{C}_n\text{H}_{2n+2}$ 

$$\therefore 12n + 2n + 2 = 72, \quad n = 5$$

The alkane is  $\text{C}_5\text{H}_{12}$ . The possible chain isomers are

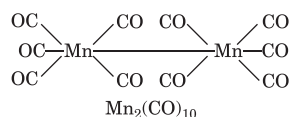
20. (8) Milliequivalents of  $K_2Cr_2O_7$  reacted with  $H_2S(N_1V_1)$   
 = milliequivalent of  $KMnO_4$  reacted with  $H_2S(N_2V_2)$   
 i.e. milliequivalent of  $KMnO_4$   
 = milliequivalent of  $H_2S$ .

Therefore,  $50 \times 0.04 \times 6 = V_2 \times 0.03 \times 5$

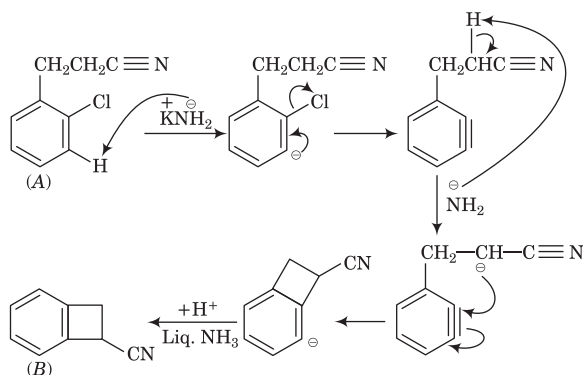
$$V_2 = 80 \text{ mL}$$

∴ The value of  $x = 8$

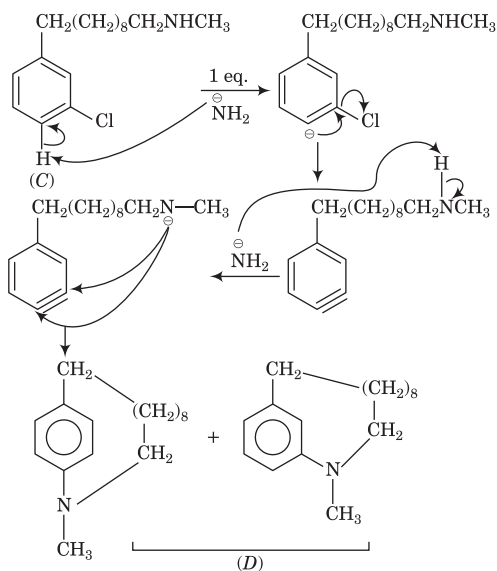
21. (0) **Thinking Process**  $Mn(CO)_5$  is radical with 17 electron configuration. Therefore, it undergoes dimerisation through the formation of  $M-M$  single bond and complex their valence shells to avoid ligand repulsion, the  $Mn(CO)_5$  units acquire staggered configuration.



22. (e)



23. (e)



24. (a) **Thinking Process** Since, enthalpy of neutralisation of a strong acid with a strong base is constant and equal to  $-57.0 \text{ kJ mol}^{-1}$ . Hence, for calculating the value of enthalpy of dissociation for acetic acid, we need to calculate enthalpy of neutralisation of  $CH_3COOH$  first. After this we can easily find enthalpy of dissociation of  $CH_3COOH$  as

Enthalpy of a dissociation of  $CH_3COOH =$  enthalpy of neutralisation of a strong acid (HCl) with strong base, (NaOH)  $-$  enthalpy of neutralisation of  $CH_3COOH$  with strong base (NaOH).

Let the heat capacity of insulated beaker is  $C$ . Mass of aqueous content in Expt. 1

$$= (100 + 100) \times 1 = 200 \text{ g}$$

Total heat capacity =  $(C + 200 \times 4.2) \text{ J/K}$

Also, moles of acid-base neutralised in Expt. 1

$$= 0.1 \times 1 = 0.1$$

Heat released in Expt.1

$$= 0.1 \times 57 = 5.7 \text{ kJ}$$

$$5.7 \times 1000 = (C + 200 \times 4.2) \Delta T$$

$$5.7 \times 1000 = (C + 200 \times 4.2) \times 5.7$$

$$C + 200 \times 4.2 = 1000$$

In 2nd Exp.  $n_{CH_3COOH} = 0.2$ ,  $n_{NaOH} = 0.1$

Total mass of aqueous content = 200 g

⇒ Total heat capacity  $(C + 200 \times 4.2) = 1000$

Heat released =  $1000 \times 5.6 = 5600 \text{ J}$

Overall only 0.1 mole of  $CH_3COOH$  taking part in neutralisation,

$$\Rightarrow \Delta H_{\text{neutralisation}} \text{ of } CH_3COOH = -\frac{5600}{0.1} = -56000 \text{ J/mol}$$

$$\Rightarrow \Delta H_{\text{ionisation}} \text{ of } CH_3COOH = 57 - 56 = 1 \text{ kJ/mol}$$

25. (b) **Key Concept** Out of 0.2 mole of  $CH_3COOH$  only 0.1 mole of  $CH_3COOH$  are taking part in the neutralisation reaction with NaOH. In the final solution, 0.1 mole of  $CH_3COOH$  and 0.1 mole of  $CH_3COONa$  are present because  $CH_3COONa$  is a salt and dissociates almost completely and reverse the reaction till equilibrium is reached. Hence, final solution is a buffer solution and we may use following formula to calculate its pH as

$$pH = pK_a + \log \frac{[\text{salt}]}{[\text{acid}]}$$

According to the formula of pH relating to  $pK_a$

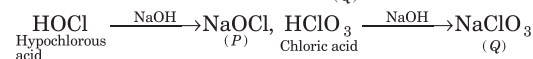
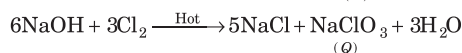
$$pH = pK_a + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

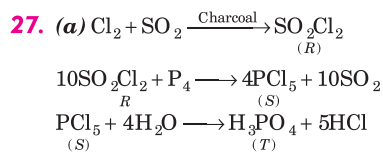
$$pH = -\log [K_a] + \log \frac{[CH_3COO^-]}{[CH_3COOH]}$$

$$pH = -\log (2 \times 10^{-5}) + \log \frac{0.1}{0.1}$$

$$pH = 5 - \log 2 + 0 = 4.7$$

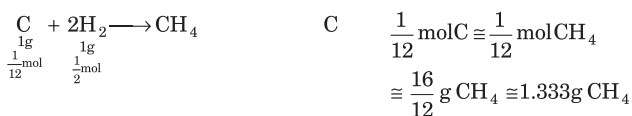
26. (a)  $2NaOH + Cl_2 \xrightarrow{\text{Cold}} NaCl + NaOCl + H_2O$  (P)



 TARGET JEE 2017


28. (c)

Reaction	Limiting reagent	Mass of product
$\text{N}_2 + 3\text{H}_2 \longrightarrow 2\text{NH}_3$ $\frac{1\text{g}}{28} \text{mol} \quad \frac{1\text{g}}{2} \text{mol}$	$\text{N}_2$	$\frac{1}{28} \text{mol N}_2 \cong \frac{1}{14} \text{mol NH}_3$ $\cong \frac{1}{14} \times 17\text{g} = 1.214 \text{g}$
$\text{CaCO}_3 \xrightarrow{\Delta} \text{CaO} + \text{CO}_2$ $\frac{1}{100} \text{mol}$	-	$\left(\frac{1}{100} \times 56\right) \text{g of CaO}$ $= 0.56 \text{g of CaO}$
$2\text{H}_2 + \text{O}_2 \longrightarrow 2\text{H}_2\text{O}$ $\frac{1\text{g}}{2} \text{mol} \quad \frac{1\text{g}}{32} \text{mol}$	$\text{O}_2$	$1 \text{mol O}_2 \cong 2\text{mol H}_2\text{O}$ $\frac{1}{32} \text{mol O}_2 \cong \frac{1}{16} \text{mol H}_2\text{O}$ $\frac{18}{16} \text{g H}_2\text{O} = 1.125 \text{g H}_2\text{O}$

29. (b)  $A \rightarrow 2, B \rightarrow 3, C \rightarrow 4, D \rightarrow 1$ 

- A.  $\text{H}_2\text{O}$  has largest H—O—H bond angle.  
 B.  $\text{H}_2\text{S}$  has lowest boiling point.  
 C.  $\text{H}_2\text{Se}$  has two lone pairs  
 D.  $\text{H}_2\text{Te}$  has largest Te—H bond length.

30. (c)

- A. Cellulose - a natural polymer of  $\alpha$ -D glucose, linked by glycoside linkage.  
 B. Nylon - 6, 6 a synthetic polymer of adipic acid and 1, 6-diaminohexane. The diacid is linked with diamine through amide linkage.  
 C. Protein - a natural polymer of  $\alpha$ -amino acids where individual amino acid units are linked by amide linkage.  
 D. Sucrose - has glycoside linkage, a disaccharide.

 Notice Board

## JEE 2017 IMPORTANT DATES

S. No.	Description	Day, Date and Time
1.	JEE (Main) 2017 (Offline exam)	Sun, 02-04-2017
2.	Results of JEE (Main) 2017	Thu, 27-04-2017
3.	Registration for JEE (Advanced) 2017	Fri, 28-04-2017, 10:00 IST to Tue, 02-05-2017, 17:00 IST
4.	Registration with Late Fee	Wed, 03-05-2017 to Thu, 04-05-2017, 17:00 IST
5.	Admit card available for downloading	Wed, 10-05-2017, 10:00 IST to Sun, 21-05-2017, 09:00 IST
6.	JEE (Advanced) 2017 Paper-1 Paper-2	Sun, 21-05-2017 09:00-12:00 IST 14:00-17:00 IST
7.	(a) Online display of ORS and scanned responses (b) Request from candidates for review of scanned responses	Wed, 31-05-2017, 10:00 IST to Sat, 03-06-2017, 17:00 IST
8.	Online display of answer keys	Sun, 04-06-2017, 10:00 IST
9.	Feedback and comments on answer keys from the candidates	Sun, 04-06-2017, 10:00 IST to Tue, 06-06-2017, 17:00 IST
10.	Declaration of JEE (Advanced) results	Sun, 11-06-2017, 10:00 IST
11.	Online registration for Architecture Aptitude Test (AAT)	Sun, 11-06-2017, 10:00 IST to Mon, 12-06-2017, 17:00 IST
12.	Architecture Aptitude Test	Wed, 14-06-2017 09:00-12:00 IST
13.	Declaration of AAT results	Sun, 18-06-2017
14.	Seat Allotment (Tentative)	Mon, 19-06-2017 to Tue, 18-07-2017

\*IST-Indian Standard Time.



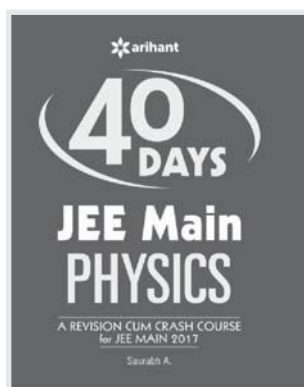
# REVISION *Cum* CRASH COURSES FOR JEE MAIN 2017

# 40 DAYS

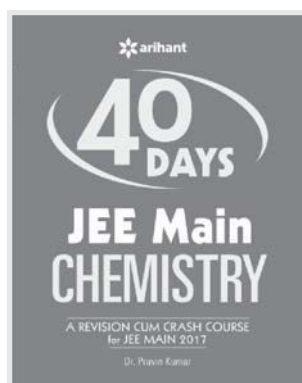
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# JEE MAIN 2017

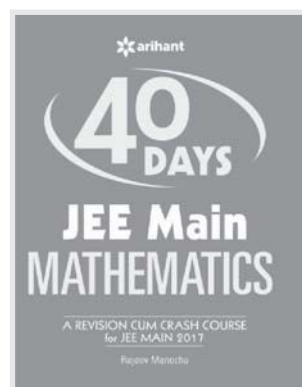
PHYSICS, CHEMISTRY, MATHEMATICS



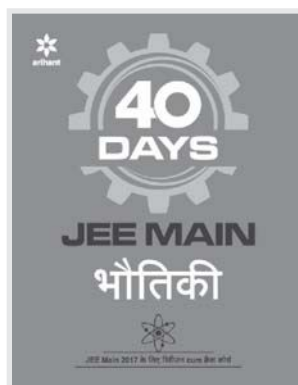
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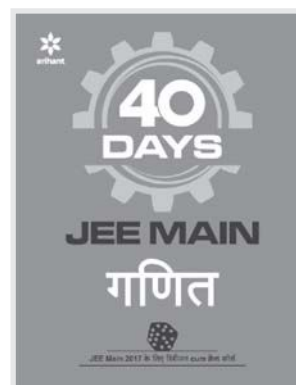
C144 ₹360



C127 ₹360



C126 ₹360



C125 ₹360

Complete Coverage of **ENGINEERING** Syllabus in  
just **40 Days** with Day wise Study and **Unit Tests & Mock Tests**

# ELECTROCHEMISTRY

▽  
Innovative problems targeted to improve your conceptual learning.

**1.** On electrolysis of an aqueous solution of NaCl, why  $H_2$  and not Na is liberated at the cathode?

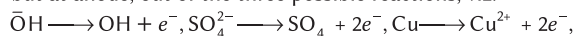
- ⊗ This is because  $H^+$  ions produced from ionisation of water have lower discharge potential than  $Na^+$  ions produced from ionisation of NaCl or reduction potential of water is greater than that of sodium.

**2.** An aqueous solution of copper sulphate is electrolysed using platinum electrodes in one case and copper electrodes in another case. Will the products of electrolysis be same or different?

- ⊗ In case of platinum electrodes, the products are Cu on cathode and  $O_2$  gas on anode. This is because out of  $Cu^{2+}$  and  $H^+$  ions (produced from  $H_2O$ ),  $Cu^{2+}$  ions have lower discharge potential. Out of  $SO_4^{2-}$  and  $\bar{O}H$  ions,  $\bar{O}H$  ions have lower discharge potential



In case of copper electrodes, product at cathode is same, viz. Cu but at anode, out of the three possible reactions, viz.



Cu is more easily oxidised than  $\bar{O}H$  and  $SO_4^{2-}$  ions.

Hence, anode of Cu dissolves into the solution to form  $Cu^{2+}$  ions.

**3.** One Faraday of electricity deposits one mol of Na from the molten salt but  $\frac{1}{3}$  mol of Al from an aluminium salt. Why?

- ⊗ The reactions at cathode for the deposition of Na and Al are  $Na^+ + e^- \longrightarrow Na$  and  $Al^{3+} + 3e^- \longrightarrow Al$ , respectively. Thus, 1 Faraday deposits 1 mol of Na, whereas 3 Faraday are required for depositing one mol of Al.

**4.** Copper is conducting as such while copper sulphate is conducting only in molten state or in aqueous solution. Explain.

- ⊗ Copper is conducting as such because it contains free electrons.  $CuSO_4$  is conducting in molten state or in aqueous solution because it gives ions only in the molten state or aqueous solution.

**5.** 1 mol of KCl dissolved in 200 cc of the solution or 1 mol of KCl dissolved in 500 cc of the solution. Which will have greater molar conductivity and why?

- ⊗ 1 mol of KCl dissolved in 500 cc of the solution will have greater molar conductivity because  $\Lambda_m = K \times V$ . With dilution,  $K$  decreases but volume increases much more so that product increases.

**6.** A 0.1 M aqueous  $Na_2SO_4$  is diluted by adding water. What will happen to the values of its conductance ( $G$ ), conductivity ( $\kappa$ ), molar conductivity ( $\Lambda_m$ ) and equivalent conductivity ( $\Lambda_{eq}$ )?

- ⊗  $\kappa$  decreases whereas  $G, \Lambda_m$  and  $\Lambda_{eq}$  increases with dilution. The conductance ( $G$ ) of a solution is directly proportional to the number of ions in solution. As on dilution, more ions are produced in solution, so conductance ( $G$ ) should also increase on dilution. The specific conductivity ( $\kappa$ ) of an electrolyte falls with dilution because the number of current-carrying particles, i.e. ions present per centimeter cube of the solution becomes less and less on dilution. However, the increase in  $\Lambda_m$  and  $\Lambda_{eq}$  on dilution is due to the fact that these are products of  $\kappa$  and  $V$  (volume) of the solution containing one gram equivalent of the electrolyte. As the decreasing value of specific conductivity ( $\kappa$ ) is more than that compensated by the increasing value of  $V$ , so the values of  $\Lambda_{eq}$  and  $\Lambda_m$ , increase with dilution.

**7.** Why in a concentrated solution, a strong electrolyte shows deviation from Debye-Huckel-Onsager equation?

- ⊗ In concentrated solution of a strong electrolyte, the interionic forces of attraction are large.

**8.** What would happen if no salt bridge were used in an electrochemical cell (like Zn—Cu cell)?

- ⊗ The metal ions ( $Zn^{2+}$ ) formed by the loss of electrons will accumulate on one electrode and the negative ions ( $SO_4^{2-}$ ) will accumulate on the other. Thus, the solutions will develop charges and the current stops flowing. Moreover, inner circuit is not completed.

**9.** If an electrochemical cell is set up as usual but there is no flow of current. What do you conclude?

- ⊗ The electrode potentials of both the electrodes are equal which depend upon the concentrations of the solution in the half-cells.

**10.** Why is it necessary to use a salt bridge in a Galvanic cell?

- ⊗ To complete the inner circuit and to maintain electrical neutrality of the electrolytic solutions of the half-cells.

**11.** How can the reduction potential of an electrode be increases?

- ⊗ For the reaction,

$$M^{n+} + ne^{-} \longrightarrow M$$

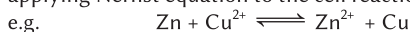
$$E_{M^{n+}/M} = E^{\circ}_{M^{n+}/M} - \frac{RT}{nF} \ln \frac{1}{[M^{n+}]}$$

$$= E^{\circ}_{M^{n+}/M} + \frac{RT}{nF} \ln [M^{n+}].$$

Thus, electrode potential can be increased either by increasing metal ion concentration, i.e.  $[M^{n+}]$  or temperature ( $T$ ).

**12.** Equilibrium constant is related to  $E^{\circ}_{\text{cell}}$  but not to  $E_{\text{cell}}$ . Explain why?

- ⊗ When equilibrium is reached in the cell reaction,  $E_{\text{cell}}$  become equal to zero. However,  $E^{\circ}_{\text{cell}}$  is a constant quantity. Hence, applying Nernst equation to the cell reaction,



$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - \frac{RT}{nF} \ln \frac{[Zn^{2+}]}{[Cu^{2+}]} = E^{\circ}_{\text{cell}} - \frac{RT}{nF} \ln K_C$$

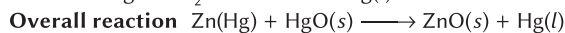
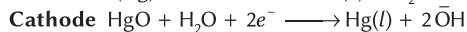
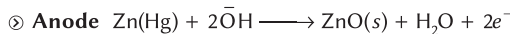
At equilibrium,  $E_{\text{cell}} = 0$ .

$$\text{Hence, } E^{\circ}_{\text{cell}} = \frac{RT}{nF} \ln K_C.$$

**13.** What is the role of  $ZnCl_2$  in a dry cell?

- ⊗  $ZnCl_2$  combines with the  $NH_3$  produced to form the complex salt,  $[Zn(NH_3)_2Cl_2]$  as otherwise the pressure developed due to  $NH_3$  would crack the seal of the cell.

**14.** Why a mercury cell gives a constant voltage throughout its life?



The cell potential is approximately 1.35V and remains constant throughout its life since, overall reaction does not involve any ion whose concentration can change during its life time.

**15.** Why does a dry cell becomes dead after a long time even if it has not been used?

- ⊗ This is because in dry cell, acidic  $NH_4Cl$  corrodes the zinc container.

**16.** Why is it not possible to determine  $\Lambda^{\circ}_m$  for weak electrolytes by extrapolation?

- ⊗ Because  $\Lambda^{\circ}_m$  for weak electrolytes does not increase linearly with dilution as for strong electrolytes.

**17.** Why is alternating current used in place of direct current in measuring the electrolytic conduction?

- ⊗ Direct current results in the electrolysis of the electrolytic solution. As a result, concentration of the electrolyte near the electrodes changes and this results change in the resistance of the solution.

**18.** Can tin coating on iron act as sacrificial anode in protecting iron against corrosion?

- ⊗ No, because tin is less readily oxidised in comparison to iron ( $E^{\circ}_{Fe^{2+}/Fe} = -0.44\text{ V}$ ,  $E^{\circ}_{Sn^{2+}/Sn} = -0.14\text{ V}$ ). Tin protects iron only as a cover.

**19.** Why is it not possible to measure the voltage of an isolated half reaction?

- ⊗ It is not possible to measure the voltage of an isolated half reaction because neither the oxidation nor the reduction can occur by itself. Therefore, we can only calculate the relative electrode potential by connecting it to some standard electrode.

**20.** Can we store copper sulphate in an iron vessel?

- ⊗ The reduction potentials of  $Cu^{2+}/Cu$  and  $Fe^{2+}/Fe$  are 0.34 V and  $-0.44\text{ V}$ , respectively. This means  $Cu^{2+}$  will be reduced to Cu and iron (Fe) will be oxidised to  $Fe^{2+}$ . In other words, the vessel will dissolve. Therefore, it is not possible to store  $CuSO_4$  in an iron vessel.

### WHAT ARE WATERMARKS?

Have you held a currency note to the light and seen all the secret pictures on it? Those are called watermarks. How watermarks are made on currency notes? The process of making watermarks is very old. It was invented in Venice in the 13th century! Though the technology has changed since, the basic method stays the same. A wet sheet of paper is passed onto a printing drum. The drum carries an etching of the picture or writing to be watermarked and is heated. As the wet paper passes around the drum, it gets the watermark. The paper is then dried and taken for the actual printing, where the visible parts of the currency note are printed with ink.

When a paper is watermarked, a very thin layer of paper is scraped off. This makes the watermarked area thinner than the rest of the paper. When you hold the paper to light, the thinner area allows more light to pass through than the thicker and that is how you can see the pattern.

Watermarks are made not only on currency notes but also for other important documents like stamp paper, top-secret government and military notes, etc.




**TARGET NEET 2017**
**MEDI QUEST**

Comprehensive Simulator Test Series for NEET &amp; AIIMS

# NEET

## SCALE UP

Mock Questions from Complete Syllabus with Hints or Crispy Solutions

**FULL TEST**

# 3

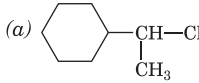
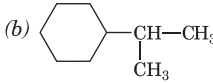
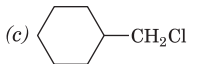
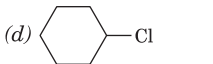
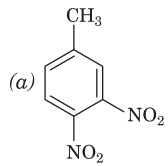
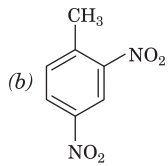
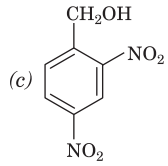
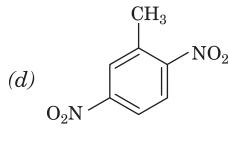
**(Complete Syllabus)  
WITH HINTS**
**INSTRUCTIONS**

- This test consists of 45 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

- The change in mass number if the number of neutrons is halved and the number of electrons is doubled in  ${}_8\text{O}^{16}$  is  
 (a) 25% decrease (b) 50% increase  
 (c) 75% increase (d) remains same
- CsBr crystallises in a body-centred cubic (bcc) lattice. The unit cell length is 436.6 pm. Given that the atomic mass of Cs = 133 u and that of Br = 80 u. The density of CsBr is  
 (a)  $0.425 \text{ g cm}^{-3}$  (b)  $8.25 \text{ g cm}^{-3}$   
 (c)  $42.5 \text{ g cm}^{-3}$  (d)  $4.25 \text{ g cm}^{-3}$
- The pH of the solution that results from the addition of 20 mL of 0.01 M  $\text{Ca}(\text{OH})_2$  to 30 mL of 0.01 M HCl is  
 (a) 11.3 (b) 10.55 (c) 2.7 (d) 83.55
- A 10.0 L cylinder of oxygen at 4.0 atm pressure and  $17^\circ\text{C}$  developed a leak. When the leak was repaired, 2.50 atm of oxygen remained in the cylinder, still at  $17^\circ\text{C}$ . How many moles of gas escaped?  
 (a) 0.63 mole (b) 0.53 mole (c) 0.75 mole (d) 0.43 mole
- The van der Waals' equation for  $\text{CH}_4$  at low pressure is  
 (a)  $pV = RT - pb$  (b)  $pV = RT - \frac{a}{V}$   
 (c)  $pV = RT + \frac{a}{V}$  (d)  $pV = RT + pb$
- Consider the following statements about peroxide ion.  
 I. It has five completely filled antibonding molecular orbitals.  
 II. It is diamagnetic.  
 III. It has bond order equal to one.  
 IV. It is isoelectronic with neon.  
 Select the correct statement and choose the correct option.  
 (a) II and III (b) I, II and IV  
 (c) I, III and IV (d) I and IV
- In the preparation of CaO from  $\text{CaCO}_3$  using the equilibrium,  

$$\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$$

$$\log K_p = 7.282 - \frac{8500}{T}$$
 For complete decomposition of  $\text{CaCO}_3$ , the temperature in  $^\circ\text{C}$  is  
 (a) 1167 (b) 894  
 (c) 8500 (d) 850
- Which of the following exhibits the maximum covalent character?  
 (a)  $\text{FeCl}_2$  (b)  $\text{AlCl}_3$   
 (c)  $\text{MgCl}_2$  (d)  $\text{SnCl}_2$

9. Sodium forms  $\text{Na}^+$  ion but it does not form  $\text{Na}^{2+}$  due to  
 (a) very low value of 1st and 2nd IE  
 (b) very high value of 1st and 2nd IE  
 (c) high value of 1st IE and low value of 2nd IE  
 (d) low value of 1st IE and high value of 2nd IE
10. The correct order for the solubility of sulphates of alkaline earth metals in water is  
 (a)  $\text{Be} > \text{Ca} > \text{Mg} > \text{Ba} > \text{Sr}$   
 (b)  $\text{Mg} > \text{Be} > \text{Ba} > \text{Ca} > \text{Sr}$   
 (c)  $\text{Be} > \text{Mg} > \text{Ca} > \text{Sr} > \text{Ba}$   
 (d)  $\text{Mg} > \text{Ca} > \text{Ba} > \text{Be} > \text{Sr}$
11. On dissolving moderate amount of sodium metal in liquid  $\text{NH}_3$  at low temperature, which one of the following does not occur?  
 (a)  $\text{Na}^+$  ions are formed in the solution  
 (b) Blue coloured solution is obtained  
 (c) Liquid  $\text{NH}_3$  becomes good conductor of electricity  
 (d) Liquid ammonia remains diamagnetic
12. A metal,  $M$  forms chlorides in its +2 and +4 oxidation states. Which of the following statements about these chlorides is correct?  
 (a)  $\text{MCl}_2$  is more volatile than  $\text{MCl}_4$   
 (b)  $\text{MCl}_2$  is more soluble in anhydrous ethanol than  $\text{MCl}_4$   
 (c)  $\text{MCl}_2$  is more ionic than  $\text{MCl}_4$   
 (d)  $\text{MCl}_2$  is more easily hydrolysed than  $\text{MCl}_4$
13. Which one of the following undergoes  $\text{S}_{\text{N}}2$  reaction faster?  
 (a)  (b)   
 (c)  (d) 
14. *p*-nitrotoluene on nitration gives  
 (a)  (b)   
 (c)  (d) 
15. On mixing a certain alkane with chlorine and irradiating it with UV light, it forms one monochloro alkane. The alkane could be  
 (a) *neo*-pentane (b) propane  
 (c) pentane (d) *iso*-pentane
16.  $\text{MnO}_4^{2-}$  undergoes disproportionation reaction in acidic medium but  $\text{MnO}_4^-$  does not because  
 (a) in  $\text{MnO}_4^{2-}$ , Mn is in intermediate oxidation state  
 (b) in  $\text{MnO}_4^-$ , Mn is in lowest oxidation state  
 (c) in  $\text{MnO}_4^-$ , Mn is in intermediate oxidation state  
 (d) None of the above
17. According to the adsorption theory of catalysis, the speed of the reaction increases because  
 (a) adsorption produces heat which increases the speed of the reaction  
 (b) adsorption lowers the activation energy of the reaction  
 (c) the concentration of reactant molecules at the active centres of the catalyst becomes high due to adsorption  
 (d) in the process of adsorption, the activation energy of the molecules are large
18. A first order reaction has a rate constant,  $k = 5.5 \times 10^{-14} \text{ s}^{-1}$ , calculate the half-life of reaction.  
 (a)  $1.26 \times 10^{14} \text{ s}$  (b)  $1.76 \times 10^{14} \text{ s}$   
 (c)  $1.36 \times 10^{14} \text{ s}$  (d)  $1.46 \times 10^{14} \text{ s}$
19. If a current of 0.5 A flows through a metallic wire for 2h, then how many electrons would flow through the wire?  
 (a)  $6.022 \times 10^{23}$  (b)  $1.202 \times 10^{23}$   
 (c)  $2.246 \times 10^{22}$  (d)  $3.02 \times 10^{24}$
20. If the half-cell reactions are given as  
 I.  $\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Fe}(\text{s}); E^\circ = -0.44 \text{ V}$   
 II.  $2\text{H}^+(\text{aq}) + \frac{1}{2}\text{O}_2(\text{g}) + 2\text{e}^- \longrightarrow \text{H}_2\text{O}(\text{l}); E^\circ = +1.23 \text{ V}$   
 Calculate the  $E^\circ$  for the reaction,  
 $\text{Fe}(\text{s}) + 2\text{H}^+ + \frac{1}{2}\text{O}_2(\text{g}) \longrightarrow \text{Fe}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$   
 (a) + 1.67 V (b) - 1.67 V  
 (c) + 0.79 V (d) - 0.79 V
21. Na crystallises in bcc while Mg in fcc type crystal lattice, the ratio of number of atoms present in the unit cell of their respective crystal is  
 (a) 1 (b) 0.5 (c) 3 (d) 4
22. Schottky defect in crystals is observed when  
 (a) density of crystal is increased  
 (b) an ion leaves its normal site and occupies an interstitial site  
 (c) equal number of cations and anions are missing from the lattice  
 (d) unequal number of cations and anions are missing from the lattice
23. A 6% solution of urea is isotonic with  
 (a) 1 M solution of glucose  
 (b) 0.05 M solution of glucose  
 (c) 6% solution of glucose  
 (d) 25% solution of glucose

 TARGET NEET 2017

24. The degree of dissociation ( $\alpha$ ) of a weak electrolyte,  $A_xB_y$ , is related to van't Hoff factor ( $i$ ) by the expression

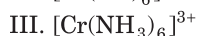
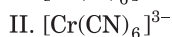
$$(a) \alpha = \frac{i-1}{(x+y-1)} \quad (b) \alpha = \frac{i-1}{x+y+1}$$

$$(c) \alpha = \frac{x+y-1}{i-1} \quad (d) \alpha = \frac{x+y+1}{i-1}$$

25. Amongst the following ions which one has the highest magnetic moment value?

- (a)  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$   
 (b)  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$   
 (c)  $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$   
 (d) All have same magnetic moment

26. Arrange the following complex ion in increasing order of crystal field splitting energy ( $\Delta_0$ ).



- (a) I < II < III  
 (b) II < I < III  
 (c) III < II < I  
 (d) I < III < II

27. Which of the following compounds has same oxidation state of the central metal atom in the cationic and anionic part?

- (a)  $[\text{Pt}(\text{NH}_3)_4][\text{PtCl}_6]$   
 (b)  $[\text{Pt}(\text{py})_4][\text{PtCl}_4]$   
 (c)  $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2][\text{PtCl}_4]$   
 (d) None of these

28. An aqueous solution of  $\text{CoCl}_2$  on addition of excess of conc.  $\text{HCl}$  turns blue due to the formation of

- (a)  $[\text{Co}(\text{H}_2\text{O})\text{Cl}_2]$   
 (b)  $[\text{Co}(\text{H}_2\text{O})_2\text{Cl}_4]^{2-}$   
 (c)  $[\text{CoCl}_4]^{2-}$   
 (d)  $[\text{Co}(\text{H}_2\text{O})_2\text{Cl}_2]$

29. Which one of the following acts as an oxidising agent?

- (a)  $\text{Np}^{4+}$   
 (b)  $\text{Sm}^{2+}$   
 (c)  $\text{Eu}^{2+}$   
 (d)  $\text{Yb}^{2+}$

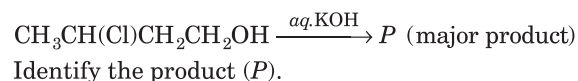
30. On heating with concentrated  $\text{NaOH}$  solution in an inert atmosphere of  $\text{CO}_2$ , white phosphorus gives a gas. Which of the following statement is incorrect about the gas?

- (a) It is highly poisonous and has rotten fish like smell  
 (b) Its solution in water decomposes in the presence of light  
 (c) It is more basic than  $\text{NH}_3$   
 (d) None of the above

31. When chlorine reacts with dil.  $\text{NaOH}$  under cold condition, the oxidation state of chlorine changes from zero to

- (a) -1 and +5  
 (b) +1 and +4  
 (c) +5 and +3  
 (d) -1 and +1

32. Consider the following reaction,

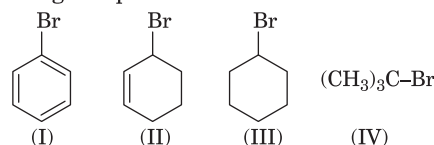


- (a)  $\text{CH}_3\text{CH}=\text{CH}-\text{CH}_2\text{OH}$   
 (b)  $\text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_2\text{OH}$   
 (c)  $\text{CH}_3-\underset{\text{O}-\text{CH}_2}{\text{CH}}-\text{CH}_2$   
 (d)  $\text{CH}_3-\underset{\text{OH}}{\text{CH}}-\text{CH}_2-\text{CH}_2\text{OH}$

33. 2° and 3° amines are fail to undergo the carbylamine test because

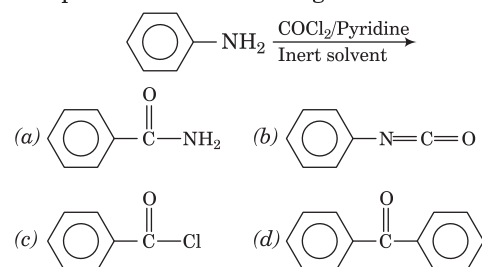
- (a) they combine with chloroform to give a stable compound  
 (b) they react with alcoholic  $\text{KOH}$   
 (c) the nitrogen atom of the amine group does not have the required number of hydrogen atoms  
 (d) All of the above

34. The increasing order for the hydrolysis of the following compounds is



- (a) I < III < II < IV  
 (b) I < IV < III < II  
 (c) IV < II < III < I  
 (d) I < III < IV < II

35. The product of the following reaction is



36. Phenol is less acidic than

- (a) ethanol  
 (b) *o*-nitrophenol  
 (c) *o*-methyl phenol  
 (d) *o*-methoxy phenol

37. The reagent which does not react with both acetone and benzaldehyde is


- (a) sodium hydrogen sulphite  
 (b) phenyl hydrazine  
 (c) Fehling's solution  
 (d) Grignard's reagent

38. The best reagent to convert pent-3-en-2-ol into pent-3-en-2-one is

- (a) pyridinium chlorochromate  
 (b) chromic anhydride in glacial acetic acid  
 (c) acidic dichromate  
 (d) acidic permanganate

39. When  $\text{CH}_2 = \text{CH} - \text{COOH}$  is reduced with  $\text{LiAlH}_4$ , the obtain compound is  
 (a)  $\text{CH}_3 - \text{CH}_2 - \text{COOH}$  (b)  $\text{CH}_2 = \text{CH} - \text{CH}_2\text{OH}$   
 (c)  $\text{CH}_3 - \text{CH}_2 - \text{CH}_2\text{OH}$  (d)  $\text{CH}_3 - \text{CH}_2 - \text{CHO}$
40. The enol form of acetone, after treated with  $\text{D}_2\text{O}$  gives  
 (a)  $\text{CH}_3 - \underset{\text{OD}}{\text{C}} = \text{CH}_2$  (b)  $\text{CH}_3 - \overset{\text{O}}{\underset{\text{O}}{\text{C}}} - \text{CH}_3$   
 (c)  $\text{CH}_2 = \underset{\text{OH}}{\text{C}} - \text{CH}_2\text{D}$  (d)  $\text{CD}_2 = \underset{\text{OD}}{\text{C}} - \text{CD}_3$
41. Out of the following, the alkene that exhibits optical isomerism is  
 (a) 3-methyl-2-pentene (b) 4-methyl-1-pentene  
 (c) 3-methyl-1-pentene (d) 2-methyl-2-pentene
42. Denaturation of proteins leads to loss of its biological activity by  
 (a) formation of amino acids  
 (b) loss of primary structure  
 (c) loss of both primary and secondary structures  
 (d) loss of both secondary and tertiary structures
43. For the formation of terylene, the number of moles of ethylene glycol required per mole of terephthalic acid is  
 (a) 1 (b) 2 (c) 3 (d) 4
44. The compound which is added to soap to impart antiseptic properties is  
 (a) sodium lauryl sulphate  
 (b) sodium dodecyl benzene sulphonate  
 (c) resin  
 (d) bithional
45. When methanol reacts with formaldehyde in the presence of excess of  $\text{HCl}$ , the product is  
 (a)  $\text{CH}_2(\text{OCH}_3)_2$  (b)  $\text{CH}_2\text{Cl}_2$   
 (c)  $\text{CH}_3\text{OCH}_2\text{OH}$  (d)  $\text{CH}_3\text{OCH}_2\text{Cl}$

## Answers with Explanation

1. (a) Atomic number ( $Z$ ) = Number of protons  
 Mass number ( $A$ ) = Number of protons ( $Z$ ) + Number of neutrons ( $N$ )
2. (d) Density ( $d$ ) =  $\frac{Z \times M}{a^3 \times N_A}$   
 where,  $Z = 1$  (for bcc),  $M$  = Molecular mass  
 $a$  = Edge length,  $N_A$  = Avogadro's number ( $6.023 \times 10^{23}$ )
3. (a) Millimoles of  $\text{H}^+$  =  $30 \times 0.01 = 0.3$   
 Millimoles of  $\text{OH}^-$  =  $20 \times 0.01 \times 2 = 0.4$   
 $\text{pOH} = 2.6999$   
 $\text{pH} = 14 - 2.6999 = 11.3$
4. (a) According to ideal gas equation,  
 $pV = nRT$
5. (b) The van der Waals' equation for 1 mol of gas is  
 $\left(p + \frac{a}{V^2}\right)(V - b) = RT$   
 At low  $p$ , volume is high, so  $(V - b) \approx V$
6. (a) Peroxide ion is  $\text{O}_2^{2-}$   
 $\text{O}_2^{2-} (18) = \text{Ar} = \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \sigma 2p_z^2$   
 $\pi 2p_x^2 \approx \pi 2p_y^2, \pi^* 2p_x^2 \approx \pi^* 2p_y^2$   
 Bond order =  $\frac{N_b - N_a}{2}$
7. (b) On complete decomposition of  $\text{CaCO}_3$ ,  $\log K_p = 0$ .
8. (b) According to Fajan's rule, smaller cation and larger anion shows more covalent character.
9. (d)
10. (c) Hydration energy causes decrease in the solubility of the sulphates as the ionic size increases.
11. (d) Due to the presence of free electrons, liquid ammonia becomes paramagnetic.
12. (c) Higher the oxidation state, smaller the size, greater will be the polarising power which results in greater covalent character.
13. (c)   $\text{CH}_2\text{Cl}$  is a primary halide.
14. (b)  $-\text{CH}_3$  is a *ortho/para* directing group and  $-\text{NO}_2$  is a *meta*-directing group.
15. (a) All H-atoms in *neo*-pentane are equivalent, thus, it will yield monochloro product.
16. (a) In  $\text{MnO}_4^{2-}$ , the oxidation number of Mn is + 6. It can increase its oxidation number upto + 7 or decrease upto 0. In  $\text{MnO}_4^-$ , Mn is in its highest oxidation state, i.e. + 7.
17. (a)
18. (a)  $t_{1/2} = \frac{0.693}{k} = \frac{0.693}{5.5 \times 10^{-14} \text{ s}^{-1}} = 1.26 \times 10^{14} \text{ s}$
19. (c) Charge ( $Q$ ) = Current ( $i$ )  $\times$  time ( $t$ )  
 $= (0.5 \text{ A}) \times (2 \times 60 \times 60 \text{ s}) = 3600 \text{ C}$   
 Number of electrons flowing through the wire on passing charge of one Faraday (96500 C) =  $6.022 \times 10^{23}$   
 Number of electrons flowing through the wire on passing a charge of 3600 C  
 $= \frac{6.022 \times 10^{23} \times (3600 \text{ C})}{(96500 \text{ C})} = 2.246 \times 10^{22}$
20. (a)  $E_{\text{cell}}^\circ = E_{\text{cathode}} - E_{\text{anode}} = + 1.23 - (- 0.44) = + 1.67 \text{ V}$
21. (b) For bcc,  $Z = 2$  per unit cell  
 For fcc,  $Z = 4$  per unit cell  
 $\therefore$  Ratio =  $\frac{2}{4} = 0.5$

To be Continued at Page 78

# THERMODYNAMICS

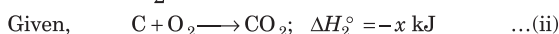
Stepwise Learning and Practice through Selective Problems

- 1 Given that,  $C + O_2 \longrightarrow CO_2$ ;  $\Delta H^\circ = -x$  kJ  
 $2CO + O_2 \longrightarrow 2CO_2$ ;  $\Delta H^\circ = -y$  kJ

The heat of formation of carbon monoxide will be

- (a)  $\frac{y-2x}{2}$  (b)  $y+2x$   
 (c)  $2x-y$  (d)  $\frac{2x-y}{2}$

- 2 (a) **Step I** Write the equation for the formation of carbon monoxide (CO).

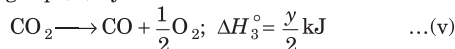


**Step II** Reverse the Eq. (iii) followed by dividing the resultant equation by 2 and also apply the same procedure for the respective  $\Delta H^\circ$  values.

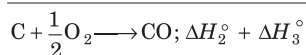
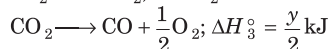
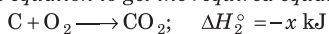
On reversing Eq. (iii), we get



On dividing Eq. (iv) by 2



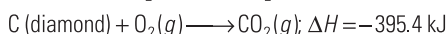
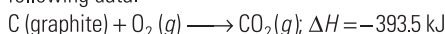
**Step III** Now, add Eqs. (ii) and (v) and also  $\Delta H^\circ$  of respective equation to get the required equation.



$$\Delta H_1^\circ = \Delta H_2^\circ + \Delta H_3^\circ \\ = -x + \frac{y}{2} = \frac{y-2x}{2}$$
 kJ

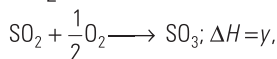
## TRY THESE

1. Calculate  $\Delta H$  (in J) for,  $C$  (graphite)  $\rightarrow$   $C$  (diamond) using the following data.



- (a) 1900 J (b)  $-788.9 \times 10^3$  J  
 (c)  $19 \times 10^4$  J (d)  $+788.9 \times 10^3$  J

2.  $S + \frac{3}{2}O_2 \longrightarrow SO_3$ ;  $\Delta H = 2x$

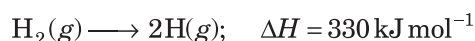
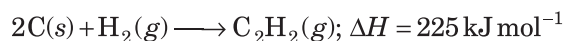


The heat of formation of  $SO_2$  is

- (a)  $2x-y$  (b)  $2x+y$   
 (c)  $x+y$  (d)  $\frac{2x-y}{2}$

2. 1. (a) 2. (a)

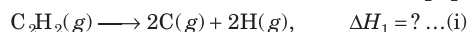
- 2 Using the data provided, calculate the multiple bond energy ( $\text{kJ mol}^{-1}$ ) of a  $C \equiv C$  bond in  $C_2H_2$ . Take the bond energy of a  $C-H$  bond as  $350 \text{ kJ mol}^{-1}$ .



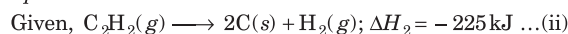
[JEE Mains 2012]

- (a) 1165 (b) 837  
 (c) 865 (d) 815

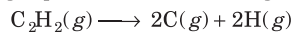
- 2 (d) **Step I** Write the expression for dissociation of  $C_2H_2$ .



**Step II** Calculate dissociation energy of  $C_2H_2$  using the given bond enthalpies by adding all the three given equations.



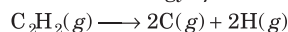
On adding Eqs. (ii), (iii) and (iv) we get, Eq. (i),



$$\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4$$

$$= -225 + 1410 + 330 = 1515$$
 kJ

**Step III** Write the expression of  $\Delta H$  relating BE and using Eq. (i) and bond energy of  $C-H$  bond which is equal to  $350 \text{ kJ mol}^{-1}$ , calculate bond energy of  $C \equiv C$ .



$$\Delta H^\circ = \Sigma \text{BE (reactant)} - \Sigma \text{BE (product)}$$

$$1515 \text{ kJ} = 2 \times (\text{BE})_{C-H} + (\text{BE})_{C \equiv C}$$

$$= 2 \times 350 + (\text{BE})_{C \equiv C}$$

$$(\text{BE})_{C \equiv C} = 1515 - 700 = 815 \text{ kJ mol}^{-1}$$

## TRY THESE

1. The bond energies of  $C-C$ ,  $C=C$ ,  $C-H$  and  $C-H$  linkages are 350, 600, 400 and  $410 \text{ kJ mol}^{-1}$ , respectively. The heat of hydrogenation of ethylene is

- (a)  $-170 \text{ kJ mol}^{-1}$   
 (b)  $-260 \text{ kJ mol}^{-1}$   
 (c)  $-400 \text{ kJ mol}^{-1}$   
 (d)  $-450 \text{ kJ mol}^{-1}$

2. If bond dissociation energies of  $XY$ ,  $X_2$  and  $Y_2$  (all diatomic molecules) are in the ratio of 1:1:0.5 and  $\Delta H_f^\circ$  for the formation of  $XY$  is  $-200 \text{ kJ mol}^{-1}$ . The bond dissociation energy of  $X_2$  will be

- (a)  $400 \text{ kJ mol}^{-1}$  (b)  $300 \text{ kJ mol}^{-1}$   
 (c)  $200 \text{ kJ mol}^{-1}$  (d)  $800 \text{ kJ mol}^{-1}$

2. 1. (a) 2. (d)



- 3 One mole of an ideal gas at 300 K in thermal contact with surroundings, expands isothermally from 1.0 L to 2.0 L against a constant pressure of 3.0 atm. In this process, the change in entropy of surroundings ( $\Delta S_{\text{surr}}$ ) in  $\text{JK}^{-1}$  is (1L atm = 101.3 J)

[JEE Advanced 2016]

- (a) 5.763 (b) 1.013 (c) -1.013 (d) -5.763

- ⊙ (c) **Step I** Write the expression which relates internal energy ( $\Delta U$ ) with heat ( $q$ ), and work ( $w$ ).

By first law of thermodynamics,

$$\Delta U = q + w \quad \dots(i)$$

**Step II** According to the given condition, the process is isothermal, hence change in internal energy ( $\Delta U$ ) is zero.

$$\Delta U = nC_v\Delta T = 0 \quad [\because \Delta T = T_2 - T_1 = 0]$$

Substitute,  $\Delta U = 0$  in Eq. (i)

$$\therefore q = -w$$

$$-q_{\text{irrev}} = w_{\text{irrev}} = p\Delta V = 3(2-1) = 3\text{L atm}$$

**Step III** Write the expression of change in entropy of surrounding and substitute the value of  $q_{\text{irrev}}$  and  $T$ .

$$\begin{aligned} \Delta S_{\text{surr}} &= \frac{q_{\text{irrev}}}{T} = \frac{(-3 \times 101.3)}{300\text{K}} \text{J} \quad [\because 1\text{L atm} = 101.3\text{J}] \\ &= -\frac{303.9\text{J}}{300\text{K}} = -1.013\text{JK}^{-1} \end{aligned}$$

**TRY THESE**

1. 2 moles of an ideal gas expanded isothermally and reversibly from 1L to 10 L at 300 K. What is the enthalpy change?

- (a) 4.98 kJ (b) 11.47 kJ (c) -11.47 kJ (d) 0 kJ

2. A piston filled with 0.04 mole of an ideal gas expands reversibly from 50 mL to 375 mL at a constant temperature of 37°C. As it does so, it absorbs 208J of heat. The values of  $q$  and  $w$  for the process will be ( $R=8.314\text{J/mol}\cdot\text{K}$ ;  $\ln 7.5=2.01$ )

- (a)
- $q=+208\text{J}$
- ,
- $w=-208\text{J}$
- (b)
- $q=-208\text{J}$
- ,
- $w=-208\text{J}$
- 
- (c)
- $q=-208\text{J}$
- ,
- $w=+208\text{J}$
- (d)
- $q=+208\text{J}$
- ,
- $w=+208\text{J}$

- ⊙ 1. (d) 2. (a)

- 4 Calculate the standard free energy change in  $\text{kJ mol}^{-1}$  for the formation of methane at 298 K. The value of  $\Delta_r H^\circ$  for  $\text{CH}_4(\text{g})$  is  $-74.81\text{kJ mol}^{-1}$  and  $S$  values for C (graphite),  $\text{H}_2(\text{g})$  and  $\text{CH}_4(\text{g})$  are 5.70, 130.7 and  $186.3\text{JK}^{-1}\text{mol}^{-1}$ , respectively.

- (a) -80.8 (b) -50.74 (c) -98.91 (d) -40.4

- ⊙ (b) **Step I** Write the equation for the formation of methane and also the expression of  $\Delta S^\circ$  relating entropies of products and reactants.

$$\begin{aligned} \text{C}_{(\text{graphite})} + 2\text{H}_2 &\longrightarrow \text{CH}_4; \Delta H^\circ = -74.81\text{kJ mol}^{-1} \\ \Delta S^\circ &= \Sigma S^\circ_{\text{products}} - \Sigma S^\circ_{\text{reactants}} \\ &= S^\circ_{\text{CH}_4(\text{g})} - [S^\circ_{\text{C}(\text{graphite})} + 2S^\circ_{\text{H}_2(\text{g})}] \\ &= [186.3 - (5.7 + 2 \times 130.7)]\text{JK}^{-1}\text{mol}^{-1} \\ &= -80.8\text{JK}^{-1}\text{mol}^{-1} = -80.8 \times 10^{-3}\text{kJK}^{-1}\text{mol}^{-1} \end{aligned}$$

**Step II** Write the Gibb's Helmholtz equation which relates  $\Delta G^\circ$  with  $\Delta H^\circ$  and  $\Delta S^\circ$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

**Step III** Substitute the value of  $\Delta H^\circ$ ,  $T$  and  $\Delta S^\circ$  in step II to calculate  $\Delta G^\circ$ .

$$\begin{aligned} \Delta G^\circ &= -74.81 - [(298 \times (-80.8 \times 10^{-3}))] \\ &= (-74.81 + 24.07)\text{kJ mol}^{-1} \\ &= -50.74\text{kJ mol}^{-1} \end{aligned}$$

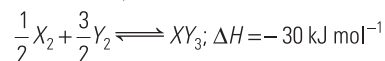
**TRY THESE**

1. For a certain process,  $\Delta H=178\text{kJ mol}^{-1}$  and  $\Delta S=160\text{JK}^{-1}\text{mol}^{-1}$ .

What is the minimum temperature at which the process is spontaneous (assuming that  $\Delta H$  and  $\Delta S$  do not vary with temperature.)

- (a) 2112.3 K (b) 136.7 K (c) 275.8 K (d) 1112.5 K

2. Standard entropies of  $X_2$ ,  $Y_2$  and  $XY_3$  are 60, 40 and  $50\text{JK}^{-1}\text{mol}^{-1}$ , respectively. For the reaction,



to be at equilibrium, the temperature should be

- (a) 500 K (b) 750 K (c) 1000 K (d) 1250 K

- ⊙ 1. (d) 2. (b)

- 5 A gas expands from a volume of  $3\text{dm}^3$  to  $5\text{dm}^3$  against a constant pressure of 3 atm. The work done during expansion is used to heat 10 moles of water at temperature 290K. Calculate the final temperature of water (specific heat of water =  $4.184\text{JK}^{-1}\text{g}^{-1}$ )

- (a) 290 K (b) 380 K (c) 320 K (d) 180 K

- ⊙ (a) **Step I** Write the expression of work done and heat absorbed, respectively.

$$\text{Work done} = p\Delta V = p(V_2 - V_1) \quad \dots(i)$$

$$\text{Heat absorbed (Q)} = ms\Delta T \quad \dots(ii)$$

where,  $m$  = mass of substance,  $s$  = specific heat,  $\Delta T$  = temperature difference.

**Step II** Equating Eq.(i) with (ii) as per question and substitute the values of  $p$ ,  $V_1$ ,  $V_2$ ,  $m$ ,  $s$ .

Given,  $p(V_2 - V_1) = ms \times \Delta T$ 

$$\begin{aligned} \Delta T &= \frac{p(V_2 - V_1)}{ms} \left[ \text{moles (n)} = \frac{\text{mass (m)}}{\text{molecular weight (M)}} \right] \\ &= \frac{3 \times (5 - 3)}{10 \times 18 \times 4.187} = 0.807 \end{aligned}$$

**Step III** Now,  $\Delta T = T_{\text{final}} - T_{\text{initial}}$ , hence substitute the values of  $\Delta T$  and  $T_{\text{initial}}$  to calculate  $T_{\text{final}}$ .

$$\begin{aligned} \text{Final temperature (T}_{\text{final}}) &= \Delta T + T_{\text{initial}} \\ &= 290 + 0.807 = 290.807\text{K} \end{aligned}$$

**TRY THESE**

1. In order to decompose 9 g of water, 142.5 kJ heat is required.

Hence, enthalpy of formation of water is

- (a) -142.5 kJ (b) +142.5 kJ (c) -285 kJ (d) +285 kJ

2. 4 g of graphite is burnt in a bomb calorimeter of heat capacity  $30\text{kJK}^{-1}$  in excess of oxygen at 1atm pressure. The temperature rises from 300 K to 304 K. What is the enthalpy of combustion of graphite (in  $\text{kJ mol}^{-1}$ )

- (a) 360 (b) 1440 (c) -360 (d) -1440

- ⊙ 1. (c) 2. (a)

# CONCEPT MAP

## your Revision Tool

### STATES OF MATTER

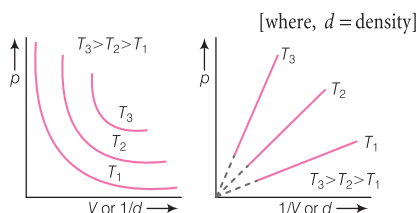
Anything that occupies space and has weight is called **matter**. In general, matter exists in three states, viz, solid, liquid and gas. Later, two more states, plasma and Bose-Einstein was considered.

#### 1 GAS LAWS

Gases show dependency on temperature, pressure and volume. The relationship of these three factors can be analysed through gas laws.

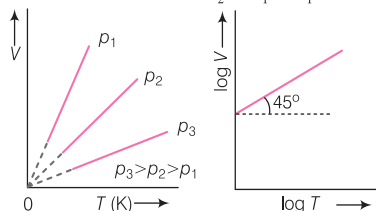
##### A BOYLE'S LAW

- At constant temperature ( $T$ ), the volume ( $V$ ) of the given amount of a gas is inversely proportional to pressure ( $p$ ).
- $V \propto \frac{1}{p}$  ( $T$  and  $n$  constant) or,  $p_1 V_1 = p_2 V_2$
- $d \propto p \propto \frac{1}{V}$  [ $T$  constant] or  $\frac{d_1}{d_2} = \frac{p_1}{p_2} = \frac{V_2}{V_1}$



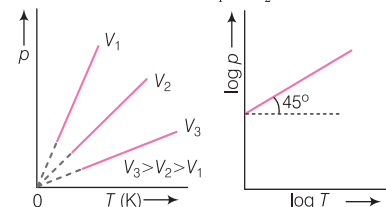
##### B CHARLES'S LAW

- At constant pressure ( $p$ ), the volume ( $V$ ) of a given amount of a gas is directly proportional to absolute temperature ( $T$ ).
- $V \propto T$  ( $p$  and  $n$  constant) or,  $\frac{V_1}{T_1} = \frac{V_2}{T_2}$
- $d \propto \frac{1}{T} \propto \frac{1}{V}$  ( $p$  constant) or,  $\frac{d_1}{d_2} = \frac{T_2}{T_1} = \frac{V_2}{V_1}$



##### C GAY-LUSSAC'S LAW

- At constant volume ( $V$ ), the pressure ( $p$ ) of a given amount of a gas is directly proportional to absolute temperature ( $T$ ).
- $p \propto T$  ( $V$  and  $n$  constant), or  $\frac{p_1}{T_1} = \frac{p_2}{T_2}$



##### D AVOGADRO'S LAW

- At constant temperature ( $T$ ) and pressure ( $p$ ), equal volumes ( $V$ ) of all the gases contain equal number of molecules.
- $V \propto n$  ( $T$  and  $p$  constant) or  $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

#### 2 IDEAL GAS EQUATIONS

- From Boyle's, Charles' and Avogadro's law,  $\frac{pV}{T} = \text{constant}$
- For 1 mole,  $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$  [Gas equation]
- For ' $n$ ' moles of gas,  $pV = nRT = \frac{m}{M} RT$
- This is called **ideal gas equation** and  $R$  is called universal gas constant.
- $\frac{p_1 V_1}{n_1 T_1} = \frac{p_2 V_2}{n_2 T_2}$  (combined gas equation)

**Note Units of  $R$ :**  $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$   
 $= 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1} = 1.99 \text{ cal mol}^{-1} \text{ K}^{-1}$   
 $= 5.189 \times 10^{19} \text{ eV mol}^{-1} \text{ K}^{-1}$

#### 3 DALTON'S LAW OF PARTIAL PRESSURE

- When two or more chemically non-reacting gases are enclosed in a vessel, the pressure exerted due to gaseous mixture is the sum of partial pressure ( $p_1, p_2, p_3, \dots, p_n$ ) due to each gas.
- $p_T = p_1 + p_2 + p_3 \dots \dots \dots + p_n = \frac{RT}{V}$

$$\text{where, } p_1 = \frac{n_1}{n_1 + n_2} p_{\text{total}} = X_1 p_{\text{total}}, p_2 = X_2 p_{\text{total}}$$

where  $X_1$  and  $X_2$  are mole fraction of gases 1 and 2, respectively.

#### 4 GRAHAM'S LAW OF DIFFUSION (OR EFFUSION)

- If a gas is allowed to escape from its container through a small hole into vacuum, the process is called **effusion**. On the other hand, **diffusion** is the passage of gas through a porous partition.
- The rate of effusion (or diffusion) of non-reacting gases under similar conditions of temperature and pressure are inversely proportional to the square root of their densities or molar masses

$$r \propto \frac{1}{\sqrt{d}} \propto \frac{1}{\sqrt{M}}$$

- If two gases are diffused (or effused) under different pressures  $p_1$  and  $p_2$ , then

$$\frac{r_1}{r_2} = \frac{V_1 t_2}{V_2 t_1} = \frac{p_1}{p_2} \sqrt{\frac{d_2}{d_1}} = \frac{p_1}{p_2} \sqrt{\frac{M_2}{M_1}}$$

- This law is helpful in determining molecular weight and vapour density of different gases.

#### 10 LIQUID STATE

Intermolecular force in liquids is intermediate of gases and solids, which is stronger than gases and weaker than solids.

- They are held together by van der Waals' forces like dipole-dipole attraction, London forces, hydrogen bonding, etc.
- They have definite volume, but not shape as the intermolecular forces are not enough to fix the molecules at a definite position in crystal lattice.
- The densities of liquids are intermediate of gases and solids and decrease with increase in temperature.

#### OTHER PHYSICAL PROPERTIES

- Evaporation** When kinetic energy of a liquid molecule exceeds intermolecular forces of attraction, it escapes as vapour and the process is called evaporation.

- Vapour Pressure** During evaporation or boiling, the pressure exerted by vapours in equilibrium with liquid at a particular temperature is called vapour pressure.

- Clausius-Clapeyron equation,

$$\log \left( \frac{p_2}{p_1} \right) = \frac{\Delta H_{\text{vap}}}{2.303 R} \left[ \frac{1}{T_1} - \frac{1}{T_2} \right], T_1 > T_2$$

where,  $\Delta H_{\text{vap}}$  is molar enthalpy of vapourisation.

#### 5 KINETIC THEORY OF GASES

This theory was developed to explain ideal gas behaviour in terms of movement of molecules.

The theory is based on the following assumptions:

- A gas consists of extremely small discrete particles called molecules, dispersed throughout the container.
- The molecules are so small that its volume is neglected in comparison to the total volume of the gas.
- The intermolecular forces are negligible. Hence, the gas molecules move freely independent of each other.
- The gas molecules move in straight line randomly with high speed. They continuously change direction on collision with each other or with the walls of container.
- The collisions are perfectly elastic resulting no loss of kinetic energy during collision.
- The effect of gravity on motion of molecules is negligible in comparison to the effect of collision.
- The pressure exerted by a gas is due to collision of gas molecules to the walls of container. Higher the number of collisions per unit time per unit area, higher is the pressure.
- At a particular instant different molecules have different speeds, however the average kinetic energy of all molecules is assumed to be directly proportional to absolute temperature.

$$E_{\text{KE}} \propto T \text{ (T is in kelvin)}$$

**Note** This theory explains macroscopic properties of gases like pressure, temperature, thermal conductivity, viscosity, etc., and microscopic properties like kinetic energy.

## A SURFACE TENSION AND SURFACE ENERGY

- The force acting along the surface of a liquid at right angle to any line per unit length is called surface tension.
- Surface tension =  $\frac{\text{Work}}{\text{Change in area}} = \frac{\text{Force}}{\text{Length}}$ ; Unit =  $\text{Nm}^{-1}$
- The energy required to increase surface area by one unit is called surface energy.
- Due to surface tension, liquids tend to rise or fall in capillary tube, and is given by  $h = \frac{2T \cos \theta}{r\rho g}$

where,  $T$  = surface tension,  $\rho$  = density of liquid  
 $r$  = radius of capillary,  $\theta$  = angle of contact.

## B VISCOSITY AND FLUIDITY

Viscosity is the measure of the resistance offered to the flow of liquid due to internal friction between two liquid layers.

- The viscous force between two liquid layers of area of cross-section  $A$ , separated by a distance  $dx$  having velocity difference  $dv$  is  $F = \eta A \frac{dv}{dx}$

where,  $\eta$  is coefficient of viscosity, and is constant for a liquid at a given temperature.

Unit of  $\eta$ :  $\text{Nsm}^{-2}$  or  $\text{Pa}\cdot\text{s}$  (SI unit), poise or  $\text{g cm}^{-1}\text{s}^{-1}$  (CGS Unit)

The reciprocal of viscosity is called fluidity.

## 6 MOLECULAR VELOCITIES

Three different types of velocities are defined for gas molecules and are given as:

### a Average Velocity ( $\bar{v}$ )

$$\bar{v} = \frac{v_1 + v_2 + \dots + v_N}{N} = \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8pV}{\pi M}} = \sqrt{\frac{8p}{\pi d}}$$

where,  $d$  = density of gas,  $M$  = molar mass of gas

### b Root Mean Square Velocity ( $v_{\text{rms}}$ )

$$v_{\text{rms}} = \sqrt{\frac{v_1^2 + v_2^2 + \dots + v_N^2}{N}} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3pV}{M}} = \sqrt{\frac{3p}{d}}$$

### c Most Probable Velocity ( $v_p$ )

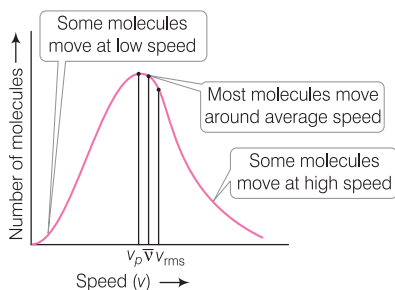
$$v_p = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2pV}{M}} = \sqrt{\frac{2p}{\rho}}$$

Relation between  $\bar{v}$ ,  $v_{\text{rms}}$  and  $v_p$ .

$$v_p : \bar{v} : v_{\text{rms}} = \sqrt{2} : \frac{\sqrt{8}}{\pi} : \sqrt{3} \quad (v_p < \bar{v} < v_{\text{rms}})$$

$$= 1 : 1.128 : 1.224$$

## Maxwell-Boltzmann distribution of Molecular Speed



## 7 IDEAL AND REAL GASES

- The gases which obey gas laws are called **ideal gases** while others are **real gases**.
- Real gases show ideal behaviour, i.e. obey gas equation under moderate conditions of temperature and pressure.
- At high pressure and low temperature, real gases show major deviation from ideal gas behaviour

### A CAUSES OF DEVIATION FROM IDEAL BEHAVIOUR

It is mainly due to the following assumptions of kinetic theory of gases which do not hold good under all conditions.

- Intermolecular forces of attraction between two gas molecules is negligible.
- Volume occupied by gas molecule is negligible in comparison to the total volume of gas.

### B EXPLANATION OF DEVIATION FROM IDEAL BEHAVIOUR

- The deviation from ideal behaviour can be explained on the basis of **compressibility factor ( $Z$ )**.

It is defined as the ratio of measured molar volume ( $V_m$ ) of a gas to the molar volume of an ideal gas ( $V_m^\circ = \frac{RT}{p}$ )

at same temperature and pressure, i.e.

$$Z = \frac{V_m}{V_m^\circ} = \frac{V_m}{RT/p} = \frac{pV_m}{RT}$$

The following three values of  $Z$  are possible:

- When  $V_m = V_m^\circ$ ,  $Z = 1$  and the gas behave as ideal (perfect) gas. At very low pressure and high temperature, real gases behave as an ideal gas.
- When  $V_m > V_m^\circ$ ,  $Z > 1$ , i.e. the gas is less compressible than expected from ideal behaviour and shows positive deviation. This happens at high pressure,  $pV_m > RT$
- When  $V_m < V_m^\circ$ ,  $Z < 1$ , i.e. the gas is more compressible than expected from ideal behaviour and shows negative deviation. This usually happens at intermediate pressure,  $pV_m < RT$ .

Note  $Z = \frac{pV_m}{RT} = \frac{p}{d \left(\frac{R}{M}\right) T}$

where,  $M$  = molar mass of gas

## 8 VAN DER WAALS' EQUATION

- In order to rectify the errors caused by ignoring the intermolecular forces of attraction and volume of gas molecules, a correction in pressure and volume terms in ideal gas equation was necessary.
- Johannes van der Waals' proposed the following modified equation which is valid for real gases upto a large range of temperature and pressure.

$$\left(p_m + \frac{an^2}{V^2}\right) (V_m - nb) = nRT$$

Labels in diagram:  
 - Ideal pressure ( $p$ )  
 - Measured pressure ( $p_m$ )  
 - Pressure correction factor to consider intermolecular forces ( $\frac{an^2}{V^2}$ )  
 - Ideal volume ( $V$ )  
 - Measured volume ( $V_m$ )  
 - Volume correction factor to consider molecular volume ( $nb$ )

### A SIGNIFICANCE OF VAN DER WAALS' CONSTANTS

- $a$  and  $b$  are van der Waals' constants, where  $a$  is an indirect measure of magnitude of attractive forces between molecules. Higher the value of  $a$ , higher is the ease of liquefaction of the gas. Hence, higher the value of  $a$ , higher is the strength of van der Waals' force.

Unit of  $a$ :  $\text{atm L}^2 \text{mol}^{-2}$  or  $\text{Nm}^4 \text{mol}^{-2}$  or  $\text{Jm}^3 \text{mol}^{-2}$

- $b$  is a measure of the portion of the gas which is not compressible. Unit of  $b$ :  $\text{L mol}^{-1}$  or  $\text{m}^3 \text{mol}^{-1}$
- van der Waals' constant  $a$  and  $b$  are related as  $T_b = \frac{a}{bR}$ , where  $T_b$  = Boyle's temperature

### B VAN DER WAALS' EQUATIONS AT DIFFERENT CONDITIONS

#### a At Low Pressure

$V \gg b$ , hence van der Waals' equation (for 1 mole of gas) becomes,  $\left(p + \frac{a}{V^2}\right)V = RT$  or  $\frac{pV}{RT} = \left(1 - \frac{a}{VRT}\right) = Z$

#### b At Extreme Low Pressure

$V \gg a, b$ , hence both the terms  $a/V^2$  and  $b$  can be neglected. Hence, van der Waals' equations becomes  $pV = RT$  (For 1 mole of gas), i.e. real gas behaves as an ideal gas.

#### c At High Pressure

$p \gg \frac{a}{V^2}$ , hence  $\frac{a}{V^2}$  can be neglected, and van der Waals' equation becomes,  $p(V - b) = RT$  (For  $n = 1$  mole) or  $\frac{pV}{RT} = Z = 1 + \frac{pb}{RT}$

#### d At Low Temperature

Both  $p$  and  $V$  are small and hence both pressure and volume corrections, are appreciable. Hence, there is no change in the van der Waals' equation.

### C LIMITATIONS OF VAN DER WAALS' EQUATION

- Although it is able to explain behaviour of real gases over a wide range of pressure and temperature, yet it shows considerable deviation at extreme low temperature and pressure.
- Values of  $a$  and  $b$  do not remain constant over the entire range of temperature and pressure.

## 9 LIQUEFACTION OF GASES

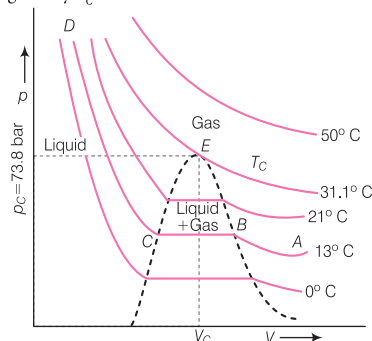
- A gas can be liquefied by decreasing temperature and increasing pressure.
- The following critical states are defined for liquefaction of gases:

- Critical Temperature ( $T_c$ )** It is the minimum temperature above which the gas cannot be liquefied, even a large pressure is applied and is given by

$$T_c = \frac{8a}{27Rb}$$

- Critical Pressure ( $p_c$ )** It is the minimum pressure required to liquefy a gas at its critical temperature and is given by  $p_c = a/27b^2$

- Critical Volume ( $V_c$ )** It is the volume occupied by a mole of gas at critical temperature and pressure and is given by  $V_c = 3b$



Isotherm of  $\text{CO}_2$  showing critical temperature

Note Critical compressibility factor ( $Z_c$ ) is given by,

$$Z_c = \frac{p_c V_c}{RT_c} = \frac{3}{8} = 0.375$$

## @ CLASS XII SYLLABUS

# Rapid

## CONCEPT REVISION

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## ►► p-BLOCK ELEMENTS

### Group 15 Elements (Nitrogen Family)

- This family contains nitrogen (N-7), phosphorus (P-15), arsenic (As-33), antimony (Sb-51), bismuth (Bi-83) with general valence electronic configuration of  $ns^2np^3$ .
- These elements are collectively called **pnictogens** (derived from Greek word 'pniomigs' meaning suffocating) and their compounds are called **pniconides**.

### General and Physical Properties

- Electronegativity, ionisation energy and electron affinity decreases while atomic radius and metallic character increases down the group.
- Melting point increases upto As and then decreases down the group.
- Boiling point increases upto Sb and then decreases from Sb to Bi.
- N and P are non-metals, As and Sb are metalloids whereas Bi is a metal.
- All elements show the property of catenation with P-atom having maximum tendency to catenate.
- All elements of group-15 show allotropy except bismuth.
- The common oxidation states of these elements are  $-3$ ,  $+3$  and  $+5$ .
- The stability of  $-3$  and  $+5$  oxidation states decreases while that of  $+3$  oxidation state increases down the group due to inert pair effect.
- Nitrogen does not show  $+5$  oxidation state due to absence of vacant  $d$ -orbitals and Bi does not show  $-3$  oxidation state due to metallic character.
- Nitrogen exists in two solid forms namely  $\alpha$ -nitrogen with cubic crystalline structure and  $\beta$ -nitrogen with hexagonal crystalline structure. The transition temperature is  $-238.5^\circ\text{C}$ .
- Similarly, other elements of group 15 (except Bi) exists in number of allotropic forms.

### REMEMBER

- Liquid nitrogen is a fluid resembling water in appearance but with a density of  $0.808\text{ g L}^{-1}$ .
- Liquid nitrogen is a common cryogen and used as refrigerant in cryopreservation, cryotherapy, etc.

### Chemical Properties

#### (i) Reaction with Hydrogen

- All elements of this group form hydrides of  $M\text{H}_3$  type.
- The order of bond angle, bond dissociation energy, basic character and stability is



- The order of acidic character,  $M\text{—H}$  bond length, reducing character and enthalpy of formation is



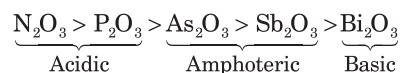
- The order of boiling point is



The high boiling point of  $\text{BiH}_3$  and  $\text{SbH}_3$  are due to higher van der Waals' forces of attraction which compensates the high boiling point of  $\text{NH}_3$  due to H-bonding.

#### (ii) Reaction with Oxygen

- They form oxides of types,  $M_2\text{O}_3$  and  $M_2\text{O}_5$ .
- Nitrogen shows all oxidation states from  $+1$  to  $+5$  in its oxides.
- Acidic character of oxides decreases down the group.



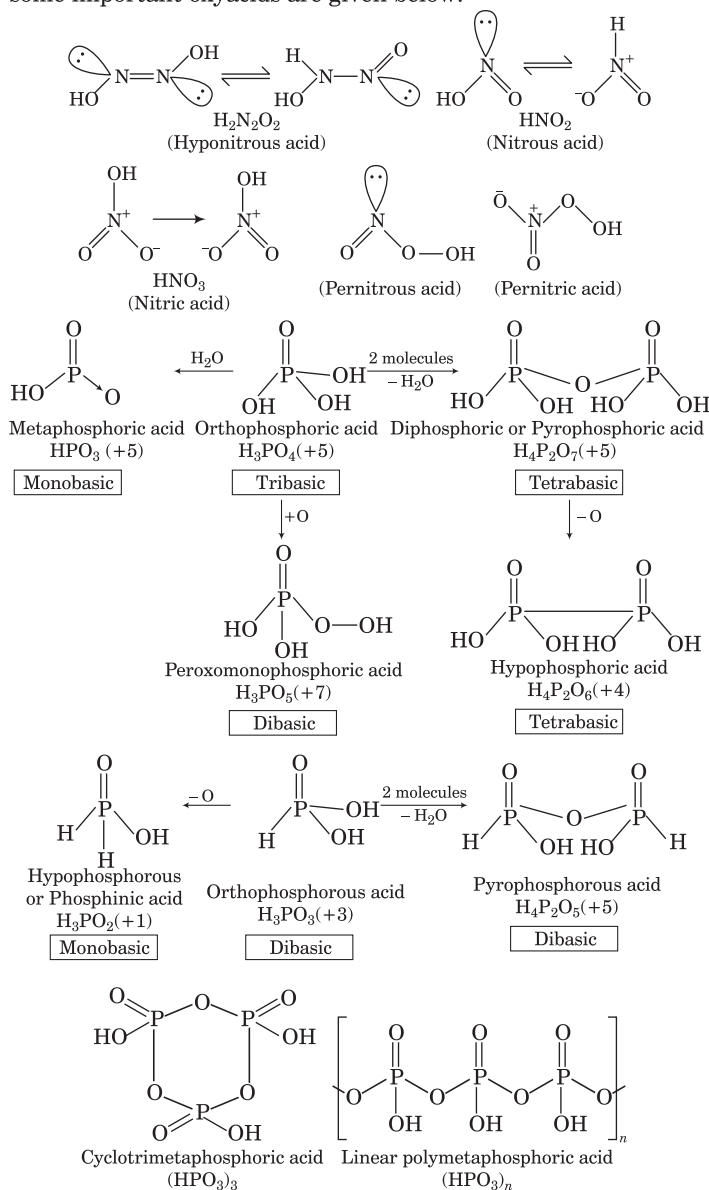
- Oxides with higher oxidation state are more acidic than the oxides with lower oxidation state for same element.

### (iii) Reaction with Halogens

- They form halides of types,  $MX_3$  and  $MX_5$ .
- $MX_5$  is more covalent than the corresponding  $MX_3$ .
- Nitrogen does not form pentahalide due to non-availability of the  $d$ -orbitals in the valence shell.
- $NX_3 > PX_3 > AsX_3 > SbX_3 > BiX_3$  (order of covalent character)
- $NI_3 > NBr_3 > NCl_3 > NF_3$  (order of basic character)  
(since, electronegativity decreases from F to I)

### (iv) Formation of Oxyacids

All elements of this group except Bi forms oxyacids. Structure of some important oxyacids are given below:



**Note** Order of strength and solubility of oxyacids is  
 $HNO_3 > H_3PO_4 > H_3AsO_4 > H_3SbO_4$

## Anomalous Behaviour of Nitrogen

Nitrogen because of its small size, high electronegativity, high ionisation energy and non-availability of  $d$ -orbital shows the following anomalous behaviour:

- It forms  $p\pi-p\pi$  multiple bonds, whereas the heavier elements of this group do not form  $p\pi-p\pi$  multiple bonds due to larger size of atomic orbitals.
- Nitrogen exists as diatomic molecule forming triple bond, whereas other exists as tetra-atomic molecule and forms single bond.
- Nitrogen forms tri-negative ion, i.e.  $N^{3-}$  while other members do not form.
- Nitrogen does not show pentavalency due to non-availability of  $d$ -orbitals while it is shown by other elements.
- Nitrogen forms five oxides (i.e.  $N_2O$ ,  $NO$ ,  $N_2O_3$ ,  $N_2O_4$  and  $N_2O_5$ ) while other members of the family form only two oxides (i.e. tri and pentaoxides).
- Nitrogen doesn't form  $p\pi-d\pi$  bond (due to the absence of  $d$ -orbitals) whereas heavier metals form this type of bond and also have a tendency to form complexes, e.g.  $[PCl_6]^-$ ,  $[AsCl_6]^-$  etc.

## Preparation and Properties of Pnictogens

### Dinitrogen

- It is prepared from the following reactions,  
 $(NH_4)_2Cr_2O_7 \xrightarrow{\text{Heat}} N_2 + 4H_2O + Cr_2O_3$   
 $Ba(N_3)_2 \xrightarrow{\text{Heat}} Ba + 3N_2$  (Pure form)
- It is inert at room temperature, but reactivity increases with increase in temperature.

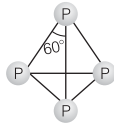
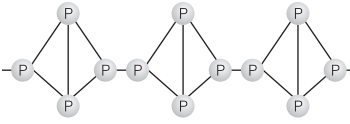
### Phosphorus

- It can be prepared by heating bone ash or phosphorite with sand ( $SiO_2$ ) and coke (C) in an electric furnace.  
 $2Ca_3(PO_4)_2 + 6SiO_2 + 10C \longrightarrow 6CaSiO_3 + 10CO + P_4$
- It occurs as phosphates in rock, soil, phospho-proteins, etc.

### Some Important Ores of Phosphorus

- Phosphorite  $Ca_3(PO_4)_2$ , apatite  $3Ca_3(PO_4)_2 \cdot CaF_2$ , chlorapatite  $3Ca_3(PO_4)_2 \cdot CaCl_2$ .
- It exists in many allotropic forms, out of which white, red and black phosphorus are important.

## RAPID CONCEPT REVISION

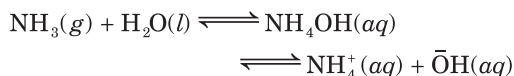
White phosphorus	Red phosphorus
It is a white waxy solid.	It is a violet red powder.
It is poisonous.	It is non-poisonous.
It is insoluble in water but soluble in CS <sub>2</sub> .	It is insoluble both in water as well as in CS <sub>2</sub> .
It glows in dark.	It doesn't glow in dark.
It is more reactive and readily catches fire in air.	It is less reactive than white phosphorus.
Its structure is 	Its structure is 

- Black phosphorus exists as  $\alpha$  and  $\beta$ -black phosphorus. When red phosphorus, is heated at 803 K it converts to  $\alpha$ -black phosphorus. White phosphorus, when heated at 473 K under high pressure of 4000-12000 atm converts to  $\beta$ -black phosphorus.

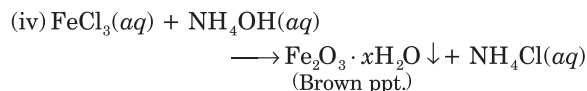
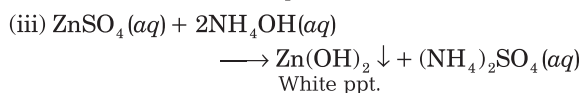
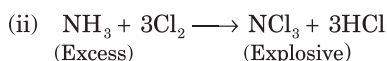
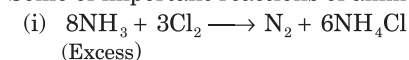
## Compounds of Nitrogen Family

### Ammonia (NH<sub>3</sub>)

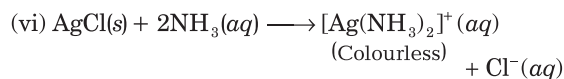
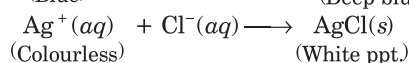
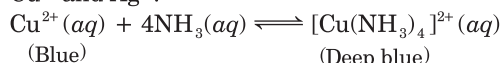
- Industrially, NH<sub>3</sub> is prepared by Haber's process from N<sub>2</sub> and H<sub>2</sub>.
- It is highly soluble in water due to H-bonding and the solution is basic due to formation of OH<sup>-</sup> ions.



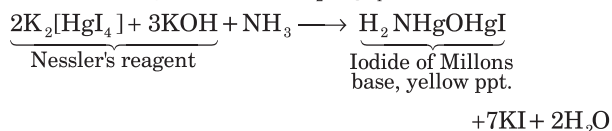
- Some of important reactions of ammonia are



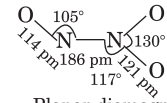
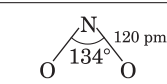
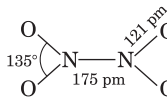
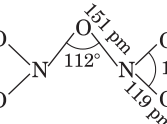
- (v) It is used in the detection of metal ions such as Cu<sup>2+</sup> and Ag<sup>+</sup>.



- (vii) NH<sub>3</sub> gives yellow-brown coloured precipitate with Nessler's reagent (i.e. alk. K<sub>2</sub>[HgI<sub>4</sub>]).



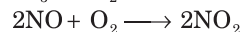
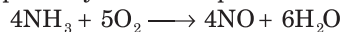
## Oxides of Nitrogen

Name of oxide	Method of preparation	Bond parameters
Dinitrogen oxide (Nitrous oxide) N <sub>2</sub> O (+1)	$\text{NH}_4\text{NO}_3 \xrightarrow{\Delta} \text{N}_2\text{O} + 2\text{H}_2\text{O}$	N—N—O 113 pm 119 pm Linear-diamagnetic
Nitrogen monoxide, (Nitric oxide) NO (+2)	$3\text{Cu} + 8\text{HNO}_3 \longrightarrow 3\text{Cu}(\text{NO}_3)_2 + 2\text{NO} + 4\text{H}_2\text{O}$	N—O 115 pm Linear-paramagnetic
Dinitrogen trioxide, N <sub>2</sub> O <sub>3</sub> (+3)	$\text{NO} + \text{NO}_2 \xrightarrow{250\text{ K}} \text{N}_2\text{O}_3$	 Planar-diamagnetic
Nitrogen dioxide, NO <sub>2</sub> (+4)	$2\text{Pb}(\text{NO}_3)_2 \xrightarrow{673\text{ K}} 4\text{NO}_2 + 2\text{PbO} + \text{O}_2$	 Angular-paramagnetic
Dinitrogen tetraoxide, N <sub>2</sub> O <sub>4</sub> (+4)	$2\text{NO}_2 \rightleftharpoons \text{N}_2\text{O}_4$ Brown Colourless	 Planar-diamagnetic
Dinitrogen pentaoxide, N <sub>2</sub> O <sub>5</sub> (+5)	$4\text{HNO}_3 + \text{P}_4\text{O}_{10} \longrightarrow 4\text{HPO}_3 + 2\text{N}_2\text{O}_5$	 Planar-diamagnetic

**Note** NO<sub>2</sub> being an odd electron species exists as a dimer, N<sub>2</sub>O<sub>4</sub>.

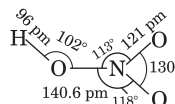
### Nitric Acid (HNO<sub>3</sub>)

- It can be prepared by Ostwald's process



- It is a strong acid and exists as planar molecule in gaseous phase.

- Its structure is as follows



- It is a strong oxidising agent.

Some important reactions of  $\text{HNO}_3$  are

### I. With Iron (Fe)

- (i)  $4\text{Fe} + 10\text{HNO}_3 \longrightarrow 4\text{Fe}(\text{NO}_3)_2 + \text{NH}_4\text{NO}_3 + 3\text{H}_2\text{O}$   
(Very dil.)
- (ii)  $4\text{Fe} + 10\text{HNO}_3 \longrightarrow 4\text{Fe}(\text{NO}_3)_2 + \text{N}_2\text{O} + 5\text{H}_2\text{O}$   
(Dil.)
- (iii)  $\text{Fe} + 6\text{HNO}_3 \longrightarrow \text{Fe}(\text{NO}_3)_3 + 3\text{NO}_2 + 3\text{H}_2\text{O}$   
(Cold and conc.)
- (iv)  $\text{Fe} + 4\text{HNO}_3 \longrightarrow \text{Fe}(\text{NO}_3)_3 + 2\text{H}_2\text{O} + \text{NO}$   
(Hot and conc.)

### II. With Zinc (Zn)

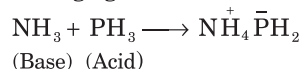
- (i)  $4\text{Zn} + 10\text{HNO}_3 \longrightarrow 4\text{Zn}(\text{NO}_3)_2 + \text{N}_2\text{O} + 5\text{H}_2\text{O}$   
(Cold and dil.)
- (ii)  $\text{Zn} + 4\text{HNO}_3 \longrightarrow \text{Zn}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$   
(Cold and conc.)

### III. With Copper (Cu)

- (i)  $10\text{HNO}_3 + 4\text{Cu} \longrightarrow \text{N}_2\text{O} + 5\text{H}_2\text{O} + 4\text{Cu}(\text{NO}_3)_2$   
(Cold and dil.)
- (ii)  $\text{Cu} + 4\text{HNO}_3 \longrightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{NO}_2 + 2\text{H}_2\text{O}$   
(Cold and conc.)
- (iii)  $12\text{HNO}_3 + 5\text{Cu} \longrightarrow \text{N}_2 + 6\text{H}_2\text{O} + 5\text{Cu}(\text{NO}_3)_2$   
(Hot and conc.)

## Phosphine ( $\text{PH}_3$ )

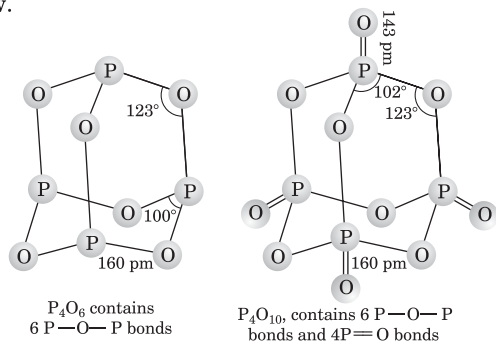
- It is prepared generally by the following method:  
 $\text{P}_4 + 3\text{NaOH} + 3\text{H}_2\text{O} \longrightarrow 3\text{NaH}_2\text{PO}_2 + \text{PH}_3$
- It is a colourless, poisonous and highly reactive gas with rotten fish like smell.
- It is a better reducing agent and more acidic than  $\text{NH}_3$ .



- A pure sample of phosphine is not spontaneously inflammable. However, when it comes in contact with air, it undergoes combustion and rings of white smoke are formed due to the presence of impurities like  $\text{P}_2\text{H}_4$  or  $\text{P}_4$  vapours. These rings are called **vortex rings** or philosopher's rings.

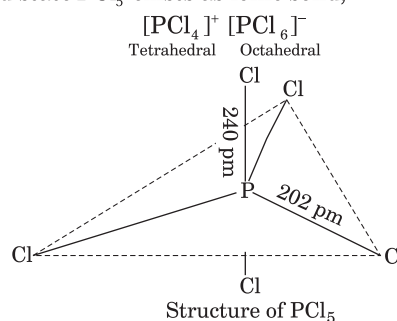
## Oxides of Phosphorus

Oxides of P are  $\text{P}_4\text{O}_6$  (a dimer of  $\text{P}_2\text{O}_3$ ) and  $\text{P}_4\text{O}_{10}$  (a dimer of  $\text{P}_2\text{O}_5$ ) which are obtained by treating white P with limited and free supply of air, respectively. Their structures are given below.



## Chlorides of Phosphorus ( $\text{PCl}_3, \text{PCl}_5$ )

- They are prepared by  
 $\text{P}_4 + 6\text{Cl}_2 \longrightarrow 4\text{PCl}_3$   
 $\text{PCl}_3 + \text{Cl}_2 \longrightarrow \text{PCl}_5$   
or  $\text{P}_4 + 10\text{SO}_2\text{Cl}_2 \longrightarrow 4\text{PCl}_5 + 10\text{SO}_2$
- $\text{PCl}_3$  and  $\text{PCl}_5$  are hydrolysed to form  $\text{H}_3\text{PO}_3$  and  $\text{H}_3\text{PO}_4$ , respectively.
- $\text{PCl}_3$  is pyramidal ( $sp^3$ ) in shape, whereas  $\text{PCl}_5$  has trigonal bipyramidal structures ( $sp^3d$ ) in gaseous and liquid phase.
- In solid state  $\text{PCl}_5$  exists as ionic solid,



## Group 16 Elements (Oxygen Family)

- This family contains oxygen (O-8), sulphur (S-16), selenium (Se-34), tellurium (Te-52) and polonium (Po-84) with general valence electronic configuration of  $ns^2np^4$ .
- The first four members are known as **chalcogens** (meaning ore forming)

## General and Physical Properties

- Oxygen is the most abundant (46.6%) element on Earth's crust.
- O and S are non-metals, Se and Te are metalloids whereas Po is a metal and radioactive.
- Oxygen is a gas while all other elements exist in solid state.
- Physical properties follow a regular trend down the group except electron gain enthalpy.
- The negative value of electron gain enthalpy increases from O to S and then decreases regularly down the group. This is due to small size of O, interelectronic repulsion is more in comparison to S. Hence, the incoming electron feels more repulsion in O than S-atom, releasing less energy in case of O-atom.
- All elements of this group have a tendency to catenate.
- They show common oxidation states of -2, +2, +4, and +6. The stability of -2 and +6 oxidation state decreases down the group, whereas the stability of +4 oxidation state increases down the group due to inert pair effect.

## RAPID CONCEPT REVISION

### REMEMBER

- All elements exhibit allotropy.
- Oxygen exists in two allotropic forms  $O_2$  and  $O_3$ .
- Sulphur exists as rhombic ( $\alpha$ -form), monoclinic ( $\beta$ -form), plastic ( $\gamma$ -form), colloidal ( $\delta$ -form),  $\lambda$ -sulphur and  $\mu$ -sulphur.

#### Rhombic sulphur

Contains cyclic  $S_8$  rings arranged in a manner to form rhombic crystal.

It is yellow in colour with melting point of 385.8K and specific gravity of 2.06.

It is stable at a temperature less than or equal to 369 K.

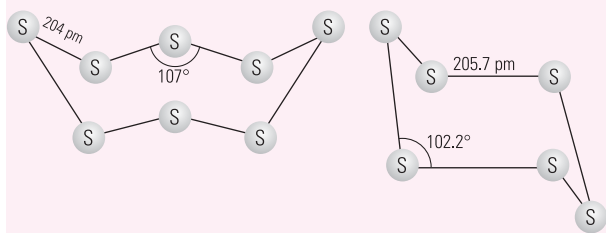
#### Monoclinic sulphur

Contains cyclic  $S_8$  rings arranged in a manner to form monoclinic crystal.

It is a colourless crystal with melting point of 393 K and specific gravity of 1.98.

It is stable at a temperature greater than or equal to 369 K.

The cyclic structure of  $S_8$  and  $S_6$  molecules are shown below.



## Chemical Properties

### Reaction with Hydrogen

- All elements of this group form hydrides of type,  $H_2M$ .
- The order of  $H-M-H$  bond angle,  $M-H$  bond dissociation energy, basic character and thermal stability is



- The order of acidic character and  $M-H$  bond distance is

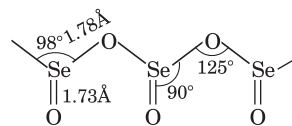


- The order of melting and boiling points (due to H-bonding in water) is

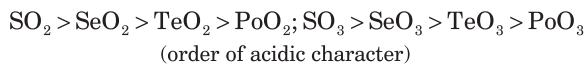


### Reaction with Oxygen

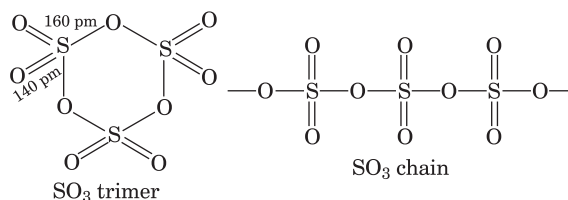
- They form oxides of types,  $MO_2$  and  $MO_3$  and in some cases it also forms,  $MO$ .
- $SO_2$  has angular structure.  $SeO_2$  in gaseous phase has angular structure but in solid state, it has polymeric structure comprising of infinite chains as shown below.



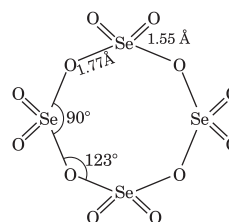
Polymeric structure of  $SeO_2$  in solid state



- In gaseous phase,  $SO_3$  has planar triangular geometry, where as in solid state it exist as either linear cyclic trimer or a polymeric chain structure as shown below:



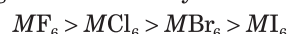
- $SeO_3$  in solid state exists as cyclic tetramer ( $Se_4O_{12}$ ) as shown below:



Cyclic structure of tetrameric,  $Se_4O_{12}$

### Oxohalides and Halides

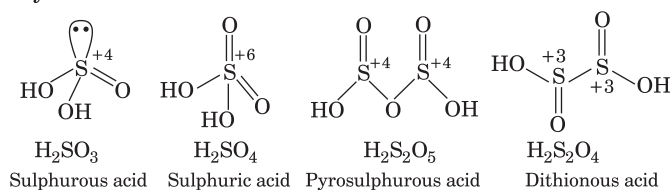
- They form oxohalides of type  $MOX_2$  with tetrahedral shape (one position occupied by a lone pair).
- They generally form halides of type  $MX_2$ ,  $MX_4$  and  $MX_6$  alongwith some other type of halides like  $M_2X_2$ ,  $M_2OX$  etc.
- The decreasing order of stability of halides is



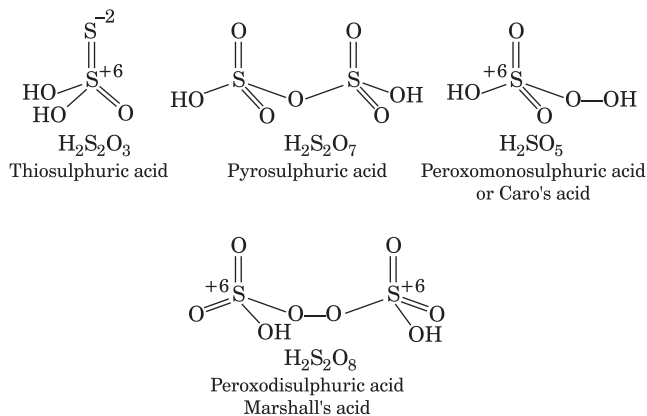
- All hexafluorides exist as gases with octahedral shape.  $SF_6$ ,  $SeF_6$  and  $TeF_6$  are gas, liquid and solid, respectively.
- They have *see-saw* geometry due to the presence of a lone pair.

### Oxyacids

These are generally formed by S, Se and Te. Structure of oxyacids of S are shown below.







## Anomalous Behaviour of Oxygen

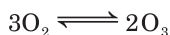
Oxygen shows anomalous behaviour due to its small size, high electronegativity and absence of  $d$ -orbital.

- It is diatomic gas while all other members are solid with eight membered puckered ring structure.
- It usually exhibits  $-2$  oxidation state. However, it also exhibits  $+2$  and  $-1$  oxidation states. Other members usually does not show these oxidation states.
- It forms  $p\pi-p\pi$  multiple bond while S form  $d\pi-p\pi$  bonds.
- It is paramagnetic while rest are not.

## Compounds of Oxygen Family

### Ozone ( $\text{O}_3$ )

- It is an allotrope of oxygen and diamagnetic in nature.
- It is formed when energy is supplied to  $\text{O}_2$  in the form of UV radiations or silent electric discharge, in an apparatus called ozoniser,



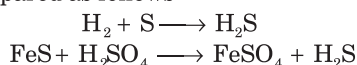
- It is highly reactive, exist in stratosphere and protects the earth from harmful UV-radiation.
- It is a powerful oxidising agent (second after  $\text{F}_2$ ) due to the formation of nascent oxygen and reacts much faster than oxygen.

### REMEMBER

$\text{O}_2$  and  $\text{O}_3^-$  are paramagnetic, whereas  $\text{O}_3$  is diamagnetic. Example of compound containing  $\text{O}_3^-$  ions is  $\text{KO}_3$  (potassium ozonide) which is an orange colour solid.

### Hydrogen Sulphide ( $\text{H}_2\text{S}$ )

- It is prepared as follows



- It is a colourless poisonous gas with rotten egg smell.

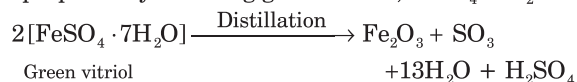
- It only acts as a reducing agent due to minimum oxidation state ( $-2$ ) of S.
- Some of the important chemical reactions are
  - $2\text{MnO}_4^- + 6\text{H}^+ + 5\text{H}_2\text{S} \longrightarrow 2\text{Mn}^{2+} + 8\text{H}_2\text{O} + 5\text{S} \downarrow$   
(Green) (Colourless)
  - $\text{Cr}_2\text{O}_7^{2-} + 8\text{H}^+ + 3\text{H}_2\text{S} \longrightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 3\text{S} \downarrow$   
(Orange) (Green)
  - $\text{H}_2\text{SO}_4 + \text{H}_2\text{S} \longrightarrow \text{SO}_2 + 2\text{H}_2\text{O} + \text{S} \downarrow$
  - $2\text{HNO}_3 + 3\text{H}_2\text{S} \longrightarrow 2\text{NO} + 4\text{H}_2\text{O} + 3\text{S} \downarrow$

## Sulphur Dioxide ( $\text{SO}_2$ ) and Sulphur Trioxide ( $\text{SO}_3$ )

- These are anhydrides of  $\text{H}_2\text{SO}_3$  and  $\text{H}_2\text{SO}_4$ , respectively.  $\text{SO}_3$  exists as  $\alpha$ - $\text{SO}_3$ ,  $\beta$ - $\text{SO}_3$  and  $\gamma$ - $\text{SO}_3$ .
- $\text{SO}_2$  acts as both oxidising and reducing agent, whereas  $\text{SO}_3$  only acts as an oxidising agent. Some of the important chemical reactions are shown below:
  - $2\text{MnO}_4^- + 5\text{SO}_2 + 2\text{H}_2\text{O} \longrightarrow 5\text{SO}_4^{2-} + 2\text{Mn}^{2+} + 4\text{H}^+$   
(Green) (Colourless)
  - $\text{Cr}_2\text{O}_7^{2-} + 3\text{SO}_2 + 2\text{H}^+ \longrightarrow 3\text{SO}_4^{2-} + 2\text{Cr}^{3+} + \text{H}_2\text{O}$   
(Orange) (Green)
  - $\text{H}_2\text{SO}_4 + \text{SO}_3 \longrightarrow \text{H}_2\text{S}_2\text{O}_7$   
(Sulphuric acid) (Oleum)
  - $\text{SO}_3 + \text{PCl}_5 \longrightarrow \text{POCl}_3 + \text{SO}_2 + \text{Cl}_2$   
(Phosphoryl chloride)

## Sulphuric Acid ( $\text{H}_2\text{SO}_4$ )

- In ancient days, it was called **oil of vitriol** because it was prepared by distilling green vitriol,  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ .



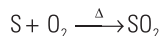
- It is a colourless, dense and viscous liquid with a melting and boiling points of 283 K and 611 K, respectively.
- It is highly soluble in water due to hydrogen bonding.
- It is a dibasic acid with different dissociation constants ( $K_{a1} > K_{a2}$ ).
- It is a strong oxidising agent due to the formation of nascent oxygen and reduced to  $\text{SO}_2$  in most of the reactions. However, it could not oxidise  $\text{F}^-$  and  $\text{Cl}^-$ .
- Some of the important reactions are:
  - $\text{H}_2\text{SO}_4 + 2\text{HI} \longrightarrow \text{SO}_2 + 2\text{H}_2\text{O} + \text{I}_2$
  - $\text{H}_2\text{SO}_4 + 6\text{HI} \longrightarrow \text{S} + 4\text{H}_2\text{O} + 3\text{I}_2$
  - $\text{H}_2\text{SO}_4 + 8\text{HI} \longrightarrow \text{H}_2\text{S} + 4\text{H}_2\text{O} + 4\text{I}_2$
  - $3\text{KClO}_3 + 3\text{H}_2\text{SO}_4 \longrightarrow 3\text{KHSO}_4 + \text{HClO}_4 + 2\text{ClO}_2 + \text{H}_2\text{O}$
  - $\text{H}_2\text{SO}_4 + \text{P}_2\text{O}_5 \longrightarrow \text{SO}_3 + 2\text{HPO}_3$
- $\text{H}_2\text{SO}_4$  acts as a strong dehydrating agent.
- It is one of the most important industrial chemical and prepared by Contact process.

## RAPID CONCEPT REVISION

### Contact Process

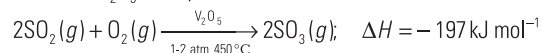
This is the commercial method for preparation of  $\text{H}_2\text{SO}_4$ . The complete procedure involves five different stages as follows.

**Stage I** Combining of sulphur with oxygen to produce  $\text{SO}_2$ .

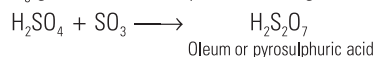


**Stage II** Purification of  $\text{SO}_2$  into the purification unit.

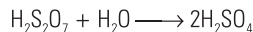
**Stage III** Preparation of  $\text{SO}_3$  by adding excess of oxygen gas to  $\text{SO}_2$  in presence of  $\text{V}_2\text{O}_5$  catalyst.



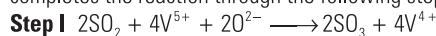
**Stage IV**  $\text{SO}_3$  gas is added to sulphuric acid to give oleum ( $\text{H}_2\text{S}_2\text{O}_7$ ).



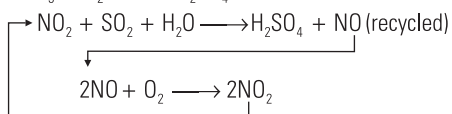
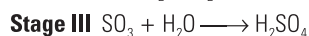
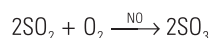
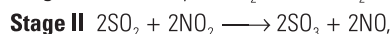
**Stage V** The oleum so formed is then added to water to form  $\text{H}_2\text{SO}_4$ .



As the production of  $\text{SO}_3$  is an exothermic process, low temperature favours the production of  $\text{SO}_3$ . However, lowering the temperature to a greater extent decreases the production of  $\text{SO}_3$ . Hence, a temperature of  $450^\circ\text{C}$  and a pressure of 1-2 atm is maintained for better production.  $\text{V}_2\text{O}_5$  acts as a catalyst and completes the reaction through the following steps:



**Lead chamber process** (which is no longer in use) involves three stages:



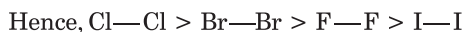
## Group 17 Elements (Halogen Family)

- This family contains fluorine (F-9), chlorine (Cl-17), bromine (Br-35), iodine (I-53) and astatine (At-85) with general valence electronic configuration of  $ns^2np^5$ .
- These elements are also called **halogens**.

## General and Physical Properties

- Physical properties follow a regular trend down the group except electron gain enthalpy and  $X-X$  bond dissociation enthalpy.
- The negative value of electron gain enthalpy increases from F to Cl and decreases regularly from Cl to I. This is due to small size of F, interelectronic repulsion is more in comparison to Cl. Hence, the incoming electron feels more repulsion in F-atom, releasing less energy.

- The  $X-X$  bond dissociation enthalpy increases from  $\text{F}_2$  to  $\text{Cl}_2$  and then show the expected decrease from  $\text{Cl}_2$  to  $\text{I}_2$ .



This is due to highest lone pair-lone pair repulsion in  $\text{F}_2$  molecule.

- Fluorine exhibit  $-1$  oxidation state only, whereas others exhibit  $-1, +1, +3, +5$  and  $+7$ . This is due to the absence of vacant  $d$ -orbital in fluorine.
- They are highly reactive and the reactivity decreases down the group.
- They are strong oxidising agents due to easy acceptance of an electron.
- Fluorine is the strongest oxidising agent and tendency to accept electron decreases down the group.
- Fluorine and chlorine are gases, bromine is a liquid and iodine exists as solid. They are coloured due to the absorption of radiation in visible region.



**Note** Despite of smaller electron gain enthalpy value of  $\text{F}_2$ , it acts as a stronger oxidising agent than  $\text{Cl}_2$  due to low  $\text{F-F}$  bond enthalpy and high hydration enthalpy of  $\text{F}^-$  ion in comparison to chlorine.

## Chemical Properties

### Reaction with Hydrogen

- They all form hydrogen halides of type  $\text{HX}$ , however the affinity for hydrogen decreases from  $\text{F}_2$  to  $\text{I}_2$ .
- The decreasing order of  $\text{H-X}$  bond enthalpy and stability is  $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$
- The decreasing order of acidic strength,  $\text{H-X}$  bond length is  $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$
- The increasing order of melting and boiling points is  $\text{HCl} < \text{HBr} < \text{HF} < \text{HI}$

However, boiling and melting points of  $\text{HF}$  are abnormally high due to H-bonding.

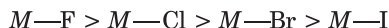
### Reaction with Oxygen

- Halogens form binary compounds with oxygen but most of them are unstable.
- Fluorine forms only  $\text{OF}_2$  and  $\text{O}_2\text{F}_2$ , out of which  $\text{OF}_2$  is more stable.
- Other forms oxides in which the oxidation state of halogen varies from  $+1$  to  $+7$ .
- Order of stability of oxides formed by halogens is  $\text{I} > \text{Cl} > \text{Br}$ , e.g.  $\text{I}_2\text{O}_7 > \text{Cl}_2\text{O}_7 > \text{Br}_2\text{O}_7$ .
- The acidic strength of oxides increases with increase in the percentage of oxygen.  
e.g.  $\text{Cl}_2\text{O}_7 > \text{Cl}_2\text{O}_6 > \text{ClO}_2 > \text{Cl}_2\text{O}$ .

### Reaction with Metals and Non-metals

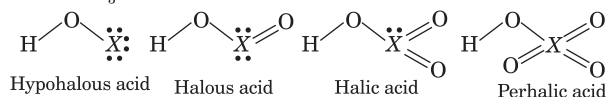
- Halogens combine with metals and non-metals to form halides such as  $\text{MgBr}_2$ ,  $\text{XeF}_6$ ,  $\text{PCl}_3$ ,  $\text{SF}_6$  etc.

- The ionic character of  $M-X$  bond decreases as the size of halogen atom increases.



## Formation of Oxoacids

- Due to small size and absence of vacant  $d$ -orbital, fluorine only forms HOF, whereas other member forms, oxoacids of type HOX, HOXO, HOXO<sub>2</sub>, HOXO<sub>3</sub>. Their structures are



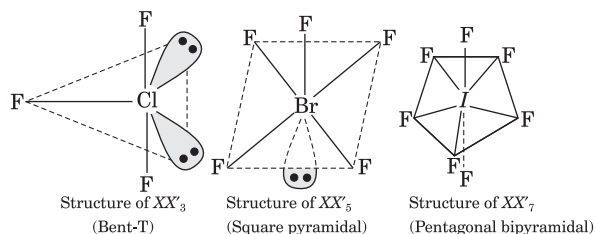
- The halide ion in all of the above acids is  $sp^3$ -hybridised and tetrahedral in shape.
- Their physical and chemical properties are given below :

Thermal stability, acidic strength	Hypohalous acid (+1)	Halous acid (+3)	Halic acid (+5)	Perhalic acid (+7)
	Decreases ↓	HOF	-	-
	HOCl	HClO <sub>2</sub>	HClO <sub>3</sub>	HClO <sub>4</sub>
	HOBr	-	HBrO <sub>3</sub>	HBrO <sub>4</sub>
	HOI	-	HIO <sub>3</sub>	HIO <sub>4</sub>
	Oxidation number, thermal stability, } Increases → covalent character, acidic strength }			

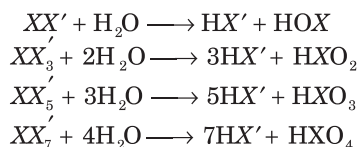
- HClO<sub>4</sub> is the strongest among all acids.

## Interhalogen Compounds

- They form interhalogen compounds of type  $XX'$ ,  $XX'_3$ ,  $XX'_5$ ,  $XX'_7$ , where  $X$  and  $X'$  are halogens of higher and smaller size, respectively.
- They are all covalent molecules and diamagnetic.
- They are more reactive than halogens (except F<sub>2</sub>) because  $X-X'$  bond is weaker than  $X-X$  bond.
- The structure of  $XX'$ ,  $XX'_3$ ,  $XX'_5$  and  $XX'_7$  are respectively linear, bent-T, square pyramidal and pentagonal bipyramidal respectively, as shown below.



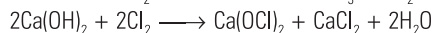
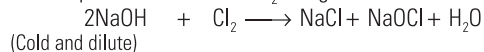
- On hydrolysis, they form the corresponding oxoacids. e.g.



## Chlorine

It is greenish yellow gas with pungent and suffocating odour. One of the important method of preparation is from Deacon's process.

Some of the important reactions of Cl<sub>2</sub> are given below:

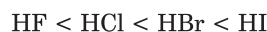


Chlorine water is a powerful bleaching agent due to the formation of nascent oxygen.

## Compounds of Halogen Family

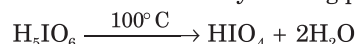
### Hydrogen Chloride (HCl)

- It is a strong monobasic acid which is colourless and pungent smelling gas.
- It acts as a reducing agent and reduces KMnO<sub>4</sub> to Mn<sup>2+</sup>, K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> to Cr<sup>3+</sup>, MnO<sub>2</sub> to Mn<sup>2+</sup>, PbO<sub>2</sub> and Pb<sub>3</sub>O<sub>7</sub> to Pb<sup>2+</sup>, etc.
- The reducing power of halogen hydrides increases from fluorine to iodine,



### Metaperiodic Acid (HIO<sub>4</sub>)

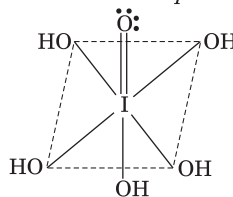
- It is a weak acid and obtained by heating paraperiodic acid



- It acts as a strong oxidising agent in acidic medium and itself reduced to I<sub>2</sub>.

### Paraperiodic Acid (HIO<sub>4</sub> · 2H<sub>2</sub>O or H<sub>5</sub>IO<sub>6</sub>)

- It is a colourless crystalline solid and deliquescent in nature.
- It is a strong acid and acts as a powerful oxidising agent.
- It gives I<sub>2</sub>O<sub>5</sub>, when heated at 100°C.
- It has octahedral structure with  $sp^3d^2$ -hybridisation.



## Group 18 Elements (Noble Gases)

This family contains helium (He-2), neon (Ne-10), argon (Ar-18), krypton (Kr-36), xenon (Xe-54) and radon (Rn-86) with general valence electronic configuration of  $ns^2np^6$ .

## General and Physical Properties

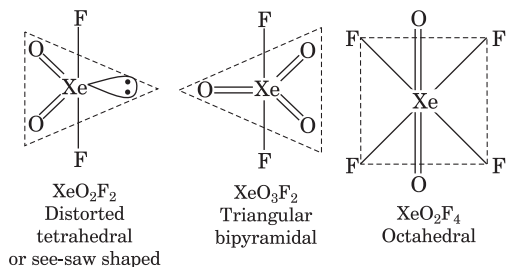
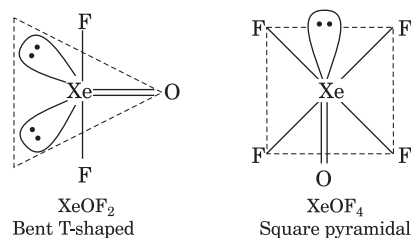
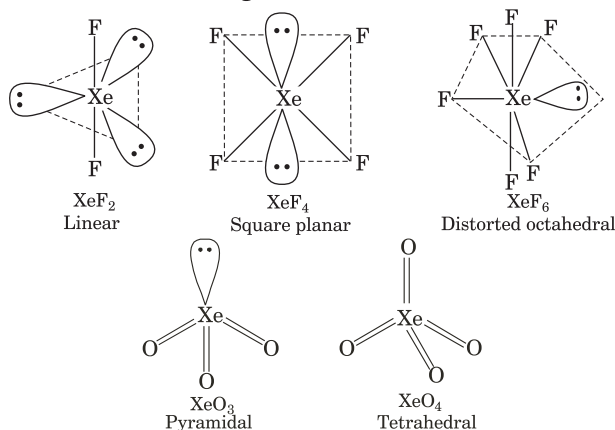
- Physical properties follow a regular trend down the group, except electron gain enthalpy.
- Due to fully filled electronic configuration, they have positive value of electron gain enthalpy that increases from He to Ne (maximum) and decreases from Ne to Rn.

## RAPID CONCEPT REVISION

- All are monoatomic gases, having very low melting and boiling points due to weak van der Waals' force. They are colourless, odourless and tasteless.
- Their order of abundance in atmosphere is  
Rn > Xe > Kr > Ar > Ne > He.

### Chemical Properties

- They are highly inert due to high value of ionisation enthalpy and positive value of electron gain enthalpy. However, Xe, react with F<sub>2</sub> and O<sub>2</sub> to form fluorides (XeF<sub>2</sub>, XeF<sub>4</sub>, XeF<sub>6</sub>), oxides (XeO<sub>3</sub>, XeO<sub>4</sub>) and oxofluorides (XeOF<sub>4</sub>, XeO<sub>2</sub>F<sub>2</sub>, XeOF<sub>2</sub>, XeO<sub>3</sub>F<sub>2</sub> etc.) due to their low ionisation enthalpy and large size.
- Structures of Xe are given below :



- Some important chemical reactions of xenon compounds are:  
 $\text{XeF}_2 + \text{PF}_5 \longrightarrow [\text{XeF}]^+ [\text{PF}_6]^-$   
 $\text{XeF}_4 + \text{SbF}_5 \longrightarrow [\text{XeF}_3]^+ [\text{SbF}_6]^-$   
 $\text{XeF}_6 + \text{MF} \longrightarrow \text{M}^+ [\text{XeF}_7]^-$  ( $\text{M} = \text{Na}, \text{K}, \text{Rb}$  or  $\text{Cs}$ )
- $\text{XeF}_4$  and  $\text{XeF}_6$  on complete hydrolysis give  $\text{XeO}_3$  and on partial hydrolysis give oxofluorides ( $\text{XeOF}_4$ ,  $\text{XeO}_2\text{F}_2$  etc.) and HF.

## MASTER STROKES

- Which of the following is the correct order of basic character?  
 (a)  $\text{NI}_3 > \text{NBr}_3 > \text{NCl}_3 > \text{NF}_3$  (b)  $\text{NI}_3 > \text{NCl}_3 > \text{NBr}_3 > \text{NF}_3$   
 (c)  $\text{NF}_3 > \text{NCl}_3 > \text{NBr}_3 > \text{NI}_3$  (d)  $\text{NF}_3 > \text{NBr}_3 > \text{NCl}_3 > \text{NI}_3$
- Bond dissociation enthalpies of  $E-\text{H}$  ( $E = \text{element}$ ) bonds are given below. Which of the following compounds will act as a strongest reducing agent?
 

Compound	$\text{NH}_3$	$\text{PH}_3$	$\text{AsH}_3$	$\text{SbH}_3$
$\Delta_{\text{diss}}(E-\text{H})/\text{kJ mol}^{-1}$	389	322	297	255

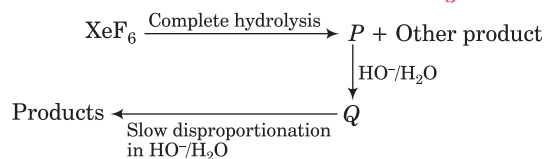
 (a)  $\text{NH}_3$  (b)  $\text{PH}_3$  (c)  $\text{AsH}_3$  (d)  $\text{SbH}_3$
- On heating white phosphorus with conc. NaOH solution in an inert atmosphere of  $\text{CO}_2$ , it gives a gas. Which of the following statements is incorrect about the gas?  
 (a) It is highly poisonous and has smell like rotten fish  
 (b) Its solution in water decomposes in the presence of light  
 (c) It is more basic than  $\text{NH}_3$   
 (d) It is less basic than  $\text{NH}_3$
- Which of the following elements can be involved in  $p\pi-d\pi$  bonding?  
 (a) Carbon (b) Nitrogen (c) Phosphorus (d) Boron
- Atoms in a  $\text{P}_4$  molecule of white phosphorus are arranged regularly  
 (a) at the corners of a cube  
 (b) at the corners of an octahedron  
 (c) at the corners of a tetrahedron  
 (d) at the centre and corners of a tetrahedron
- Which of the following statements is not correct for oxoacids of phosphorus?  
 (a) Orthophosphoric acid is used in the manufacture of triple super phosphate  
 (b) Hypophosphorus acid is a diprotic acid  
 (c) All oxoacids contain tetrahedral four coordinated phosphorus  
 (d) All oxo-acids contain atleast one  $\text{P}=\text{O}$  unit and one  $\text{P}-\text{OH}$  group
- Which of the following properties is not shown by NO?  
 (a) It is paramagnetic in liquid state  
 (b) It is a neutral oxide  
 (c) It combines with oxygen to form nitrogen dioxide  
 (d) Its bond order is 2.5  
[JEE Main 2014]
- The product formed in the reaction of  $\text{SOCl}_2$  with white phosphorus is  
 (a)  $\text{PCl}_3$  (b)  $\text{SO}_2\text{Cl}_2$  (c)  $\text{SCl}_2$  (d)  $\text{POCl}_3$   
[JEE Adv. 2014]

9. The reaction of zinc with dilute and concentrated nitric acid, respectively, produces [JEE Main 2016]  
 (a)  $\text{NO}_2$  and  $\text{NO}$  (b)  $\text{NO}$  and  $\text{N}_2\text{O}$   
 (c)  $\text{NO}_2$  and  $\text{N}_2\text{O}$  (d)  $\text{N}_2\text{O}$  and  $\text{NO}_2$
10. Which order is incorrect among the following options?  
 (a) Reducing property –  $\text{H}_3\text{PO}_4 > \text{H}_3\text{PO}_3 > \text{H}_3\text{PO}_2$   
 (b) Oxidation state of nitrogen –  $\text{N}_2\text{O} < \text{NO} < \text{N}_2\text{O}_3 < \text{N}_2\text{O}_5$   
 (c) Basicity –  $\text{NH}_3 > \text{PH}_3 > \text{AsH}_3 > \text{SbH}_3$   
 (d) Boiling point –  $\text{SbH}_3 > \text{AsH}_3 > \text{NH}_3 > \text{PH}_3$
11. Oxidation of ammonia with  $\text{CuO}$  produce a gaseous chemical which can also be obtained by  
 (a) heating ammonium nitrate  
 (b) reacting excess of ammonia with chlorine  
 (c) heating potassium dichromate  
 (d) catalytic oxidation of ammonia
12. In case of nitrogen,  $\text{NCl}_3$  is possible but not  $\text{NCl}_5$  while in case of phosphorus, both  $\text{PCl}_3$  as well as  $\text{PCl}_5$  are possible. It is due to  
 (a) lower electronegativity of P but not in N  
 (b) lower tendency of H—bond formation in P than N  
 (c) availability of vacant *d*-orbital in P but not in N  
 (d) occurrence of P in solid while N in gaseous state at room temperature
13. Which of the following statement is incorrect for white and red phosphorus?  
 (a) They can be oxidised by heating in air  
 (b) They both are soluble in  $\text{CS}_2$   
 (c) They consists of same kind of atoms  
 (d) They can be converted into one another
14. The compound of sulphur used as a solvent in rubber industry is  
 (a)  $\text{SO}_2(\text{OH})\text{Cl}$  (b)  $\text{SO}_2$  (c)  $\text{SO}_3$  (d)  $\text{S}_2\text{Cl}_2$
15. What may be expected to happen when phosphine gas is mixed with chlorine gas?  
 (a)  $\text{PCl}_5$  and  $\text{HCl}$  are formed and the mixture cools down  
 (b)  $\text{PH}_3 \cdot \text{Cl}_2$  is formed with warming up  
 (c)  $\text{PCl}_3$  and  $\text{HCl}$  are formed and the mixture warms up  
 (d) The mixture only cools down
16. Which of the element listed below occurs in allotropic forms?  
 (a) Sulphur (b) Copper (c) Iodine (d) Silver
17. In the reaction,  $\text{HCOOH} \xrightarrow{\text{H}_2\text{SO}_4} \text{CO} + \text{H}_2\text{O}$ ;  
 $\text{H}_2\text{SO}_4$  acts as  
 (a) reducing agent (b) oxidising agent  
 (c) dehydrating agent (d) All of these
18. Which of the following statements regarding ozone is not correct?  
 (a) The ozone molecule is angular in shape  
 (b) The ozone is a resonance hybrid of two structures  
 (c) The oxygen-oxygen bond length in ozone is identical with that of molecular oxygen  
 (d) Ozone is used as germicide and disinfectant for the purification of air
19. Aqueous solutions of hydrogen sulphide and sulphurdioxide when mixed together, yield  
 (a) sulphur trioxide and water  
 (b) hydrogen and sulphurous acid  
 (c) sulphur and water  
 (d) hydrogen peroxide and sulphur
20. On heating oxalic acid with conc.  $\text{H}_2\text{SO}_4$ , the products obtained are  
 (a)  $\text{H}_2\text{O}$  and  $\text{H}_2\text{S}$  (b)  $\text{CO}$ ,  $\text{CO}_2$  and  $\text{H}_2\text{O}$   
 (c)  $\text{CO}_2$  and  $\text{H}_2\text{S}$  (d) oxalic sulphate
21. Which acid is known as Marshall's acid?  
 (a)  $\text{H}_2\text{S}_2\text{O}_3$  (b)  $\text{H}_2\text{SO}_5$  (c)  $\text{H}_2\text{S}_2\text{O}_7$  (d)  $\text{H}_2\text{S}_2\text{O}_8$
22. Which of the following are peroxyacids of sulphur?  
 (a)  $\text{H}_2\text{SO}_5$  and  $\text{H}_2\text{S}_2\text{O}_8$  (b)  $\text{H}_2\text{SO}_5$  and  $\text{H}_2\text{S}_2\text{O}_7$   
 (c)  $\text{H}_2\text{S}_2\text{O}_7$  and  $\text{H}_2\text{S}_2\text{O}_8$  (d)  $\text{H}_2\text{S}_2\text{O}_6$  and  $\text{H}_2\text{S}_2\text{O}_7$
23. S—S bond is present in  
 (a)  $\alpha - (\text{SO}_3)_n$  (b)  $\gamma - (\text{S}_3\text{O}_9)$  (c)  $\text{H}_2\text{S}_2\text{O}_3$  (d)  $\text{H}_2\text{S}_2\text{O}_8$
24. Which of the following statements is incorrect?  
 (a) In  $\text{OF}_2$ , oxidation state of oxygen is + 2  
 (b) Sulphur shows strong tendency to catenation while oxygen shows this tendency to a limited extent  
 (c) The transition temperature of rhombic and monoclinic sulphur is  $369^\circ\text{C}$   
 (d) Oxygen is most abundant element in the Earth's crust followed by sulphur in 16th group
25. Iodine is formed when potassium iodide reacts with a solution of  
 (a)  $\text{ZnSO}_4$  (b)  $\text{CuSO}_4$  (c)  $(\text{NH}_4)_2\text{SO}_4$  (d)  $\text{Na}_2\text{SO}_4$
26. What is a product obtained in the reaction of  $\text{HgCl}_2$  with  $\text{Hg}(\text{CN})_2$ ?  
 (a)  $(\text{CN})_2$   
 (b)  $\text{Hg}(\text{CN})\text{Cl}$   
 (c)  $\text{Hg}[\text{Hg}(\text{CN})_2\text{Cl}_2]$   
 (d) Addition compound of  $\text{HgCl}_2 \cdot \text{Hg}(\text{CN})_2$
27. When  $\text{Br}_2$  is treated with aqueous solutions of  $\text{NaF}$ ,  $\text{NaCl}$  and  $\text{NaI}$  separately  
 (a)  $\text{F}_2$ ,  $\text{Cl}_2$  and  $\text{I}_2$  are liberated (b)  $\text{F}_2$  and  $\text{Cl}_2$  are liberated  
 (c)  $\text{I}_2$  is liberated (d)  $\text{Cl}_2$  is liberated
28. Among the following oxoacids, the correct decreasing order of acidic strength is [2014 JEE Main]  
 (a)  $\text{HOCl} > \text{HClO}_3 > \text{HClO}_2 > \text{HClO}_4$   
 (b)  $\text{HClO}_4 > \text{HOCl} > \text{HClO}_2 > \text{HClO}_3$   
 (c)  $\text{HClO}_4 > \text{HClO}_3 > \text{HClO}_2 > \text{HOCl}$   
 (d)  $\text{HClO}_2 > \text{HClO}_4 > \text{HClO}_3 > \text{HOCl}$
29. Which among the following is the most reactive? [JEE Main 2015]  
 (a)  $\text{Cl}_2$  (b)  $\text{Br}_2$  (c)  $\text{I}_2$  (d)  $\text{ICl}$
30. The formation of  $\text{O}_2^+[\text{PtF}_6]^-$  is the basis for the formation of xenon fluorides. This is because  
 I.  $\text{O}_2$  and  $\text{Xe}$  have comparable sizes.  
 II. Both  $\text{O}_2$  and  $\text{Xe}$  are gases.  
 III.  $\text{O}_2$  and  $\text{Xe}$  have comparable ionisation energies.  
 IV.  $\text{O}_2$  and  $\text{Xe}$  have comparable electronegativities.  
 (a) Both I and II (b) Both I and III  
 (c) Both II and III (d) Both II and IV
31. The geometry of  $\text{XeOF}_4$  molecule is  
 (a) tetrahedral (b) square pyramidal  
 (c) square planar (d) octahedral


**RAPID CONCEPT REVISION**

- 32.** Which of the following forms of interhalogen compounds does not exist?  
 (a)  $\text{IF}_7$  (b)  $\text{ClF}_3$  (c)  $\text{ICl}$  (d)  $\text{BrCl}_7$
- 33.** Choose the incorrect statement from the following.  
 (a) Fluoride ion has higher energy than other halide ions  
 (b) Most volatile hydride is HF  
 (c) Fluorine has a lesser tendency to form cation than anion  
 (d) Except fluorine other halogens form polyhalide ions
- 34.** Which of the following is incorrect?  
 (a)  $\text{ClO}_4^-$  has  $3d\pi-p\pi$  bonds  
 (b)  $\text{ClO}_3^-$  and  $\text{NO}_3^-$  are isostructural  
 (c)  $\text{Cl}_2\text{O}_7$  is most acidic oxide  
 (d)  $\text{ClO}^-$  is strong conjugate base
- 35.** One gas bleaches the colour of flowers by reduction while another gas by oxidation. The gases respectively are  
 (a)  $\text{SO}_2$  and  $\text{Cl}_2$  (b)  $\text{CO}_2$  and  $\text{Cl}_2$   
 (c)  $\text{NO}$  and  $\text{Cl}_2$  (d)  $\text{H}_2\text{S}$  and  $\text{Br}_2$
- 36.** Which of the following pairs shows correct match between formula and structure of the species?  
 (a)  $[\text{BrF}_2]^+$  : non-linear (b)  $[\text{ICl}_4]^-$  : tetrahedral  
 (c)  $\text{IF}_6$  : trigonal bipyramidal (d)  $\text{BrF}_3$  : trigonal pyramidal
- 37.** Which of the following is the life saving mixture for an asthma patient?  
 (a) Mixture of helium and oxygen  
 (b) Mixture of neon and oxygen  
 (c) Mixture of xenon and nitrogen  
 (d) Mixture of argon and oxygen
- 38.** Which of the following is not obtained by direct reaction of constituent elements?  
 (a)  $\text{XeO}_3$  (b)  $\text{XeF}_2$  (c)  $\text{XeF}_6$  (d)  $\text{XeF}_4$
- 39.** Which one has the highest boiling point?  
 (a) He (b) Ne (c) Kr (d) Xe

- 40.** Under ambient conditions, the total number of gases released as products in the final step of the reaction scheme shown below is



- (a) 0 (b) 1 (c) 2 (d) 3

**Answers**

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (a)  | 2. (c)  | 3. (d)  | 4. (a)  | 5. (c)  |
| 6. (b)  | 7. (a)  | 8. (a)  | 9. (d)  | 10. (a) |
| 11. (b) | 12. (c) | 13. (b) | 14. (d) | 15. (a) |
| 16. (a) | 17. (c) | 18. (c) | 19. (c) | 20. (a) |
| 21. (d) | 22. (a) | 23. (d) | 24. (c) | 25. (b) |
| 26. (d) | 27. (a) | 28. (c) | 29. (d) | 30. (b) |
| 31. (c) | 32. (d) | 33. (b) | 34. (b) | 35. (a) |
| 36. (a) | 37. (a) | 38. (a) | 39. (d) | 40. (c) |


**Notice Board**
**NEET (UG) 2017 Important Information at a Glance**
**1. General Details**

Schedule for online submission of application forms	31-01-2017 to 01-03-2017
Last date for successful final transaction of fee	01-03-2017
Date of uploading of Admit-Cards on website	15-04-2017
Date of Examination, NEET (UG)-2017	07-05-2017
Display of OMR Sheet	Will be intimated through website
Display of Answer Key	Will be intimated through website
Declaration of Result	08-06-2017

**2. Time Schedule**

- (a) Entry in the Examination Hall : 7:30 AM to 9:30 AM
- (b) Checking of Admit Cards by the invigilator : 9:30 AM to 9:45 AM
- (c) Distribution of Test Booklet : 9:45 AM
- (d) Seal of the Test Booklet to be broken/opened to take out the Answer Sheet : 9:55 AM
- (e) Latest Entry in the Examination Hall : 9:55 AM
- (f) Test Commences : 10:00 AM
- (g) Test Concludes : 01:00 PM

**3. Material to be brought on the day of examination :**

: Admit Card, Passport size Photograph and Post Card Size Photograph affixed on proforma.

**4. Rough Work**

: All rough work is to be done in the Test Booklet only. The candidate will not do any rough work or put stray mark on the machine gradable Answer Sheet.

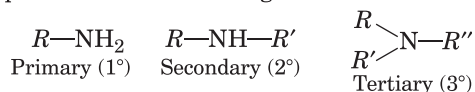
**5. Use of Blue/Black Ball Point Pen only**

: Pen will be provided at the centre for writing of particulars on the Test Booklet and responses on the Answer Sheet.

# ORGANIC COMPOUNDS CONTAINING NITROGEN

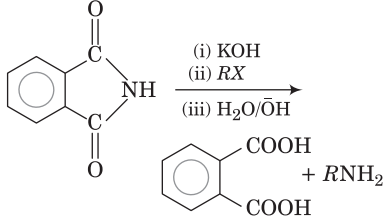
## Aliphatic Amines

- Amines are alkyl or aryl derivatives of ammonia having general formula  $RNH_2$ ,  $R_2NH$  or  $R_3N$ , where,  $R$  is an alkyl or aryl group.
- Amines are classified as primary ( $1^\circ$ ), secondary ( $2^\circ$ ) or tertiary ( $3^\circ$ ) depending upon the number of alkyl or aryl groups attached to the nitrogen atom.



## Methods of Preparation

### I. For Primary Amines

S.No.	Methods	Reactions involved
1.	By reduction of (i) Alkyl nitriles  (ii) Nitroalkanes  (iii) Oximes  (iv) Amides	$R-C \equiv N \xrightarrow[\text{Na}]{LiAlH_4} RCH_2NH_2$ $R-C \equiv N \xrightarrow[\text{Alcohol}]{Na} RCH_2NH_2$ <p>(Mendius reaction)</p> $RNO_2 + 3H_2 \xrightarrow[\text{or LAH or H}_2/\text{Pt}]{Ni/250^\circ C} RNH_2 + 2H_2O$ $R-CH=NOH \xrightarrow[\text{Ether}]{LiAlH_4} RCH_2NH_2 + H_2O$ $RCONH_2 \xrightarrow{LiAlH_4} RCH_2NH_2 + H_2O$
2.	Gabriel phthalimide synthesis	
3.	Reductive amination of carbonyl compounds	$RCHO \xrightarrow[-H_2O]{NH_3} R-\overset{H}{\underset{ }{C}}=NH$ <p>Imine</p> $\xrightarrow[Ni \text{ or } NaBH_3CN]{H_2} RCH_2NH_2$
4.	Curtius method	$RCOCl \xrightarrow{NaN_3} R-\overset{+}{C}(=O)-N=N=N \xrightarrow[\text{alkyl shift}]{\Delta, \text{Intramolecular}}$ $R-N=C=O \xrightarrow[\Delta]{2NaOH} RNH_2 + Na_2CO_3$

5.	Hofmann bromamide degradation	$RCONH_2 + Br_2 + 4KOH \xrightarrow{\Delta} RNH_2 + 2KBr + K_2CO_3 + 2H_2O$
6.	Schmidt rearrangement	$R-\overset{O}{\parallel}{C}-OH + N_3H \xrightarrow[\Delta]{\text{conc. H}_2\text{SO}_4} RNH_2 + CO_2 + N_2$

### II. For Secondary Amines

1.	Reaction of $RX$ with $1^\circ$ -amine	$RNH_2 + RX \xrightarrow{NaOH} R_2NH + NaX + H_2O$
2.	By reduction of (i) isocyanide (ii) N-substituted amides	$R-N \equiv C + 2H_2 \xrightarrow{Ni \text{ or } Pt} RNHCH_3$ $RCONHR' \xrightarrow[\text{Ether}]{LiAlH_4} RCH_2NHR'$
3.	Reductive amination of carbonyl compounds	$RCHO \xrightarrow{R'NH_2} [R-\overset{H}{\underset{ }{C}}=NR']$ <p>Imine</p> $\xrightarrow[Ni]{H_2} R-CH_2-NH-R'$

### III. For Tertiary Amines

1.	Reaction of excess $RX$ with $NH_3$	$3RX + NH_3 \rightarrow \left[ \overset{+}{R_3N} \right] X^- \xrightarrow{NaOH} R_3N + NaX + H_2O$
2.	Reduction of N, N-disubstituted amides	$R-\overset{O}{\parallel}{C}-NR'_2 \xrightarrow[\text{Ether}]{LiAlH_4} RCH_2NR'_2$
3.	Decomposition of tetra-alkyl ammonium hydroxide	$R_4N^+OH^- \xrightarrow{\Delta} R_3N + H_2O + CH_2=CH_2$

### IV. For Mixture of Amines

1.	Hofmann ammonolysis method	$RI \xrightarrow[-HI]{NH_3/393K} R\ddot{N}H_2 \xrightarrow[-HI]{RI} R_2\ddot{N}H$ $\xrightarrow[-HI]{RI} R_3\ddot{N} \xrightarrow[-HI]{RI} [R_4N^+]I^-$
2.	By reacting alcohols with ammonia	$ROH + NH_3 \xrightarrow[620K]{Al_2O_3} RNH_2 \xrightarrow[-H_2O]{ROH} R_2NH$ $\xrightarrow[-H_2O]{ROH} R_3N \xrightarrow[-H_2O]{ROH} R_4N^+OH^-$

## RAPID CONCEPT REVISION

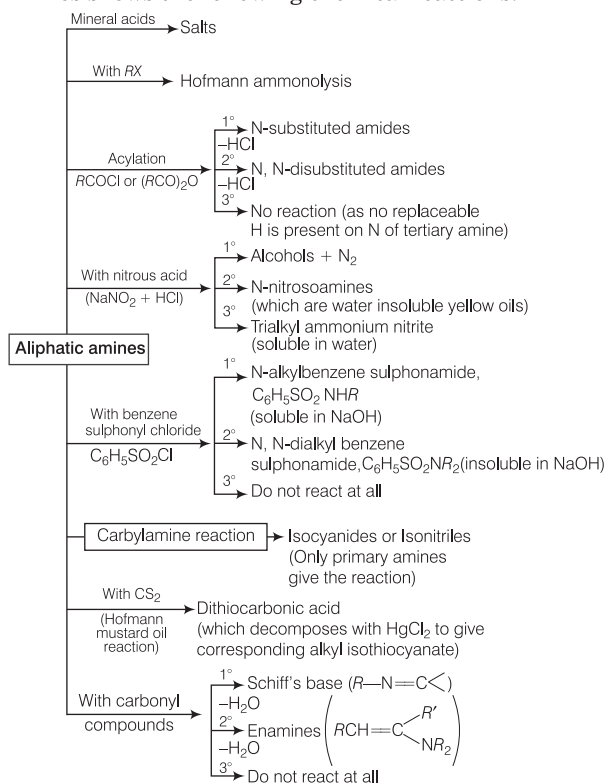
### Physical Properties

- Lower amines are gases or low-boiling liquids with a characteristics ammonia like smell.
- These are soluble in water due to intermolecular hydrogen bonding and the order of solubility is  $1^\circ$  amines  $>$   $2^\circ$  amines  $>$   $3^\circ$  amines (due to decrease in extent of H-bonding from  $1^\circ$  to  $3^\circ$  amine).
- Boiling point order is  $1^\circ$  amine  $>$   $2^\circ$  amine  $>$   $3^\circ$  amine.
- Basic character of amines** They possess different order of basic strength in gaseous and aqueous phase due to steric hindrance and solvation effect.

Gaseous phase	Aqueous phase
In gaseous phase, the order of basicity is as expected, i.e. $R_3N > R_2NH > RNH_2 > NH_3$ $3^\circ > 2^\circ > 1^\circ$ where, $R =$ alkyl group	Due to solvation effect and steric hindrance by alkyl group in aqueous phase, the order of basic strength is deviated from normal and shows the following order: $(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$ $(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2 > NH_3$

### Chemical Properties

- Amines are reactive due to high electronegativity difference between N and H-atom.
- Amines shows the following chemical reactions:

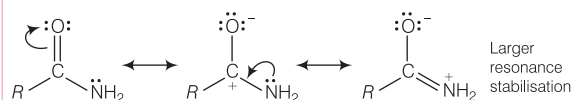


**Note** The above chemical reactions can be used to distinguish among  $1^\circ$ ,  $2^\circ$  and  $3^\circ$  amines. These reactions are also applicable to aromatic amines.

### Basicity of Amides

- Amides are far less basic than amines.
- The  $pK_a$  value of conjugate acid of a typical amide is zero.
- An amide is stabilised by resonance involving the non-bonding pair of electrons on the nitrogen atom.

#### Amides



- However, electron withdrawing nature of the carbonyl group of amide also contribute in its less basic nature.

### Aromatic Amines

- The amines in which N-atom is directly attached to the benzene nucleus are called **aromatic amines**.
- These are also divided into  $1^\circ$ ,  $2^\circ$  and  $3^\circ$  amines based on the number of H-atoms of  $NH_3$  replaced by aryl group.

### Methods of Preparation

These are prepared by the following methods:

Methods	Reactions involved
1. Reduction of nitro compounds	$C_6H_5NO_2 \xrightarrow[H_2/Ni, 250^\circ C]{\text{or } LiAlH_4} C_6H_5NH_2$
2. Ammonolysis of aryl chlorides	$C_6H_5Cl + 2NH_3 \xrightarrow[\text{Under pressure}]{CuCl_2/210^\circ C} C_6H_5NH_2$
3. Hofmann's bromamide degradation reaction	$ArCONH_2 \xrightarrow[(Br_2 + NaOH)]{NaOBr} ArNH_2 + CO_2$
4. Reduction of azo compounds	$ArN=NAr \xrightarrow[Ni, \Delta]{H_2} ArNH \cdot NHAr$ $2ArNH_2 \xrightarrow[Ni, \Delta]{H_2}$
6. Schmidt reaction	$C_6H_5COOH + N_3H \xrightarrow{\text{conc. } H_2SO_4} C_6H_5NH_2 + CO_2 + N_2$

### Physical Properties

- These are colourless liquids or solids having characteristic odour.
- These turn brown in air due to oxidation.



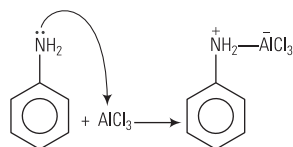
- (iii) These have high boiling point due to intermolecular H-bonding and are sparingly soluble in water.
- (iv) These are less basic than the corresponding aliphatic amines due to electron withdrawing nature of benzene ring and basicity decreases as the number of benzene ring directly attached to N-atom increases.

## Chemical Properties

Aromatic amines also give most of chemical reactions that are shown by aliphatic amines with the only difference of that the alkyl group is substituted by the aryl group. Apart from that they give electrophilic aromatic substitution reactions.

### REMEMBER

Aniline does not undergo Friedel-Crafts alkylation and acetylation due to the formation of salt with  $\text{AlCl}_3$ , the reagent used in Friedel-Crafts reaction. After formation of salt, the N-atom of aniline acquires positive charge and act as a strong deactivating group for further reaction.

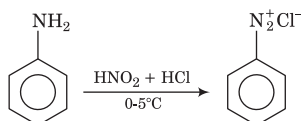


## Benzene Diazonium Salts ( $\text{ArN}_2^+ \text{X}^-$ )

- These salts contain benzene diazonium ( $\text{ArN}_2^+$ ) ion that is stabilised by resonance.
- Presence of electron releasing groups like  $-\text{NR}_2$ ,  $-\text{OR}$ , etc. at *o/p*-position in the benzene ring stabilises the benzene diazonium salt.

## Method of Preparation

It is prepared through diazotisation reaction as given below:

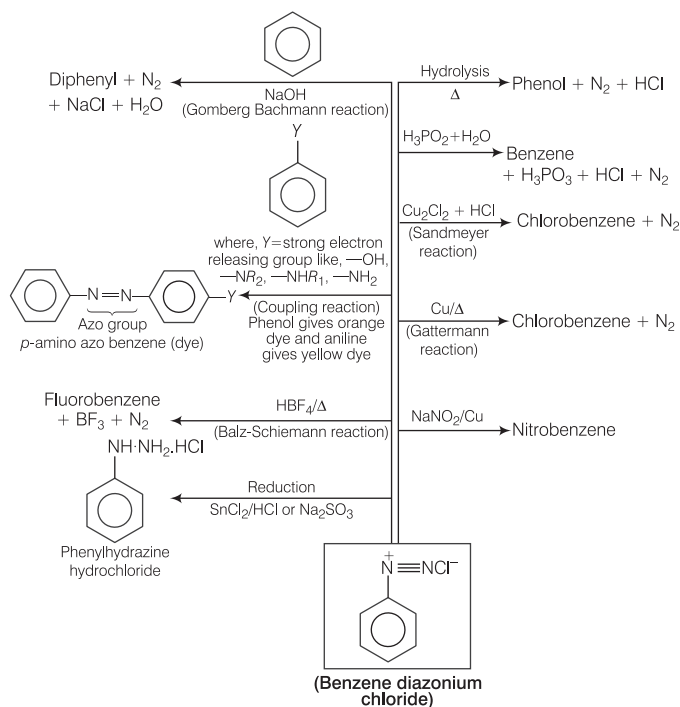


## Physical Properties

- These are colourless crystalline solids but get colour when exposed to air.
- Due to their ionic nature, they are water soluble.
- In aqueous solution, these are good conductors of electricity.

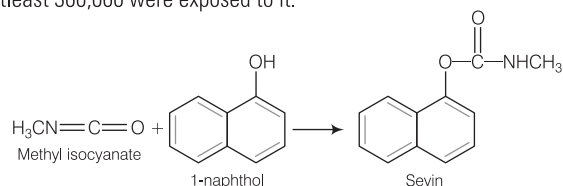
## Chemical Properties

These are soluble in water due to their ionic nature. They give the following chemical reactions:



## Bhopal Gas Tragedy

This tragedy was happened in India, in 1984, in the city Bhopal. There was a massive leak of methyl isocyanate, used in the preparation of insecticide, Sevin. It resulted in the deaths of more than 2000 people, atleast 300,000 were exposed to it.



This catastrophe, the worst chemical industrial accident in history, led to a complete reappraisal of the safety measures for the handling of large quantities to toxic chemicals. The toxicity of the isocyanate function derives from its rapid reaction with nucleophilic sites in biological molecules. Indiscriminate attack on the hydroxy, amino and thiol groups, e.g. peptides and proteins inactivates them with respect to their biological function, other substances, which would be similarly affected by such attack, include small molecules taking part in the transmission of nerve impulses and various aspects of cell regulation.

## Cyanides and Isocyanides

These are isomeric derivatives of HCN represented as:



## RAPID CONCEPT REVISION

### Methods of Preparation

These are prepared through the following reactions:

- $RX + NaCN \longrightarrow RCN$  (Cyanide) +  $NaX$
- $RX + AgCN \longrightarrow RNC$  (Isocyanide) +  $AgX$
- Acid amide  $\xrightarrow[\text{Dehydration}]{P_2O_5/\Delta} RCN$
- $RMgX \xrightarrow[\text{Dry ether}]{CICN} RCN + Mg(Cl)X$
- $ArN_2Cl \xrightarrow{CuCN + HCN} ArCN + N_2 + KCl$
- $R-NH_2 + CHCl_3 + 3KOH(\text{alc.}) \xrightarrow[-3KCl, -3H_2O]{\text{Carbylamine reaction}} R-NC$

### Physical Properties

- Lower members are colourless liquids but higher members are crystalline solids.
- Cyanides have pleasant odours but isocyanides have unpleasant odour.
- Cyanides have higher boiling points than the corresponding isocyanides.

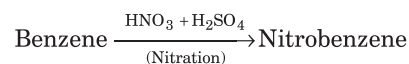
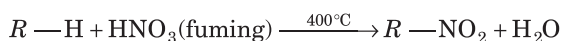
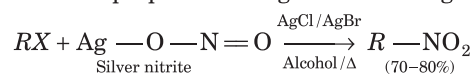
### Chemical Properties

They show the following chemical properties:

- $R-C \equiv N \xrightarrow[\text{Hydrolysis}]{H_3O^+ / \bar{O}H} RCOOH$
- $R-C \equiv N \xrightarrow[\text{Partial hydrolysis}]{\text{conc. } HCl / H_2SO_4} RCONH_2$
- $R-N \equiv C \xrightarrow[\text{Hydrolysis}]{H_3O^+} RNH_2 + HCOOH$
- $R-C \equiv N \xrightarrow[\text{Mendius reaction}]{LiAlH_4} RCH_2NH_2$
- $R-N \equiv C \xrightarrow[\text{Hydrolysis}]{LiAlH_4} RNHCH_3$
- $R-C \equiv N \xrightarrow[(ii) H_3O^+]{(i) RMgX} R-\overset{R'}{C}=O + Mg(OH)X$

### Nitro Compounds

- These are alkyl or aryl compounds containing  $-NO_2$  group.
- These are prepared through the following reactions:

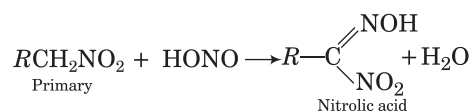
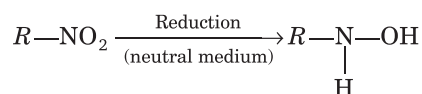
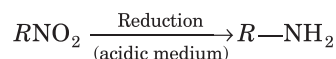


### Physical Properties

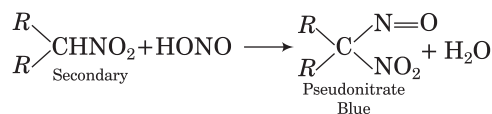
- Nitroalkanes are colourless, pleasant smelling liquids while aromatic nitro compounds can be pale yellow liquids or solids with distinct smell.
- They have higher boiling points than the corresponding hydrocarbons.
- They are more soluble in non-polar solvents than in polar solvents due to absence of hydrogen bonding.

### Chemical Properties

They show the following chemical reactions:



Dissolves in NaOH to give blood red colouration.

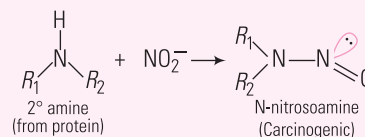


Does not dissolve in alkali

### N-Nitrosoamines : A powerful Carcinogen

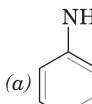
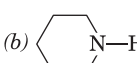
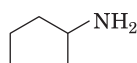
Sodium nitrite is added to meat as a preservative to inhibit the growth of Clostridium botulinum and to prevent the meat from turning brown.

However, inside our stomach, the low pH stimulates the reaction of nitrite ion with secondary amine found in meat to produce carcinogenic N-nitrosoamines.



- Some common N-nitrosoamines are N-nitrosodimethyl amine and N-nitrosopyridine.
- Cigarette smoke also contains carcinogenic N-nitrosodimethyl amine.

# MASTER STROKES

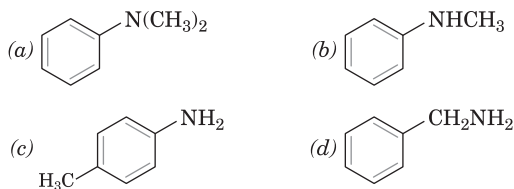
- 1.** The test to distinguish primary, secondary and tertiary amine is [JEE Main 2016]  
 (a) mustard oil test (b)  $C_6H_5SO_2Cl$   
 (c) Sandmeyer's reaction (d) Carbylamine reaction
- 2.**  $>C=O$  compounds reacts with  $NH_3$  or amines followed by  $H_2/Ni$ . The reaction is called [JEE Main 2016]  
 (a) Mendius reaction (b) Hofmann bromamide  
 (c) Reductive amination (d) Gabriel's phthalimide
- 3.**  $(CH_3)_3N \xrightarrow[(ii) H_2O, \Delta]{(i) BrCN} [X]$ , here  $[X]$  is  
 (a)  $CH_3NH_2$  (b)  $(CH_3)_2NH$   
 (c)  $(CH_3)_3NO$  (d)  $(CH_3)_2NNO$
- 4.** The compound which on reaction with aqueous nitrous acid at low temperature produces an oily nitrosamine is  
 (a) methylamine (b) ethylamine  
 (c) diethylamine (d) triethylamine
- 5.**  $CH_3NH_2 + CHCl_3 + KOH \longrightarrow$  Nitrogen containing compound +  $KCl + H_2O$ . Nitrogen containing compound is  
 (a)  $CH_3CN$  (b)  $CH_3NHCH_3$   
 (c)  $CH_3-\bar{N} \equiv \bar{C}$  (d)  $CH_3-\bar{N} \equiv \bar{C}$
- 6.** On heating an aliphatic primary amine with chloroform and ethanolic potassium hydroxide, the organic compound formed is [JEE Main 2014]  
 (a) an alkanol (b) an alkanediol  
 (c) an alkyl cyanide (d) an alkyl isocyanide
- 7.** Benzamide on treatment with  $POCl_3$  gives  
 (a) aniline (b) benzonitrile  
 (c) chlorobenzene (d) benzyl amine
- 8.** The gas leaked from a storage tank of the Union Carbide plant in Bhopal gas tragedy was [JEE Main 2016]  
 (a) methyl isocyanate (b) methylamine  
 (c) ammonia (d) phosgene
- 9.** Considering the basic strength of amines in aqueous solution, which one has the smallest  $pK_b$  value? [JEE Main 2014]  
 (a)  $(CH_3)_2NH$  (b)  $CH_3NH_2$   
 (c)  $(CH_3)_3N$  (d)  $C_6H_5NH_2$
- 10.** A compound of molecular formula,  $C_3H_9N$  when reacts with benzene sulphonyl chloride gives a product soluble in dilute  $NaOH$  solution. The compound should be  
 (a)  $(CH_3)_3N$   
 (b)  $(CH_3)_2CH-NH_2$   
 (c)  $\begin{array}{c} CH_3 \\ \diagdown \\ NH \\ \diagup \\ C_2H_5 \end{array}$   
 (d) All of the above
- 11.** Which of the following is the strongest base in aqueous solution?  
 (a)  $(CH_3)_3N$  (b)  $(CH_3)_2NCH_2CH_2OH$   
 (c)  $CH_3CH_2CH_2NHOH$  (d)  $(CH_3)_2NOH$
- 12.**  $N_2$  gas is liberated when  $(HCl + NaNO_2)$  react with which of the following compounds?  
 I.  $CH_3CH_2NH_2$   
 II. Urea  
 III.  $CH_3CONH_2$   
 IV.  $C_6H_5CH_2NH_2$   
 Choose the correct option.  
 (a) I, II and IV  
 (b) I, III and IV  
 (c) II, III and IV  
 (d) I, II, III and IV
- 13.** A positive carbylamine test is given by  
 (a) N, N-dimethylaniline (b) 2, 4-dimethylaniline  
 (c) N-methyl-o-methylaniline (d) p-methylbenzylamine
- 14.** Which of the following is the weakest Bronsted base?  
 (a)  (b)   
 (c)  $CH_3NH_2$  (d) 
- 15.** When  $\left[ CH_3CH_2CH_2-\overset{\overset{CH_3}{|}}{N^+}-\underset{\underset{CH_3}{|}}{CH_2}CH_3 \right] \bar{O}H$  is heated, then  
 (a) propane is the major product  
 (b) ethane and  $C_3H_7N(CH_3)_2$  are the only products  
 (c) ethene and propane are obtained with ethene as the major product  
 (d) equimolar amounts of ethene and propene are obtained
- 16.** Carbylamine test is performed in alc.  $KOH$  by heating a mixture of  
 (a) chloroform and silver powder  
 (b) trihalogenated methane and a primary amine  
 (c) an alkyl halide and a primary amine  
 (d) an alkyl cyanide and a primary amine
- 17.** During diazotisation of benzenamine with sodium nitrite and hydrochloric acid, the excess of hydrochloric acid is used primarily to  
 (a) check the hydrolysis of  $C_6H_5-OH$   
 (b) ensure a stoichiometric amount of nitrous acid  
 (c) check the concentration of free aniline  
 (d) neutralise any base formed during reaction

## RAPID CONCEPT REVISION

**18.** Benzene diazonium chloride on treatment with hypophosphorous acid and water in the presence of  $\text{Cu}^+$  catalyst produces

- (a) benzene (b) toluene  
(c) aniline (d) chlorobenzene

**19.** Which one of the following compound would form a brilliant coloured dye on treatment with  $\text{NaNO}_2$  in dil. HCl followed by addition to an alkaline solution of  $\beta$ -naphthol?



**20.** Hydrolysis of acetonitrile in acidic medium gives

- (a)  $\text{CH}_3\text{CH}_2\text{NH}_2$  (b)  $\text{CH}_3\text{COOH}$   
(c)  $\text{CH}_3\text{CONH}_2$  (d)  $\text{CH}_3\text{CHO}$

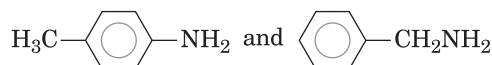
**21.** Hydroazobenzene on treatment with  $\text{H}_2\text{SO}_4$  forms

- (a) azobenzene (b) azobenzene sulphonic acid  
(c) benzidine (d) None of these

**22.** Decomposition of benzene diazonium chloride by using  $\text{Cu}_2\text{Cl}_2/\text{HCl}$  to form chlorobenzene is called

- (a) Raschig's reaction (b) Sandmeyer's reaction  
(c) Kolbe's reaction (d) Cannizzaro's reaction

**23.** Which of the following reagents will be useful for a simple chemical test to distinguish between



- (a)  $\text{C}_6\text{H}_5\text{SO}_2\text{Cl}$  and  $\text{OH}^-$  in  $\text{H}_2\text{O}$   
(b) HONO, then  $\beta$ -naphthol  
(c) Dilute HCl  
(d)  $\text{AgNO}_3$  in  $\text{H}_2\text{O}$

**24.** Which of the following statements is correct?

- (a) Aniline is a stronger base than ethyl amine  
(b) Aniline is a stronger base than *p*-methoxyaniline  
(c) Aniline must be acetylated before nitration with an acidic mixture  
(d) Aniline is soluble in an ammonium hydroxide solution

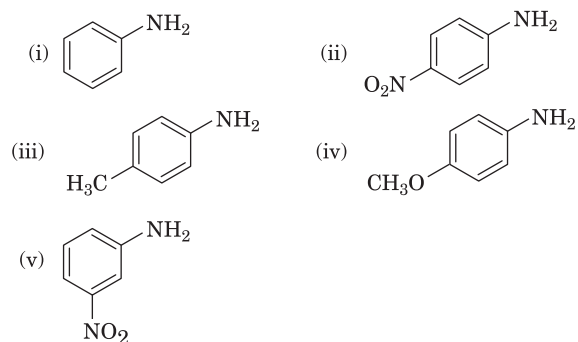
**25.** Chlorobenzene can be prepared by reacting aniline with

- (a) hydrochloric acid  
(b) cuprous chloride  
(c) chlorine in the presence of anhyd.  $\text{AlCl}_3$   
(d) nitrous acid followed by heating with cuprous chloride

**26.** *p*-chloroaniline and anilinium hydrochloride can be distinguished by

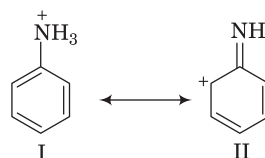
- (a) Sandmeyer reaction (b)  $\text{NaHCO}_3$   
(c)  $\text{AgNO}_3$  (d) Carbylamine test

**27.** The correct increasing order of basic nature of the following bases is



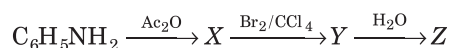
- (a) II < V < I < III < IV  
(b) V < II < I < III < IV  
(c) II < V < I < IV < III  
(d) V < II < I < IV < III

**28.** Examine the following two structures of anilinium ion and choose the correct statements.



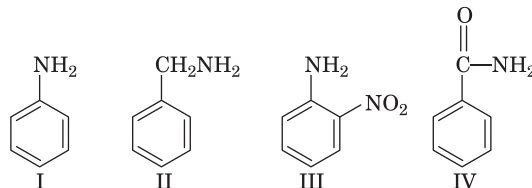
- (a) II is not an acceptable canonical structure because carbonium ions are less stable than ammonium ions  
(b) II is not an acceptable canonical structure because it is non-aromatic  
(c) II is not an acceptable canonical structure because the nitrogen has 10 valence electrons  
(d) II is an acceptable canonical structure

**29.** Identify the product (Z) in the following reaction scheme



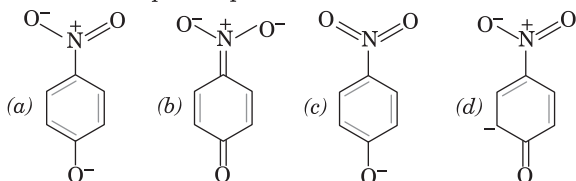
- (a) *p*-bromoaniline  
(b) *p*-bromoacetophenone  
(c) *p*-bromoacetanilide  
(d) *o*-bromoacetophenone

**30.** The correct increasing order of basicity of the following compounds (weakest  $\rightarrow$  strongest) is

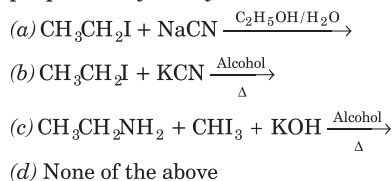


- (a) IV < II < I < III  
(b) IV < I < III < II  
(c) IV < III < I < II  
(d) II < I < III < IV

31. The most unlikely representation of resonance structures of *p*-nitrophenoxide ion is



32. Which of the following reactions can be used to prepare ethyl isocyanide?



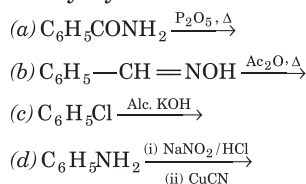
33. Which one of the following statements about  $\text{CH}_3\text{CN}$  is incorrect?

- (a) The bond between C and N is a triple bond  
 (b) The C—C—N bond angle is  $180^\circ$   
 (c) The carbon-carbon bond is longer than the carbon-nitrogen bond  
 (d) It has a relatively high boiling point due to hydrogen bonding

34. Treatment of nitrobenzene with acetyl chloride in the presence of anhydrous  $\text{AlCl}_3$  gives

- (a) 2-nitroacetophenone (b) 3-nitroacetophenone  
 (c) 4-nitroacetophenone (d) None of these

35. Phenyl cyanide cannot be obtained by



36. Which of the following compound results into formation of benzene nitrile on its hydrolysis?

- (a) Benzamide (b) Benzoic acid  
 (c) Benzoyl chloride (d) Benzophenone

37. Ethyl isocyanide on hydrolysis in acidic medium generates

- (a) ethylamine salt and methanoic acid  
 (b) propanoic acid and ammonium salt  
 (c) ethanoic acid and ammonium salts  
 (d) methylamine salt and ethanoic acid

38. Which of the following statements is not correct?

- (a) Alkyl isocyanides have bad odours while alkyl cyanides have pleasant odours  
 (b) Alkyl cyanides are not poisonous as KCN  
 (c) Alkyl cyanides have lower boiling points than the corresponding alkyl isocyanides  
 (d) Acetonitrile is soluble in water but not in methyl carbylamine

39. Tertiary nitroalkanes cannot tautomerise because  
 (a) their tautomeric forms are highly unstable  
 (b) they do not contain any multiple bond  
 (c) they do not have labile H-atom  
 (d) they are not basic in nature



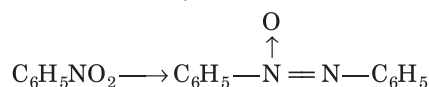
The compound X is

- (a)  $\text{SnCl}_2/\text{HCl}/\text{H}_2\text{O}$ , boil  
 (b)  $\text{H}_2/\text{Pd—BaSO}_4$   
 (c)  $\text{LiAlH}_4/\text{ether}$   
 (d)  $\text{NaBH}_4/\text{ether}/\text{H}_3\text{O}^+$

41. Commonly used catalyst in the preparation of acylonitrile from propylene, ammonia and oxygen is

- (a) silver (b) bismuth molybdates  
 (c) caesium chloride (d) nickel

42. The conversion,



can be brought about by reduction with

- (a)  $\text{Na}_3\text{AsO}_3/\text{NaOH}$  (b) glucose/HCl  
 (c)  $\text{Zn}/\text{NaOH}$  (d)  $\text{LiAlH}_4/\text{ether}$

43. Which of the following reaction can produce aniline as major product?

- (a)  $\text{C}_6\text{H}_5\text{NO}_2 + \text{Zn}/\text{KOH}$   
 (b)  $\text{C}_6\text{H}_5\text{NO}_2 + \text{Zn}/\text{NH}_4\text{Cl}$   
 (c)  $\text{C}_6\text{H}_5\text{NO}_2 + \text{LiAlH}_4$   
 (d)  $\text{C}_6\text{H}_5\text{NO}_2 + \text{Zn}/\text{HCl}$

44. Nitrobenzene undergoes reduction with  $\text{Zn}/\text{alc. KOH}$  to form a compound A. The number of  $\sigma$  and  $\pi$ -bonds in A, are respectively

- (a) 17, 6 (b) 27, 6  
 (c) 27, 8 (d) 17, 8

45. In electrophilic aromatic substitution reaction, the nitro group is *meta* directing because it

- (a) decreases electron density at *meta*-position  
 (b) increases electron density at *meta*-position  
 (c) increases electron density at *ortho* and *para*-positions  
 (d) decreases electron density at *ortho* and *para*-positions

### Answers

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (b)  | 2. (c)  | 3. (b)  | 4. (c)  | 5. (d)  |
| 6. (d)  | 7. (b)  | 8. (a)  | 9. (a)  | 10. (b) |
| 11. (d) | 12. (d) | 13. (d) | 14. (a) | 15. (c) |
| 16. (b) | 17. (c) | 18. (a) | 19. (c) | 20. (b) |
| 21. (c) | 22. (b) | 23. (b) | 24. (b) | 25. (d) |
| 26. (c) | 27. (a) | 28. (c) | 29. (a) | 30. (c) |
| 31. (c) | 32. (c) | 33. (d) | 34. (c) | 35. (c) |
| 36. (b) | 37. (a) | 38. (c) | 39. (c) | 40. (d) |
| 41. (b) | 42. (a) | 43. (d) | 44. (b) | 45. (d) |

# ▶▶ **d AND f-BLOCK ELEMENTS**

## **d-Block Elements** (Transition Elements)

These are also called **transition elements** because they provide a transition between electropositive metals of *s*-block elements and more electronegative metals of *p*-block elements.

- They are present in 4th (Sc to Zn), 5th (Y to Cd), 6th (La to Hg) and 7th (Ac to Cn) period of periodic table.
- They have general valence electronic configuration of  $(n-1)d^{1-10}ns^{0-2}$ , where  $(n-1)$  stands for inner *d*-orbital. However, there are many exceptional electronic configurations like Cu, Cr, etc., due to a very small energy difference between  $(n-1)d$  and *ns*-orbitals.

## General and Physical Properties

### Atomic Radius

- On moving left to right, it decreases for first five elements and then becomes almost constant for next five elements of the series.
- The reason is that the pairing of electrons in *d*-orbitals after  $d^5$ -configuration, gives rise to increasing influence for screening effect.
- The increased effective nuclear charge (ENC) and increased screening effect balance each other to result in constancy in atomic size.

### REMEMBER

Due to lanthanide contraction, there is a very small change (0.01 Å) or almost no change in atomic radius from 4*d*-series (5th period) to 5*d*-series (6th period). Most of the elements have almost similar atomic radius values that favours the formation of alloys.

### Ionisation Enthalpy

- The ionisation enthalpy of *d*-block elements is higher than *s*-block elements and lower than the *p*-block elements.
- It generally increases from left to right across a period but the increase is not regular due to almost similar atomic radius.

### REMEMBER

Due to lanthanide contraction, the ionisation energy of 5*d*-series (6th period) elements is higher than the corresponding 3*d*- and 4*d*-series (4th and 5th period) elements.

## Nature of Bond and Metallic Character

They generally form metallic, ionic and covalent bond.

- All transition elements are metals with high melting point, boiling point, conductivity, etc., due to the formation of metallic bond.
- However, melting and boiling points of Zn, Cd and Hg are low due to fully-filled electronic configuration that resist the removal of electron and hence form weak metallic bond.

## Oxidation States

- They show variable oxidation states due to incomplete *d*-orbitals.
- The oxidation states of different elements of 3*d*-series is shown below:

Element	Outer electronic configuration	Oxidation states
Sc	$3d^1 4s^2$	+2, +3
Ti	$3d^2 4s^2$	+2, +3, +4
V	$3d^3 4s^2$	+2, +3, +4, +5
Cr	$3d^5 4s^1$	+1, +2, +3, +4, +5, +6
Mn	$3d^5 4s^2$	+2, +3, +4, +5, +6, +7
Fe	$3d^6 4s^2$	+2, +3, +4, +5, +6
Co	$3d^7 4s^2$	+2, +3, +4
Ni	$3d^8 4s^2$	+2, +3, +4
Cu	$3d^{10} 4s^1$	+1, +2
Zn	$3d^{10} 4s^2$	+2

## Colour

Most of the compounds of transition metals are coloured in solid state or solutions due to the presence of unpaired electrons, that is excited from lower energy *d*-orbital to higher energy *d*-orbital.

## Magnetic Properties

Most of the transition metals and their complexes are paramagnetic due to the presence of unpaired electrons. The magnetic moment associated with unpaired electrons is calculated as

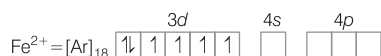
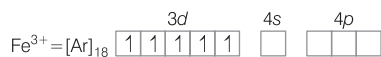
$$\mu = \sqrt{n(n+2)} \text{ BM}$$

where, *n* = number of unpaired electrons.

### Predicting Magnetic Behaviour of Complex Compounds Formed by *d*-Block Elements

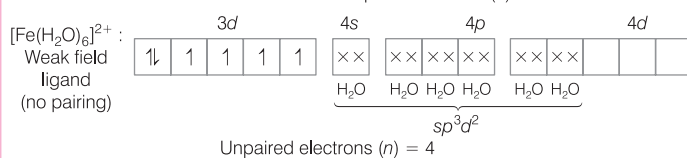
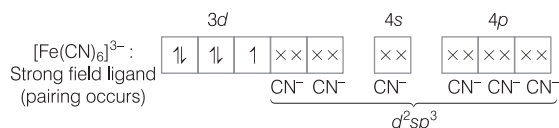
**Step I** Identify the oxidation state of the cation present in the complex, e.g. in  $[\text{Fe}(\text{CN})_6]^{3-}$  and  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$ , the oxidation state of iron are +3 and +2, respectively.

**Step II** Write the valence electronic configuration of cation, e.g.



**Step III** Find whether the ligand is a strong field or weak field. Here,  $\text{CN}^-$  is a strong field ligand, whereas  $\text{H}_2\text{O}$  is a weak field ligand.

**Step IV** Pairing of *d*-orbital electrons takes place in case of strong field ligands and no pairing takes place in case of weak field ligands, e.g.



**Step V** Apply the formula,  $\mu = \sqrt{n(n+2)}$ , BM to find magnetic moment in case of transition metal ions, e.g.

$$\text{In } [\text{Fe}(\text{CN})_6]^{3-}, n = 1 \Rightarrow \mu = \sqrt{3} \text{ BM}$$

$$\text{In } [\text{Fe}(\text{H}_2\text{O})_6]^{2+}, n = 4 \Rightarrow \mu = \sqrt{24} \text{ BM}$$

**Step VI** When  $n = 0$ , the substance is diamagnetic and colourless, otherwise, when  $n \geq 1$ , the substance is paramagnetic and coloured.

Some important alloys are given below:

S.No.	Name	Composition
1.	Brass	Cu = 60 – 80% Zn = 20 – 40%
2.	Bronze	Cu = 75 – 90% Sn = 10 – 25%
3.	Aluminium bronze	Cu = 90% Al = 10%
4.	Phosphorus bronze	Cu = 85% Sn = 13% P = 2%
5.	Silica bronze	Cu = 97% Sn = 2% Si = 1%
6.	German silver or nickel silver	Cu = 50% Zn = 30% Ni = 20%
7.	Gun metal	Cu = 88% Sn = 10% Zn = 2%
8.	Monel metal	Cu = 30% Ni = 67% Fe + Mn = 3%

## Reactivity

The transition elements have less tendency to react due to their high heat of sublimation, high ionisation energies and low heats of hydration.

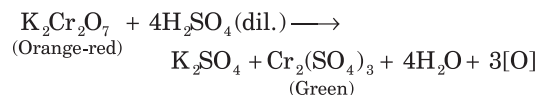
## Compounds of *d*-Block Elements

### Potassium Dichromate ( $\text{K}_2\text{Cr}_2\text{O}_7$ )

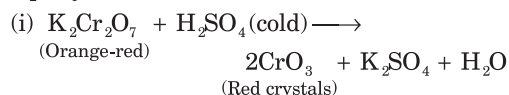
- It is manufactured from chromite ore,  $\text{FeO} \cdot \text{Cr}_2\text{O}_3$ .
- It is an orange red prismatic crystal that is moderately soluble in water but highly soluble in hot water.
- When heated, it is decomposed to  $\text{Cr}_2\text{O}_3$



- It acts as a strong oxidising agent in the presence of dilute  $\text{H}_2\text{SO}_4$  due to the formation of nascent oxygen.



- It oxidises KI,  $\text{FeSO}_4$  and  $\text{H}_2\text{S}$  to  $\text{I}_2$ ,  $\text{Fe}_2(\text{SO}_4)_3$  and S, respectively.
- It reacts differently with different concentration of  $\text{H}_2\text{SO}_4$ .



## Catalytic Properties

Transition elements on account of their variable valency have the ability to form intermediate compounds very readily thus, acts as good catalysts.

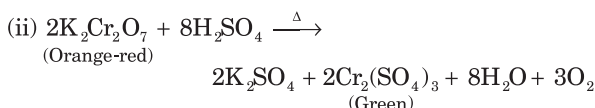
## Complex Formation

They have the unique tendency to form complex compounds due to small size, high positive charge density and vacant *d*-orbitals to accept electron pair from ligands.

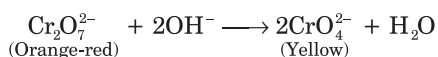
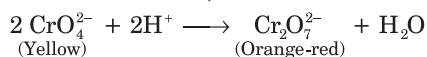
## Alloy Formation

Different transition metals, due to similarity in the radii favours their homogeneous mixing at high temperature forming different alloys.

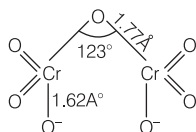
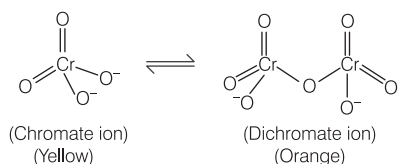
## RAPID CONCEPT REVISION



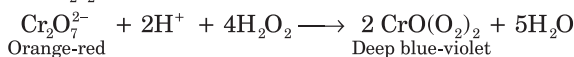
- In acidic and basic medium, it reacts as follows



Hence, it is evident that an equilibrium is maintained between the concentration of  $Cr_2O_7^{2-}$  and  $CrO_4^{2-}$  that can be altered by altering the pH of the solution.

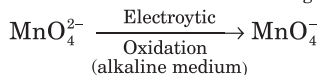
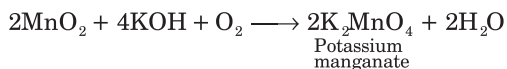


- Acidified solution of  $K_2Cr_2O_7$  reacts with  $H_2O_2$  producing  $CrO(O_2)_2$ .



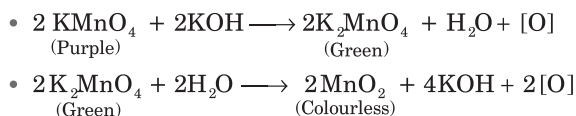
### Potassium Permanganate ( $KMnO_4$ )

- Commercially, it is prepared from pyrolusite ore ( $MnO_2$ ). Alkaline oxidative fusion of  $MnO_2$  followed by electrolytic oxidation gives  $KMnO_4$ .

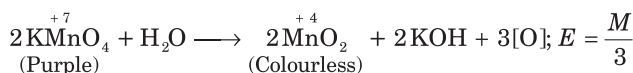


- It is a purple black prismatic crystal, when dissolved in water gives dense pink or purple colour solution.
- It is a good oxidising agent but the course of reaction depends on whether the reaction is carried out in acidic, alkaline or neutral medium.

#### (i) In alkaline medium



#### Overall reaction

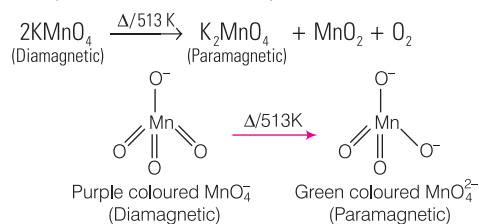


- In alkaline medium,  $KMnO_4$  oxidises  $I^-$ ,  $NH_3$ , nitrotoluene etc., to  $IO_3^-$ ,  $N_2$ , nitrobenzoic acid, etc., respectively.

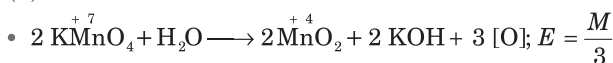
### Magnetic Behaviour of Manganate and Permanganate Ion

Although the manganate ( $MnO_4^{2-}$ ) and permanganate ( $MnO_4^-$ ) ions have tetrahedral shape, they have different colour and magnetic behaviour.

Green coloured,  $MnO_4^{2-}$  ion is paramagnetic with one unpaired electron, whereas the purple coloured,  $MnO_4^-$  ion is diamagnetic.  $MnO_4^-$  is decomposed to  $MnO_4^{2-}$  ion, when heated at 513 K.

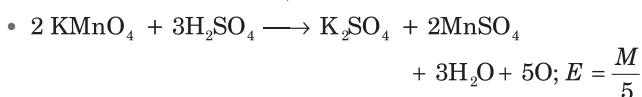


#### (ii) In neutral medium



- In neutral medium,  $KMnO_4$  oxidises  $Mn^{2+}$ ,  $Na_2S_2O_3$ ,  $H_2S$  etc., to  $MnO_2$ ,  $Na_2S_4O_6$ ,  $S$ , etc., respectively.

#### (iii) In acidic medium ( $H_2SO_4$ and hot $HCl$ is used to create acidic medium)

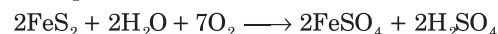


- In acidic medium,  $KMnO_4$  oxidises  $Fe(II)$  salt,  $H_2C_2O_4$ ,  $H_2S$ ,  $SO_2$ ,  $SO_3^{2-}$ ,  $NO_2^-$ ,  $I^-$ ,  $H_2O_2$ , etc., to  $Fe(III)$  salt,  $CO_2$ ,  $S$ ,  $H_2SO_4$ ,  $SO_4^{2-}$ ,  $NO_3^-$ ,  $I_2$ ,  $O_2$ , etc., respectively.

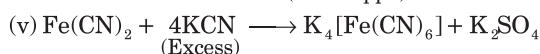
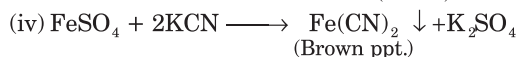
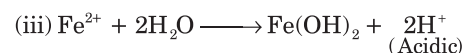
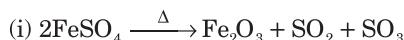
**Note** Here,  $HCl$  is not taken to create acidic medium because  $HCl$  is oxidised to chlorine by  $KMnO_4$ .

### Ferrous Sulphate or Green Vitriol ( $FeSO_4 \cdot 7H_2O$ )

- It is prepared industrially by slow oxidation of iron pyrites ( $FeS_2$ ) in presence of air.



- It is used in the treatment of iron deficiency and in different industries.
- It shows the following chemical properties:







## RAPID CONCEPT REVISION

- Due to lanthanide contraction, the size of 5th and 6th period transition elements are identical and hence, it becomes very difficult to separate these elements.
- Also, due to lanthanide contraction, 5th and 6th period transition elements resemble each other more likely than 4th period transition elements.

## Physical and Chemical Properties

### Atomic Radius

They have almost similar radius and does not follow any regular trend due to lanthanide contraction.

### REMEMBER

The lanthanide series elements have almost similar physical and chemical properties due to their similarity in radius. Hence, it becomes very difficult to separate lanthanide series elements from each other. Ion exchange method and valence exchange method are the most effective methods to separate them.

### Ionisation Enthalpy

They have low ionisation enthalpy as compared to *s*-block elements and Al. Hence, they are more electropositive and highly reactive.

### Oxidation State

- Lanthanides exhibit + 2, + 3 and + 4 oxidation state but +3 is the most stable one. Therefore, they are primarily trivalent.
- Actinides show a variety of oxidation states from +2 to +7. Also, their stability vary among different elements.

### Colour and Magnetic Behaviour

- Both lanthanides and actinides form coloured complexes because of *f-f* transition due to presence of partly filled *f*-orbitals.

- All lanthanoids are coloured, except  $\text{La}^{3+}$ ,  $\text{Ce}^{3+}$ ,  $\text{Gd}^{3+}$ ,  $\text{Lu}^{3+}$ ,  $\text{Yb}^{3+}$ .
- All lanthanoids are paramagnetic, except  $\text{Lu}^{3+}$ ,  $\text{Yb}^{2+}$  and  $\text{Ce}^{4+}$ .

### REMEMBER

During the calculation of magnetic moment for *f*-block elements, both spin quantum number(s) and orbital quantum numbers (*l*) are considered. Hence,

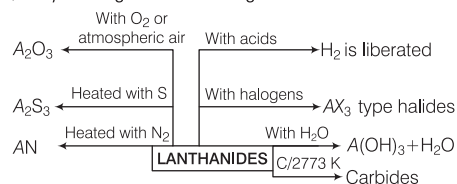
$$\mu_{\text{eff}} = \sqrt{4s(s+1) + l(l+1)} \text{ BM}$$

### Reactivity

Due to low ionisation energy which is comparable with *s*-block elements, they are highly electropositive and hence, more reactive.

### Reactivity of Lanthanides

- Lanthanides are much more reactive than Al and their reactivity is comparable to that of magnesium.
- Hence, they undergo the following chemical reactions:



Here, A = lanthanides

- The hydrides of lanthanides are basic and the basicity decreases from left [ $\text{Ce(OH)}_3$ ] to right [ $\text{Lu(OH)}_3$ ] due to decrease in ionic radius. Hence, the order of basicity is  $\text{Ce(OH)}_3 > \text{Pr(OH)}_3 > \text{Nd(OH)}_3 \dots$   
 $\dots \text{Tm(OH)}_3 > \text{Yb(OH)}_3 > \text{Lu(OH)}_3$
- The hydroxides react with concentrated alkali to form complexes.  
 $\text{Lu(OH)}_3 + 3\text{NaOH} \longrightarrow 3\text{Na}^+ + [\text{Lu(OH)}_6]^{3-}$

## MASTER STROKES

1. Which of the following compounds is not yellow coloured? [JEE Main 2015]

- (a)  $\text{Zn}_2[\text{Fe(CN)}_6]$  (b)  $\text{K}_3[\text{Co(NO}_2)_6]$   
 (c)  $(\text{NH}_4)_3[\text{As(Mo}_3\text{O}_{10})_4]$  (d)  $\text{BaCrO}_4$

2. Which of the following compounds is metallic and ferromagnetic? [JEE Main 2015]

- (a)  $\text{CrO}_2$  (b)  $\text{VO}_2$  (c)  $\text{MnO}_2$  (d)  $\text{TiO}_2$

3. Zinc does not show variable valency like *d*-block elements because

- (a) it is low melting  
 (b) *d*-orbital is complete  
 (c) it is a soft metal  
 (d) two electrons are present in the outermost orbit

4. Which series of reactions correctly represents chemical relations related to iron and its compounds?

- (a)  $\text{Fe} \xrightarrow{\text{dil. H}_2\text{SO}_4} \text{FeSO}_4 \xrightarrow{\text{H}_2\text{SO}_4, \text{O}_2} \text{Fe}_2(\text{SO}_4)_3 \xrightarrow{\text{Heat}} \text{Fe}$   
 (b)  $\text{Fe} \xrightarrow{\text{O}_2, \text{Heat}} \text{FeO} \xrightarrow{\text{dil. H}_2\text{SO}_4} \text{FeSO}_4 \xrightarrow{\text{Heat}} \text{Fe}$   
 (c)  $\text{Fe} \xrightarrow{\text{Cl}_2, \text{Heat}} \text{FeCl}_3 \xrightarrow{\text{Heat, air}} \text{FeCl}_2 \xrightarrow{\text{Zn}} \text{Fe}$   
 (d)  $\text{Fe} \xrightarrow{\text{O}_2, \text{Heat}} \text{Fe}_3\text{O}_4 \xrightarrow{\text{CO, 600}^\circ\text{C}} \text{FeO} \xrightarrow{\text{CO, 700}^\circ\text{C}} \text{Fe}$

5. Why HCl is not used to make the medium acidic in oxidation reactions of  $\text{KMnO}_4$  in acidic medium?

- (a) Both HCl and  $\text{KMnO}_4$  act as oxidising agents  
 (b)  $\text{KMnO}_4$  oxidises HCl into  $\text{Cl}_2$  which is also an oxidising agent

- (c)  $\text{KMnO}_4$  is a weaker oxidising agent than  $\text{HCl}$   
 (d)  $\text{KMnO}_4$  acts as a reducing agent in the presence of  $\text{HCl}$
- 6.** Cuprous ion is colourless while cupric ion is coloured because  
 (a) both have half-filled  $p$  and  $d$ -orbitals  
 (b) cuprous and cupric ions have complete and incomplete  $d$ -orbitals, respectively  
 (c) cuprous and cupric ions have incomplete and complete  $d$ -orbitals, respectively  
 (d) Both have unpaired electrons in  $d$ -orbitals
- 7.** The catalytic activity of the transition metals and their compounds are described by their  
 (a) magnetic behaviour  
 (b) chemical reactivity  
 (c) ability to adopt multiple oxidation states and their complexing ability  
 (d) unfilled  $d$ -orbitals
- 8.** The magnetic moment is associated with its spin angular momentum and orbital angular momentum. Spin only magnetic moment value of  $\text{Cr}^{3+}$  ion is  
 (a) 2.87 BM (b) 3.87 BM  
 (c) 3.47 BM (d) 3.57 BM
- 9.** On heating  $\text{K}_2\text{Cr}_2\text{O}_7$  with  $\text{NaCl}$  and conc.  $\text{H}_2\text{SO}_4$ , the gas liberated is  $\text{CrO}_2\text{Cl}_2$ . The fumes when passed through  $\text{NaOH}$  solution form  
 (a)  $\text{CrO}_4^{2-}$  (b)  $\text{CrCl}_3$   
 (c)  $\text{Cr}_2\text{O}_3$  (d)  $\text{CrOCl}_2$
- 10.** Among  $\text{K}$ ,  $\text{Ca}$ ,  $\text{Fe}$  and  $\text{Zn}$ , the element which can form more than one binary compound with chlorine is  
 (a)  $\text{Fe}$  (b)  $\text{Zn}$  (c)  $\text{K}$  (d)  $\text{Ca}$
- 11.** Which of the following has the maximum number of unpaired  $d$ -electrons?  
 (a)  $\text{Fe}^{2+}$  (b)  $\text{Cu}^+$  (c)  $\text{Zn}$  (d)  $\text{Ni}^{3+}$
- 12.** Which of the following arrangements does not represent the correct order of the property stated against it?  
 (a)  $\text{V}^{2+} < \text{Cr}^{2+} < \text{Mn}^{2+} < \text{Fe}^{2+}$  : Paramagnetic behaviour  
 (b)  $\text{Ni}^{2+} < \text{Co}^{2+} < \text{Fe}^{2+} < \text{Mn}^{2+}$  : Ionic size  
 (c)  $\text{Co}^{3+} < \text{Fe}^{3+} < \text{Cr}^{3+} < \text{Sc}^{3+}$  : Stability in aqueous solution  
 (d)  $\text{Sc} < \text{Ti} < \text{Cr} < \text{Mn}$  : Number of oxidation states
- 13.** Copper exhibits only + 2 oxidation state in its stable compounds. Choose the correct option.  
 (a) Copper is transition metal in +2 state  
 (b) + 2 state compounds of copper are formed by exothermic reactions  
 (c) Electronic configuration of copper in +2 state is  $[\text{Ar}]3d^9, 4s^0$   
 (d) Copper gives coloured compounds in +2 state
- 14.** Which of the following statements about the interstitial compounds is incorrect?  
 (a) They retain metallic conductivity  
 (b) They are chemically reactive  
 (c) They are much harder than the pure metal  
 (d) They have higher melting points than the pure metal
- 15.** Electronic configuration of a transition elements  $X$  in + 3 oxidation state is  $[\text{Ar}] 3d^5$  and  $Y$  in + 2 state is  $[\text{Ar}] 3d^8$ . What are the atomic numbers of  $X$  and  $Y$ , respectively  
 (a) 23 and 26 (b) 26 and 28  
 (c) 21 and 25 (d) 24 and 26
- 16.** All the following statements about the  $3d$ -series elements are true except that  
 (a) scandium has lowest density  
 (b) enthalpy of atomisation of zinc is lowest  
 (c) first ionisation energy of  $\text{Sc}$  is lowest and zinc is highest  
 (d) scandium has lowest melting point
- 17.**  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  absorbs green and yellow region part of visible light. Then, the transmitted colour of the compound is  
 (a) purple (b) green (c) blue (d) red
- 18.** Experimental value of magnetic moment of  $\text{Mn}^{2+}$  complex is 5.96 BM. This indicates  
 (a) axial and orbital motion of electron in same direction  
 (b) axial and orbital motion of electron in opposite direction  
 (c) electron does not exhibit orbital motion, it only exhibits axial motion  
 (d) electron does not exhibit axial motion, it only exhibits orbital motion
- 19.** Among the following pair of ions, the lower oxidation state in aqueous solution is more stable in  
 (a)  $\text{V}^{2+}, \text{VO}^{2+}$  (b)  $\text{Cr}^{2+}, \text{Cr}^{3+}$   
 (c)  $\text{Ti}^+, \text{Ti}^{3+}$  (d)  $\text{Cu}^+, \text{Cu}^{2+}$
- 20.** Which of the following is the incorrect statement for transition metals?  
 (a) They have high melting and boiling points  
 (b) They form ionic and covalent compounds  
 (c) They do not show variable valency  
 (d) Their compounds are generally coloured
- 21.** Which of the following pairs of elements cannot form an alloy?  
 (a)  $\text{Zn}, \text{Cu}$  (b)  $\text{Fe}, \text{Hg}$  (c)  $\text{Fe}, \text{C}$  (d)  $\text{Hg}, \text{Na}$
- 22.** Which of the following is the green coloured powder produced when ammonium dichromate is used in fire works?  
 (a)  $\text{Cr}$  (b)  $\text{CrO}_3$  (c)  $\text{Cr}_2\text{O}_3$  (d)  $\text{CrO}(\text{O}_2)$
- 23.**  $\text{CuSO}_4$  when reacts with  $\text{KCN}$  forms  $\text{CuCN}$  which is insoluble in water. It is soluble in excess of  $\text{KCN}$ , due to formation of which of the following complex  
 (a)  $\text{K}_2[\text{Cu}(\text{CN})_4]$  (b)  $\text{K}_3[\text{Cu}(\text{CN})_4]$   
 (c)  $\text{CuCN}_2$  (d)  $\text{Cu}[\text{KCu}(\text{CN})_4]$
- 24.** Which of the following statements regarding transition elements is false?  
 (a) They are all metals  
 (b) They easily form complex coordination compounds  
 (c) They form compounds containing unpaired electrons and their ions are mostly coloured  
 (d) They show multiple oxidation states always differing by units of two


**RAPID CONCEPT REVISION**

- 25.** In Cu how many electrons have spin in one direction and in other direction? (Atomic number = 29)
- (a) 13 electrons have spin in one direction and 16 electrons in other direction  
 (b) 14 electrons have spin in one direction and 15 electrons in other direction  
 (c) one electron can have spin only in the clockwise direction  
 (d) None of the above
- 26.** Many copper (I) compounds are unstable in aqueous solution and undergo disproportionation as  $2\text{Cu}^+ \longrightarrow \text{Cu} + \text{Cu}^{2+}$ . This is due to
- (a) free energy change of reaction is positive  
 (b) free energy of reaction is negative  
 (c) second ionisation energy of Cu is higher than first ionisation energy  
 (d) hydration energy of  $\text{Cu}^+$  is less than  $\text{Cu}^{2+}$
- 27.**  $\text{KMnO}_4$  can be prepared from  $\text{K}_2\text{MnO}_4$  as per the reaction,
- $$3\text{MnO}_4^{2-} + 2\text{H}_2\text{O} \rightleftharpoons 2\text{MnO}_4^- + \text{MnO}_2 + 4\text{OH}^-$$
- The reaction can go completion by removing  $\text{OH}^-$  ions by adding
- (a) HCl (b) KOH (c)  $\text{CO}_2$  (d)  $\text{SO}_2$
- 28.** Pyrolusite in  $\text{MnO}_2$  is used to prepare  $\text{KMnO}_4$ . Steps are  $\text{MnO}_2 \xrightarrow{\text{I}} \text{MnO}_4^{2-} \xrightarrow{\text{II}} \text{MnO}_4^-$
- Here, I and II are
- (a) fused with KOH/air, electrolytic oxidation  
 (b) fused with KOH/air, electrolytic reduction  
 (c) fuse with conc.  $\text{HNO}_3$ /air, electrolytic oxidation  
 (d) All are correct
- 29.** A transition metal A has 'spin-only' magnetic moment value of 1.8 BM. When it is reacted with dilute sulphuric acid in the presence of air, a compound B is formed. B reacts with compound C to give compounds D with liberation of iodine. Then, the metal A and compounds B, C and D are respectively
- (a) Ti,  $\text{TiSO}_4$ , KI and  $\text{TiI}_2$  (b) Zn,  $\text{ZnSO}_4$ , KI and  $\text{Zn}_2\text{I}_2$   
 (c) Cu,  $\text{CuSO}_4$ , KI and  $\text{Cu}_2\text{I}_2$  (d) Cu,  $\text{CuSO}_4$ ,  $\text{Cu}_2\text{I}_2$  and  $\text{CuI}_2$
- 30.** Which one of the following acts as an oxidising agent?
- (a)  $\text{Np}^{4+}$  (b)  $\text{Sm}^{2+}$  (c)  $\text{Eu}^{2+}$  (d)  $\text{Yb}^{2+}$
- 31.** Across the lanthanide series, the basicity of lanthanide hydroxides
- (a) increases  
 (b) decreases  
 (c) first increases and then decreases  
 (d) first decreases and then increases
- 32.** The +3 ion of which one of the following has half-filled 4f-subshell?
- (a) La (b) Lu (c) Gd (d) Ce
- 33.** Select the correct statement.
- (a)  $\text{Pu}^{4+}$  disproportionates to  $\text{Pu}^{3+}$  and  $\text{PuO}_2^{2+}$  in strongly acidic medium  
 (b) Maximum oxidation state of Np is +7  
 (c)  $\text{UO}_2^{2+}$  is stable  
 (d) All of the above are correct statements
- 34.** The lanthanoids contraction is related to
- (a) atomic radii (b) atomic as well as  $M^{3+}$  radii  
 (c) valence electrons (d) oxidation states
- 35.** The reason for the stability of  $\text{Gd}^{3+}$  ion is
- (a) half-filled 4f-subshell  
 (b) completely filled 4f-subshell  
 (c) possesses the general electronic configuration of noble gases  
 (d) empty 4f-subshell
- 36.** The electronic configuration of actinoids cannot be assigned with degree of certainty because of
- (a) overlapping of inner orbitals  
 (b) free movement of electrons all over the orbitals  
 (c) small energy difference between 5f and 6d levels  
 (d) None of the above
- 37.** The general electronic configuration of actinides is  $(n-2)f^{1-14} (n-1)d^{0-1} ns^2$ . Which one of the following actinides has one electron in 6d-orbital?
- (a) Cm ( $Z=96$ ) (b) Lr ( $Z=103$ )  
 (c) Np ( $Z=93$ ) (d) All of these
- 38.** More number of oxidation states are exhibited by the actinoids than by the lanthanoids. The main reason for this is
- (a) lesser energy difference between 5f- and 6d-orbitals than between 4f- and 5f-orbitals  
 (b) greater metallic character of the lanthanoids than that of the correspondings actinoids  
 (c) more reactive nature of the actinoids  
 (d) more energy difference between 5f- and 6d-orbitals than between 4f- and 5d-orbitals.
- 39.** The actinoids exhibit more number of oxidation states in general than the lanthanoids. This is because
- (a) the 5f-orbitals are more buried than the 4f-orbitals  
 (b) there is a similarity between 4f and 5f-orbitals in their angular part of the wave function  
 (c) the actinides are more reactive than the lanthanides  
 (d) the 5f-orbitals extend farther from the nucleus than the 4f-orbitals
- 40.** Identify the incorrect statement among the following.
- (a) There is a decreases in the radii of the atoms or ions as one proceeds from La to Lu  
 (b) Lanthanoid contraction is the accumulation of successive shrinkages  
 (c) As a result of lanthanoid contraction, the properties of 4d-series of the transition elements have no similarities with the 5d-series of elements  
 (d) Shielding power of 4f-electrons is quite weak
- 41.** The compound used in enrichment of uranium for nuclear power plant is
- (a)  $\text{U}_3\text{O}_8$  (b)  $\text{UF}_6$  (c)  $\text{UCl}_4$  (d)  $\text{UO}_2(\text{NO}_2)_2$
- 42.** Lanthanides contraction causes
- (a) small increases in basic strength of oxides of lanthanides  
 (b) great variation in chemical properties of lanthanides  
 (c) small increases in electronegativities of lanthanides  
 (d) small decreases in standard electrode potential value of lanthanides

**To be Continued at Page 87**


**TARGET NEET 2017**
**MEDI QUEST**

Comprehensive Simulator Test Series for NEET &amp; AIIMS

# NEET

## SCALE UP

Mock Questions from Complete Syllabus with Answer key.

**FULL TEST**

# 4

 (Complete Syllabus)  
WITH ANSWER KEY

**INSTRUCTIONS**

- This test consists of 45 questions and each question is allotted 4 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/4 marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
- There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted according as per instructions.

1. The temperature dependence of rate constant ( $K$ ) of a chemical reaction is represented in terms of Arrhenius equation,  $K = Ae^{-E_a/RT}$ .

 Activation energy  $E_a$  of the reaction can be determined by plotting,

- (a)  $\log K$  vs  $1 / \log T$       (b)  $K$  vs  $T$   
(c)  $K$  vs  $1 / \log T$       (d)  $\log K$  vs  $1 / T$

2. The approximate time duration in hour to electroplate 30 g of calcium from molten calcium chloride using a current of 5 A is  
(a) 80      (b) 16      (c) 8      (d) 10

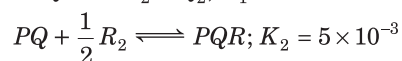
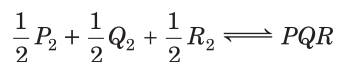
3. For a first order reaction, quarter life time is 138.6 sec. Which of the following is the correct value for specific reaction rate constant in  $\text{sec}^{-1}$   
(a)  $10^{-2}$       (b)  $10^{-1}$       (c)  $10^{-3}$       (d)  $10^{-7}$

4. NaCl shows Schottky whereas AgCl shows Frenkel defects. Their electrical conductivities arise due to  
(a) lower coordination number of NaCl  
(b) higher coordination number of AgCl  
(c) motion of ions  
(d) motion of electrons

5. A solution of a non-volatile solute in water freezes at  $-0.30^\circ\text{C}$ . The vapour pressure of pure water at 298 K is 23.51 mm of Hg and  $K_f$  for water is 1.86 degree/molal. What would be the vapour pressure of this solution at 298 K?

- (a) 13 mm of Hg      (b) 23.44 mm of Hg  
(c) 20.03 mm of Hg      (d) None of these

6. Consider the following two reversible reactions,  
 $2PQ \rightleftharpoons P_2 + Q_2; K_1 = 2.5 \times 10^5$


 What would be the value of  $K_3$  for the reaction,


- (a)  $2.5 \times 10^{-3}$       (b)  $2.5 \times 10^3$   
(c)  $1 \times 10^{-3}$       (d)  $5 \times 10^{-3}$

7. An atom with electronic configuration  $1s^2 2s^2, 2p^6, 3s^2, 3p^6 3d^3, 4s^2$  is placed in  
(a) fifth group      (b) fifteenth group  
(c) second group      (d) third group

8. In Victor Meyer's experiment, 0.23 g of a volatile solute displaces air which measures 112 mL at NTP. What would be the vapour density of substance?  
(a) 20.02      (b) 23.01  
(c) 25.03      (d) 10.05

9. Glucose has difference from fructose in the fact that it  
(a) does not undergo hydrolysis  
(b) gives silver mirror with Tollen's reagent  
(c) is monosaccharide  
(d) None of the above

 TARGET NEET 2017

10. While moving down a group in the periodic table, which of the following statement would be incorrect?
- All the atoms have the same number of valence electrons
  - Atomic radii increases
  - Electronegativity decreases
  - Metallic character decreases and the basic nature of their oxides decreases.

11. Which of the following is correct about the order,  $\text{BeH}_2 < \text{MgH}_2 < \text{CaH}_2 < \text{SrH}_2 < \text{BaH}_2$ ?
- increase in ionic nature
  - increase in solubility
  - increases in hydration energy
  - None of the above

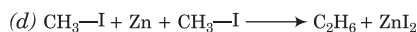
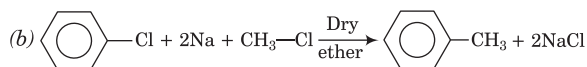
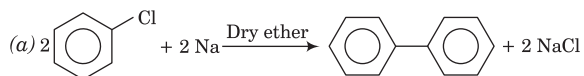
12. A 0.01 M complex of  $\text{CoCl}_2$  and  $\text{NH}_3$  (molar ratio 1 : 4) is found to have effective molarity of 0.02 M. What would be the formula of the complex compound?
- $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$
  - $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$
  - $[\text{Co}(\text{NH}_3)_4]\text{Cl}_3$
  - $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}$

13.  $[\text{Ni}(\text{en})_3]^{2+}$  is nearly  $10^{10}$  times more stable than  $[\text{Ni}(\text{NH}_3)_6]^{2+}$  because
- $\text{NH}_3$  is the weakest ligand
  - 'en' is a chelating ligand which forms thermodynamically more stable complexes.
  - six  $\text{NH}_3$  ligands cause steric hindrance around the  $\text{Ni}^{2+}$  center
  - $\text{NH}_3$  evaporates easily and causes instability to the  $[\text{Ni}(\text{NH}_3)_6]^{2+}$  complex

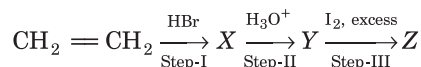
14. Choose the correct statement regarding lanthanides.
- Basic character of oxides of lanthanides increases from La to Lu
  - These are as reactive as alkali metals
  - Fluorides and oxalates of lanthanides are insoluble in water
  - These burn in oxygen to give their dioxides

15. Choose the correct statement from the following?
- $\alpha$ -sulphur is most stable form exists at room temperature
  - $\beta$ -sulphur exists as blue coloured crystals
  - $\beta$ -sulphur is insoluble in  $\text{CS}_2$
  - Rhombic ( $\alpha$ ) form cannot change into monoclinic form ( $\beta$ )

16. Which of the following reaction is an example of Wurtz reaction?

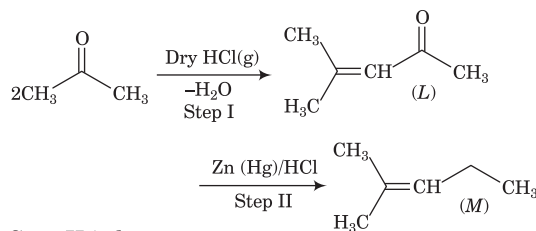


17. In the reaction,



product formed in step III is

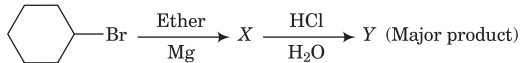
- $\text{CH}_3\text{CHO}$
  - $\text{CHI}_3$
  - $\text{C}_2\text{H}_5\text{I}$
  - $\text{C}_2\text{H}_5\text{OH}$
18. Which one of the following is not an antimalarial compound?
- Quinine
  - Chloroquine
  - Ranitidine
  - Primaquine
19. Which of the following salt would give  $\text{SO}_2$  with hot and dil.  $\text{H}_2\text{SO}_4$  and also decolourises  $\text{Br}_2$  water
- $\text{Na}_2\text{SO}_3$
  - $\text{NaHSO}_4$
  - $\text{Na}_2\text{SO}_4$
  - $\text{Na}_2\text{S}$
20. A compound 'P' when treated with nitric acid in the presence of sulphuric acid gives compound 'Q' which is then reduced with Sn and HCl to aniline. The compound 'P' will be
- acetamide
  - ethane
  - benzene
  - toluene
21. Choose the appropriate reagent from the following to distinguish benzyl alcohol and benzyl methyl ether
- acidic  $\text{K}_2\text{Cr}_2\text{O}_7$
  - alkaline  $\text{K}_2\text{Cr}_2\text{O}_7$
  - $\text{Br}_2 / \text{CCl}_4$
  - NaOH
22. In the reaction sequence,



Step II is known as

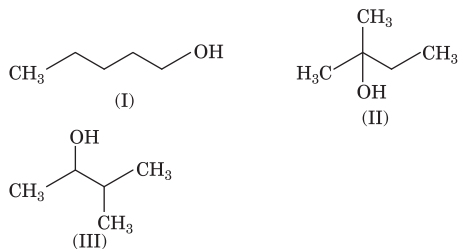
- Wolff-Kishner reduction
  - Aldol-condensation
  - Clemmensen reduction
  - Meerwein-Ponndorf-Verley reduction
23. Select the correct statement from the following.
- 4-nitro benzoic acid is less acidic than picric acid
  - Benzoic acid is less acidic than phenol
  - 4-methoxy benzoic acid is less basic than 4-methyl benzoic acid
  - 2-fluoro benzoic acid is more basic than 2-chloro benzoic acid
24. The equivalent conductance at infinite dilution of HCl and NaCl are 426.15 and 126.15  $\text{mho cm}^2 \text{g}^{-1} \text{eq}^{-1}$ , respectively. It can be said that the mobility of
- $\text{H}^+$  ions is much more than that of  $\text{Cl}^-$  ions
  - $\text{Cl}^-$  ions is much more than that of  $\text{H}^+$  ions
  - $\text{H}^+$  ions is much more than that of  $\text{Na}^+$  ions
  - $\text{Na}^+$  ions is much more than that of  $\text{H}^+$  ions

- 25.** The equivalent mass of  $\text{KMnO}_4$  in the following reaction,  
 $\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \rightarrow \text{Mn}^{2+} + 5\text{Fe}^{3+} + 4\text{H}_2\text{O}$   
 ( $M$  = Molecular mass) is  
 (a)  $\frac{M}{2}$  (b)  $\frac{M}{3}$  (c)  $\frac{M}{4}$  (d)  $\frac{M}{5}$
- 26.** Consider the following statements about chemisorption.  
 I. It is reversible in nature  
 II. It first increases with increase in temperature and then with pressure  
 III. It involves the formation of a compound on the surface of the solid adsorbent  
 Choose the correct statement.  
 (a) Only I (b) Only II  
 (c) Both (a) and (b) (d) All of these
- 27.**  $\text{CaO}$  and  $\text{NaCl}$  have same crystal structure and nearly the same ionic radii. If ' $X$ ' is the lattice energy of  $\text{NaCl}$ , what would be the lattice energy of  $\text{CaO}$ ?  
 (a)  $4X$  (b)  $\frac{X}{2}$  (c)  $\frac{X}{8}$  (d)  $2X$
- 28.** Consider the following aqueous solutions,  
 I.  $10^{-4}\text{M}$   $\text{KCl}$  II.  $10^{-3}\text{M}$  urea  
 III.  $10^{-3}\text{M}$   $\text{CaCl}_2$  IV.  $10^{-3}\text{M}$   $\text{KCl}$   
 the correct decreasing order of boiling point is  
 (a)  $\text{II} > \text{III} > \text{I} > \text{IV}$  (b)  $\text{III} > \text{II} > \text{IV} > \text{I}$   
 (c)  $\text{I} = \text{IV} > \text{II} > \text{IV}$  (d)  $\text{I} > \text{IV} > \text{II} > \text{III}$
- 29.** For a reaction at 300 K, enthalpy and entropy changes are  $-11.5 \times 10^3 \text{ J mol}^{-1}$  and  $-105 \text{ J K}^{-1} \text{ mol}^{-1}$ , respectively. The reaction is  
 (a) spontaneous (b) non-spontaneous  
 (c) data is insufficient (d) cannot predict
- 30.** Pure ammonia is kept in a vessel at a temperature where its dissociation constant ( $\alpha$ ) is considerable. What would be happened at equilibrium?  
 (a)  $\alpha$  does not change with pressure  
 (b) concentration of ammonia does not change with pressure  
 (c) concentration of hydrogen is less than that of nitrogen  
 (d)  $K_p$  does not change significantly with pressure
- 31.** What would be the number of gram molecules of oxygen in  $6.02 \times 10^{24}$   $\text{CO}$  molecules?  
 (a) 10 g molecules (b) 5 g molecules  
 (c) 1 g molecules (d) 0.5 g molecules
- 32.** Which of the following pair of species consists two lone pair on central atom.  
 (a)  $\text{CCl}_4$ ,  $\text{BX}_4^-$  (b)  $\text{PH}_3$ ,  $\text{NH}_3$  (c)  $\text{OF}_2$ ,  $\text{SCl}_2$  (d)  $\text{TeCl}_4$ ,  $\text{SF}_4$
- 33.** Consider the following reaction sequence,  

$$M \xrightarrow{\text{O}_2} M_2\text{O} \xrightarrow{\text{O}_2} M_2\text{O}_2 \xrightarrow{\text{O}_2} \text{MO}_2$$
  
 ' $M$ ' represents which of the following metals.  
 (a) K (b) Rb  
 (c) Cs (d) All of these
- 34.** In group IV-A of the extended form of the periodic table, the oxidising power of tetravalent species varies in the order  
 (a)  $\text{Ge} > \text{Sn} > \text{Pb}$  (b)  $\text{Pb} > \text{Sn} > \text{Ge}$   
 (c)  $\text{Pb} > \text{Ge} > \text{Sn}$  (d)  $\text{Ge} > \text{Pb} > \text{Sn}$
- 35.**  $\text{M}(\text{H}_2\text{O})_6]^{2+}$  obeys 18-electron rule. ' $M$ ' refers to  
 (a) Mn (b) Fe (c) Ni (d) Co
- 36.** The reason behind the fact that, 'In the silver plating of copper,  $\text{K}[\text{Ag}(\text{CN})_2]$  is used instead of  $\text{AgNO}_3$  is  
 (a) more voltage is needed  
 (b) a thin layer of Ag is formed on Cu  
 (c)  $\text{Ag}^+$  ions are completely removed from solution  
 (d) less availability of  $\text{Ag}^+$  ion, as Cu cannot displace Ag from  $[\text{Ag}(\text{CN})_2]^-$  ion.
- 37.** Choose the correct statement regarding bleaching powder.  
 (a) It is a pale green powder  
 (b) Filtrate of bleaching powder gives the test of chloride  
 (c) It loses its chlorine on reacting with carbon dioxide  
 (d) In acidic medium, it reduces KI solution into  $\text{I}_2$
- 38.** Consider the following compounds,  
 I.  $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{OH}$  II.  $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$   
 Choose the correct option  
 (a) 'I' is stronger acid than 'II'  
 (b) 'II' is stronger acid than 'I'  
 (c) Acid anion obtained in 'I' is stabilised by resonance  
 (d) Acid anion obtained in 'II' is stabilised by hyper-conjugation
- 39.** In the reaction,  
  
 The major product (Y) is  
 (a) hexane (b) cyclohexane  
 (c) cyclohexyl cyclohexane (d) cyclohexyl ether
- 40.** An alkyl chloride produces a single alkene on reaction with sodium ethoxide and ethanol. The alkene further undergoes hydrogenation to yield 2-methyl-butane. The unknown alkyl chloride is  
 (a)  $\text{ClCH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$  (b)  $\text{ClCH}_2\text{C}(\text{CH}_3)_2\text{CH}_3$   
 (c)  $\text{ClCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$  (d)  $\text{CH}_3\text{C}(\text{Cl})(\text{CH}_3)\text{CH}_2\text{CH}_3$
- 41.** The structure of  $\alpha$ -amino acid,  $\text{H}_2\text{N}-\overset{\text{COOH}}{\underset{\text{R}}{\text{C}}}-\text{H}$  will exist at which pH value?  
 (a) 0 (b) 2 (c) 4 (d) 7
- 42.**  $\text{C}_6\text{H}_5\text{NH}_2 \xrightarrow{(\text{CH}_3\text{CO})_2\text{O}} \text{X} \xrightarrow{\text{Br}_2/\text{CCl}_4} \text{Y} \xrightarrow[\text{H}^+]{\text{HOH}} \text{Z}$ . Product 'Z' would be  
 (a) bromo acetophenone (b) *o*-bromo acetanilide  
 (c) *p*-bromo aniline (d) *o*-bromo acetophenone

 TARGET NEET 2017

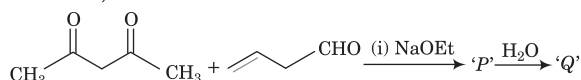
43. Consider the following alcohols,



The correct order of their solubility is

- (a) I > II > III (b) III > II > I  
 (c) II > I > III (d) II > III > I

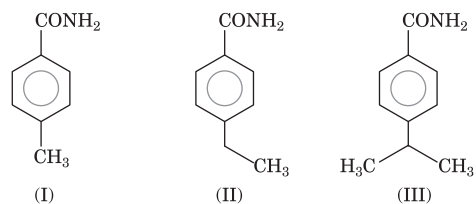
44. Consider the following sequence of chemical reaction,



How many number of carbonyl group present in the product 'Q'?

- (a) 2 (b) 3 (c) 1 (d) 0

45. Considering the following acid amide,



Choose the correct decreasing order of reactivity of these amides in Hofmann-bromamide reaction.

- (a) I > II > III (b) II > III > I (c) III > II > I (d) II > I > III

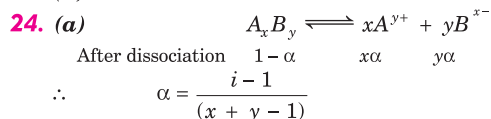
### Answers

1. (d) 2. (c) 3. (a) 4. (c) 5. (b)  
 6. (c) 7. (a) 8. (b) 9. (b) 10. (d)  
 11. (a) 12. (a) 13. (b) 14. (c) 15. (a)  
 16. (c) 17. (b) 18. (c) 19. (a) 20. (c)  
 21. (a) 22. (c) 23. (a) 24. (c) 25. (d)  
 26. (a) 27. (a) 28. (b) 29. (b) 30. (d)  
 31. (b) 32. (c) 33. (d) 34. (b) 35. (b)  
 36. (d) 37. (c) 38. (b) 39. (b) 40. (a)  
 41. (a) 42. (c) 43. (b) 44. (b) 45. (a)

### Continued from Page 45

22. (c) In Schottky defect, equal number of cations and anions are missing from their position.

23. (a)



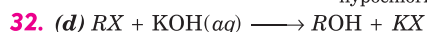
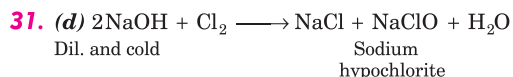
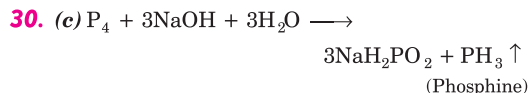
25. (b) More the number of unpaired electrons, higher is the magnetic moment.

26. (d) CFSE is higher when the complex contain strong field ligand. Thus, crystal field splitting energy increases in the order  $[\text{Cr}(\text{Cl})_6]^{3-} < [\text{Cr}(\text{NH}_3)_6]^{3+} < [\text{Cr}(\text{CN})_6]^{3-}$ .

27. (b)

28. (c)  $\text{CoCl}_2$ , a weak Lewis acid, reacts with chloride ion to produce salt containing tetrahedral,  $[\text{CoCl}_4]^{2-}$  ion.

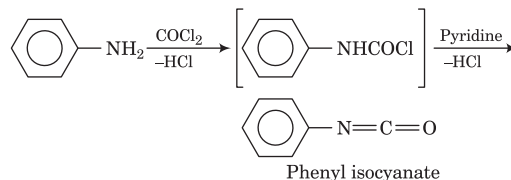
29. (a)



33. (b)

34. (d) Cyclic and tertiary halides undergo hydrolysis by  $\text{S}_{\text{N}}1$  mechanism and involve the formation of carbocation intermediate.

35. (b)



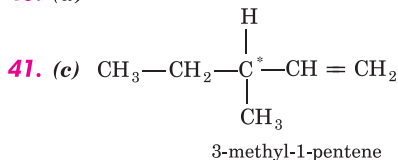
36. (b) Due to -R effect of  $-\text{NO}_2$  group, o-nitrophenoxide ion is more stable than phenoxide ion.

37. (c)

38. (b) Chromic anhydride in glacial acetic acid while other reagents will also affect  $\text{C}=\text{C}$  bond.

39. (b)  $\text{LiAlH}_4$  reduces  $-\text{COOH}$  to  $-\text{CH}_2\text{OH}$  without affecting  $\text{C}=\text{C}$  bond.

40. (a)



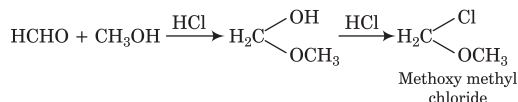
It has one chiral centre.

42. (d) Denaturation is coagulation of proteins by heating.

43. (a) For the preparation of terylene, n moles of glycol are required for n moles of terephthalic acid.

44. (d) Bithional is added to soap to impart antiseptic properties.

45. (d) With the excess of methanol, acetal is formed but with excess of  $\text{HCl}$ ,  $\alpha$ -chloroethers are formed.

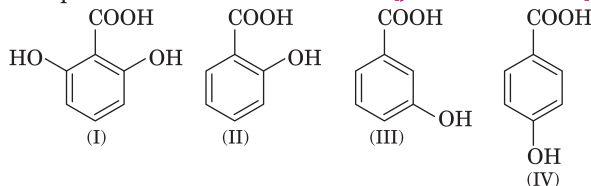




# ALDEHYDES, KETONES AND CARBOXYLIC ACIDS

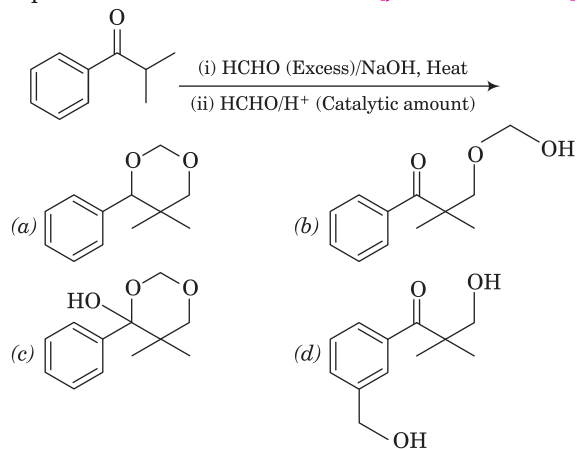
A collection of best asked questions from JEE to revise your concepts

7. The correct order of acidity for the following compounds is

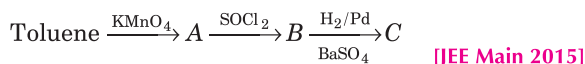


- (a) I > II > III > IV  
(b) III > I > II > IV  
(c) III > IV > II > I  
(d) I > III > IV > II

2. The major product of the following reaction sequence is



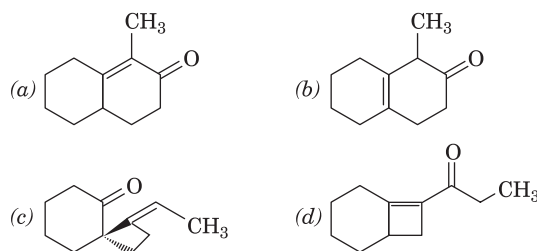
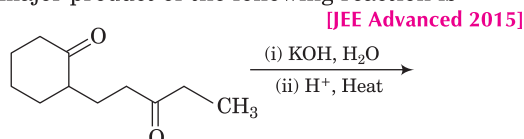
3. In the following sequence of reaction,



The product C is

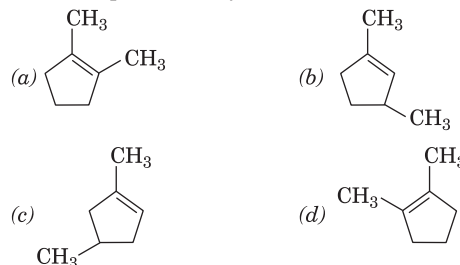
- (a)  $\text{C}_6\text{H}_5\text{COOH}$  (b)  $\text{C}_6\text{H}_5\text{CH}_3$   
(c)  $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$  (d)  $\text{C}_6\text{H}_5\text{CHO}$

4. The major product of the following reaction is



5. Which compound would give 5-keto-2-methyl hexanal upon ozonolysis?

[JEE Main 2015]

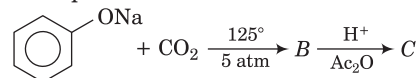


6. The most suitable reagent for the conversion of  $R-\text{CH}_2-\text{OH} \rightarrow R-\text{CHO}$  is

[JEE Main 2014]

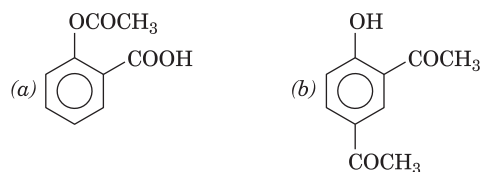
- (a)  $\text{KMnO}_4$   
(b)  $\text{K}_2\text{Cr}_2\text{O}_7$   
(c)  $\text{CrO}_3$   
(d) PCC (pyridinium chlorochromate)

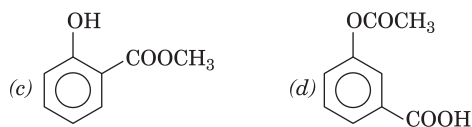
7. Sodium phenoxide when heated with  $\text{CO}_2$  under pressure at  $125^\circ\text{C}$  yields a product which on acetylation produces C.



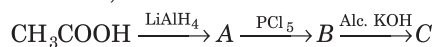
The major product C would be

[JEE Main 2014]



 GOLDEN OLDIES


8. In the reaction,

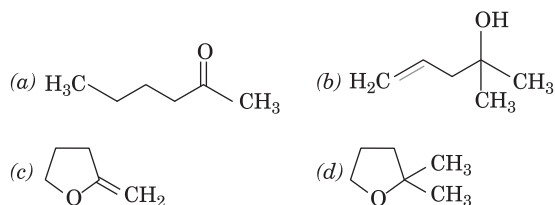
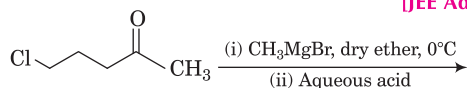


The product C is [JEE Main 2014]

- (a) acetaldehyde (b) acetylene  
(c) ethylene (d) acetyl chloride

9. The major product in the following reaction is

[JEE Adv. 2014]



10. An organic compound A upon reacting with  $\text{NH}_3$  gives B. On heating, B gives C. C in the presence of KOH reacts with  $\text{Br}_2$  to give  $\text{CH}_3\text{CH}_2\text{NH}_2$ . A is

[JEE Main 2013]

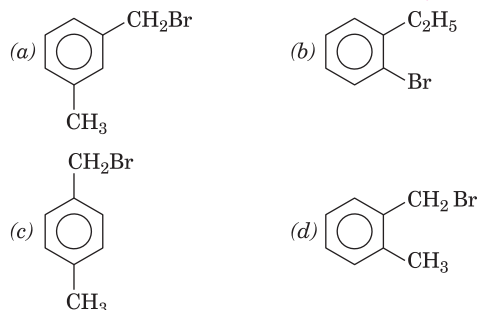
- (a)  $\text{CH}_3\text{COOH}$  (b)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$   
(c)  $\text{CH}_3-\underset{\text{CH}_3}{\text{CH}}-\text{COOH}$  (d)  $\text{CH}_3\text{CH}_2\text{COOH}$

11. A compound with molecular mass 180 is acylated with  $\text{CH}_3\text{COCl}$  to get a compound with molecular mass 390. The number of amino groups present per molecule of the former compound is [JEE Main 2013]

- (a) 2 (b) 5 (c) 4 (d) 6

12. Compound (A),  $\text{C}_8\text{H}_9\text{Br}$  gives a white precipitate when warmed with alcoholic  $\text{AgNO}_3$ . Oxidation of (A) gives an acid (B),  $\text{C}_8\text{H}_6\text{O}_4$ . (B) easily forms anhydride on heating. Identify the compound (A).

[JEE Main 2013]

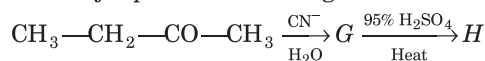


13. The compound that does not liberate  $\text{CO}_2$  on treatment with aqueous sodium bicarbonate solution is

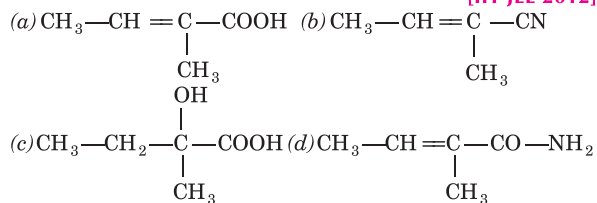
[JEE Adv. 2013]

- (a) benzoic acid (b) benzenesulphonic acid  
(c) salicylic acid (d) carboic acid (Phenol)

14. The major product H in the given reaction sequence is

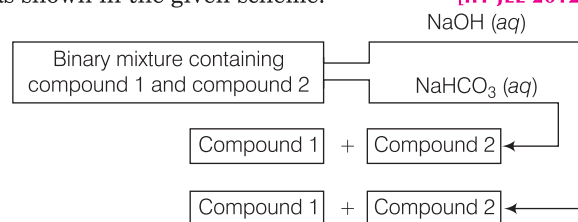


[IIT JEE 2012]



15. Identify the binary mixture(s) that can be separated into individual compounds by differential extraction, as shown in the given scheme.

[IIT JEE 2012]



- (a)  $\text{C}_6\text{H}_5\text{OH}$  and  $\text{C}_6\text{H}_5\text{COOH}$   
(b)  $\text{C}_6\text{H}_5\text{COOH}$  and  $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$   
(c)  $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$  and  $\text{C}_6\text{H}_5\text{OH}$   
(d)  $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$  and  $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$

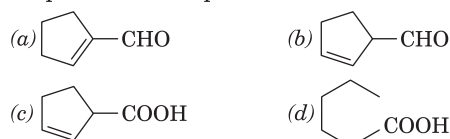
16. The carboxyl functional group ( $-\text{COOH}$ ) is present in

[IIT JEE 2012]

- (a) picric acid (b) barbituric acid  
(c) ascorbic acid (d) aspirin

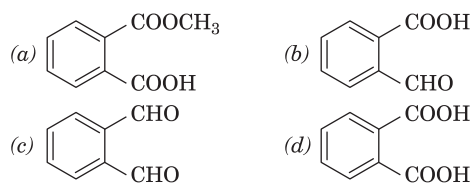
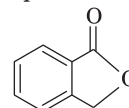
17. Cyclohexene on ozonolysis followed by reaction with zinc dust and water gives compound E. Compound E on further treatment with aqueous KOH yields compound F. Compound F is

[IIT JEE 2007]



18. Which of the following reactants on reaction with conc. NaOH followed by acidification gives following lactone as the main product?

[IIT JEE 2006]

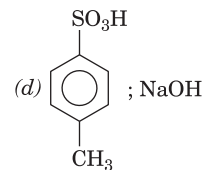
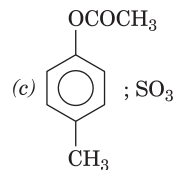
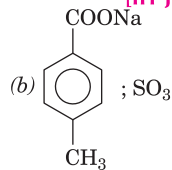
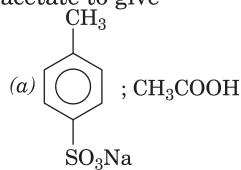


19. Butan-2-one can be converted to propanoic acid by which of the following?

[IIT JEE 2006]

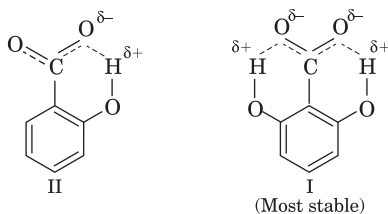
- (a)  $\text{NaOH}$ ,  $\text{NaI}/\text{H}^+$  (b) Fehling's solution  
(c)  $\text{NaOH}$ ,  $\text{I}_2/\text{H}^+$  (d) Tollen's reagent

20. 4-methyl benzene sulphonic acid reacts with sodium acetate to give

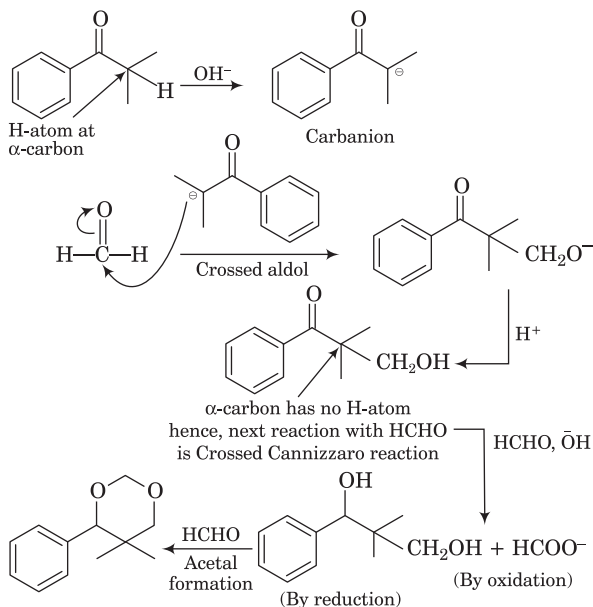


## Answers with Explanation

1. (a) **Thinking Process** —OH group displays both kinds of effect; an electron withdrawing acid-strengthening inductive effect from the *meta*-position and an electron releasing acid weakening resonance effect from the *para*-position (at this position, resonance effect overweighs the inductive effect). Thus, III > IV *o*-hydroxybenzoic acid (II) is far stronger than the corresponding *meta* and *para* isomers as the carboxylate ion is stabilised by intramolecular H-bonding. 2,6-dihydroxy benzoic acid (I) forms carboxylate ion which is further stabilised by intramolecular H-bonding. Thus, correct order is I > II > III > IV

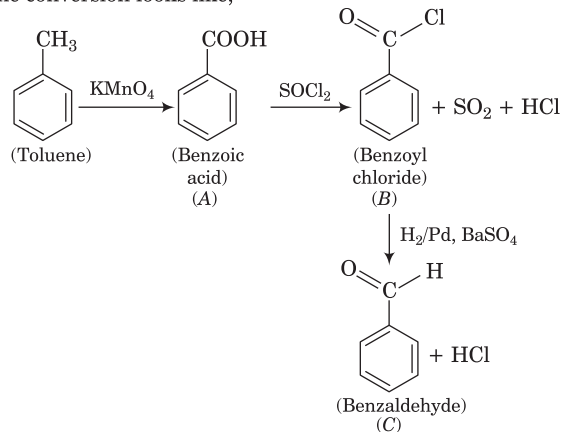


2. (a) **Key Concept** Alkali abstracts proton from  $\alpha$ -position of carbonyl group and generates carbanion. This carbanion attacks at electron deficient carbon of carbonyl group and further gives crossed-Aldol reaction.

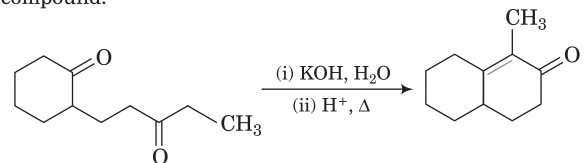


3. (d) Toluene undergoes oxidation with  $\text{KMnO}_4$ , forms benzoic acid. In this conversion, alkyl part of toluene converts into carboxylic group. Further, benzoic acid reacts with thionyl chloride ( $\text{SOCl}_2$ ) to give benzoyl chloride which upon reduction with  $\text{H}_2/\text{Pd}$  or  $\text{BaSO}_4$  forms benzaldehyde (Rosenmund reduction).

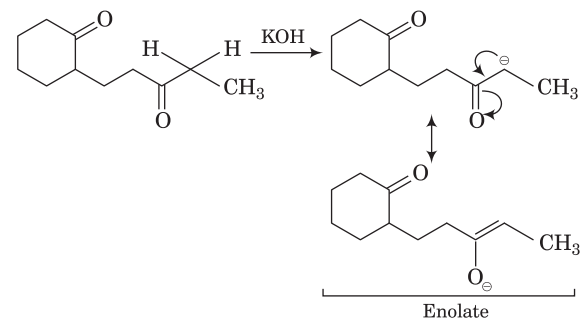
The conversion looks like,



4. (a) When the given compound undergoes reaction with a base like  $\text{KOH}$ , followed by hydrolysis and then further heating results in the formation of  $\alpha$ ,  $\beta$ -unsaturated compound.

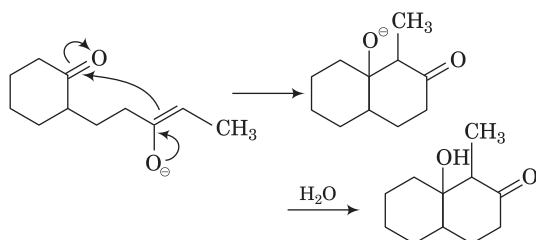


- Step 1** Formation of enolate by the abstraction of  $\text{H}^+$  from less-hindered site of ketone.

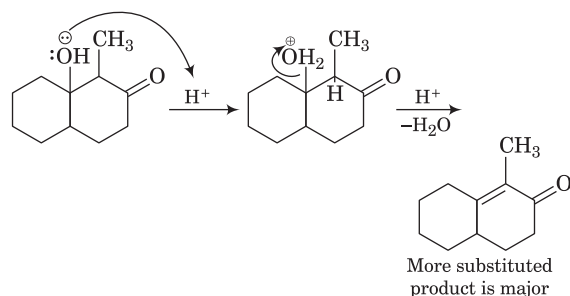


## GOLDEN OLDIES

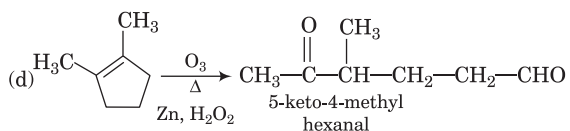
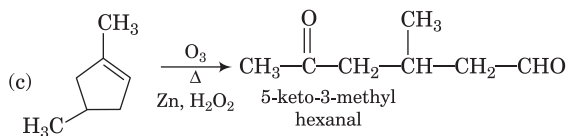
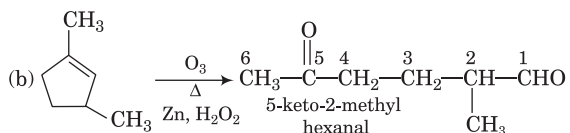
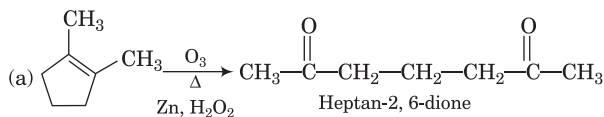
**Step 2** Intramolecular cyclisation takes place in  $S_N2$  manner forming more stable six-membered cyclic compound.



**Step 3** Further abstraction of  $H^+$  from solvent takes place for the removal of  $H_2O$  molecule as a good leaving group and then after heating main product form which is  $\alpha, \beta$ -unsaturated carbonyl compound.



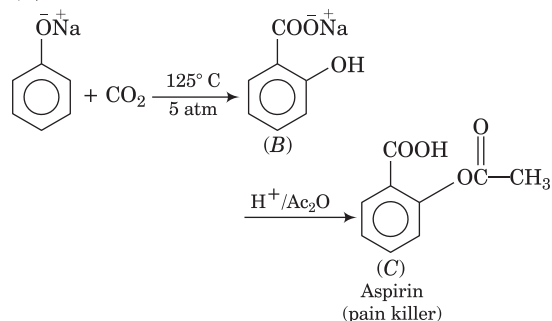
5. (b)



6. (d)  $R-\text{CH}_2\text{OH} \xrightarrow{\text{PCC}} R-\text{CHO}$

Pyridinium chlorochromate (PCC) is the mild oxidising agent which causes conversion of alcohol to aldehyde while other reagents cause conversion of alcohol to acid.

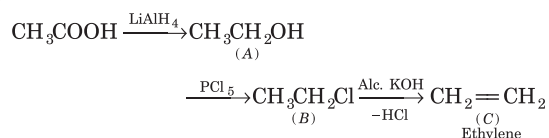
7. (a) It is a Kolbe-Schmidt reaction.



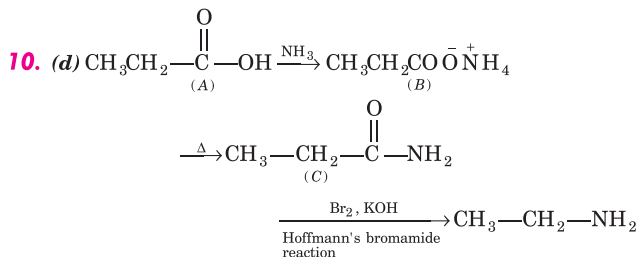
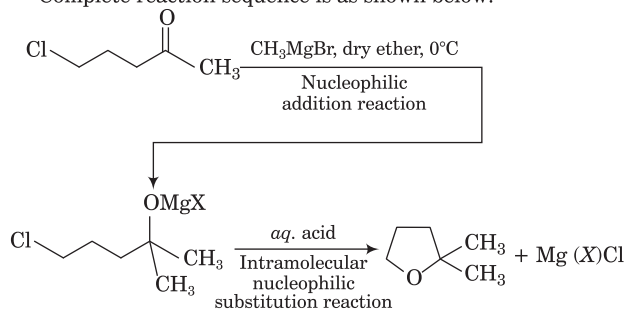
The second step of the reaction is an example of acetylation reaction.

8. (c) **Key Concept** This problem is based on successive reduction, chlorination and elimination reaction. To solve such problem, use the function of the given reagents.

- $\text{LiAlH}_4$  causes reduction
- $\text{PCl}_5$  causes chlorination
- Alc.  $\text{KOH}$  causes elimination reaction



9. (d) **Thinking Process** This problem includes concept of nucleophilic addition reaction to carbonyl compound (ketone here) and intramolecular nucleophilic substitution reaction. Complete reaction sequence is as shown below:

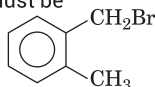


11. (b)  $R-\text{NH}_2 + \text{CH}_3\text{C}(=\text{O})\text{Cl} \xrightarrow{-\text{HCl}} R-\text{NH}-\text{C}(=\text{O})\text{CH}_3$

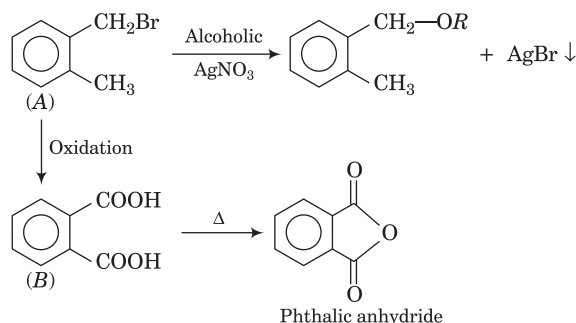
Since, each  $-\text{COCH}_3$  group displace one H atom in the reaction of one mole of  $\text{CH}_3\text{C}(=\text{O})\text{Cl}$  with one  $-\text{NH}_2$  group, the molecular mass increases with 42 units.

Since, the mass increases by  $(390 - 180) = 210$ , hence the number of  $-\text{NH}_2$  group is  $\frac{210}{42} = 5$ .

- 12. (d) Thinking Process** Compound A gives a precipitate with alcoholic  $\text{AgNO}_3$ , so it must contain Br in side chain. On oxidation, it gives  $\text{C}_8\text{H}_6\text{O}_4$ , which shows the presence of two alkyl chains attached directly to the benzene nucleus. Since, compound B gives anhydride on heating, the two alkyl substituent must occupy adjacent (1, 2) position. Thus, A must be

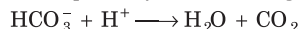


The reactions are as follows:



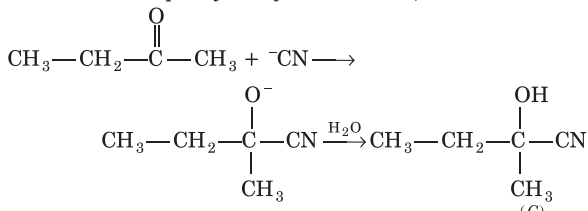
- 13. (d)**  $\text{NaHCO}_3 \rightleftharpoons \text{Na}^+ + \text{HCO}_3^-$

$\text{HCO}_3^-$  is decomposed by acid releasing  $\text{CO}_2$

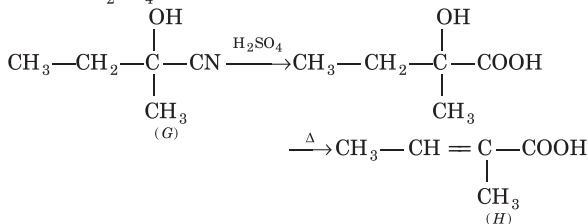


If acid is stronger than  $\text{HCO}_3^-$  then  $\text{CO}_2$  is released. Phenol is less acidic and thus does not liberate  $\text{CO}_2$  with  $\text{NaHCO}_3$ .

- 14. (a)** The first step is cyanohydrin reaction,



In the second step, the  $-\text{CN}$  of intermediate (G) is first hydrolysed and then dehydrated on heating in the presence of conc.  $\text{H}_2\text{SO}_4$ .

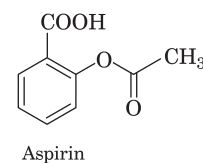
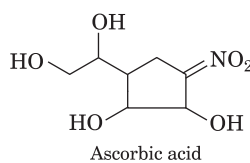
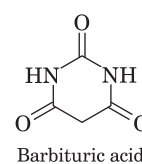
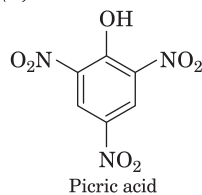


- 15. (b, d)** For separation by differential extraction one of the component must form salt with the given base so that the salt will be extracted in aqueous layer leaving other component in organic layer.

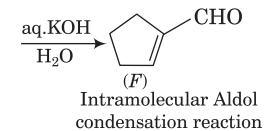
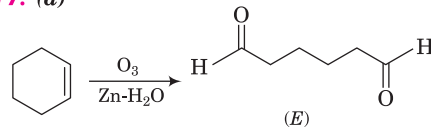
(a) Both phenol and benzoic acid forms salt with  $\text{NaOH}$ , hence this mixture can not be separated.

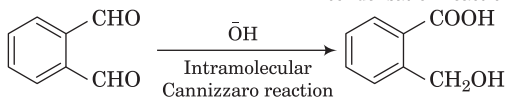
- (b) Benzoic acid forms salt with  $\text{NaOH}$  while benzyl alcohol does not, hence the mixture can be separated using  $\text{NaOH}$ . Also, benzoic acid forms salt with  $\text{NaHCO}_3$  but benzyl alcohol does not, hence  $\text{NaHCO}_3$  can be used for separation.
- (c) Neither benzyl alcohol nor phenol forms salt with  $\text{NaHCO}_3$ , hence mixture cannot be separated using  $\text{NaHCO}_3$ .
- (d)  $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$  forms salt with  $\text{NaOH}$ ,  $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$  does not, hence mixture can be separated using  $\text{NaOH}$ .  $\text{C}_6\text{H}_5\text{CH}_2\text{COOH}$  forms salt with  $\text{NaHCO}_3$ ,  $\text{C}_6\text{H}_5\text{CH}_2\text{OH}$  does not, hence mixture can be separated using  $\text{NaHCO}_3$ .

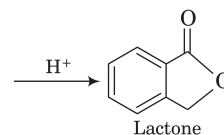
- 16. (d)** Structures of the various compounds are

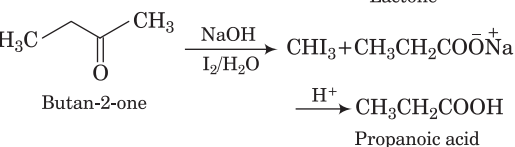


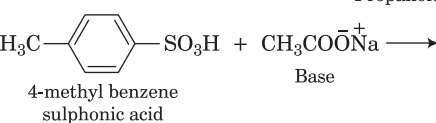
- 17. (a)**

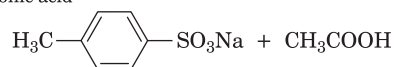


- 18. (c)** 
- Intramolecular Cannizzaro reaction



- 19. (c)** 
- Butan-2-one
- Propanoic acid

- 20. (a)** 
- 4-methyl benzene sulphonic acid
- Base

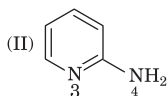
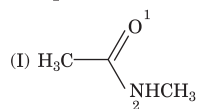


# BRAIN TEASERS

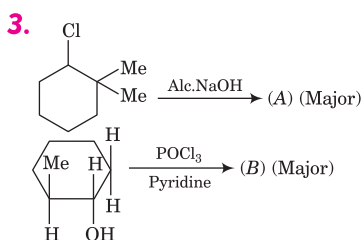


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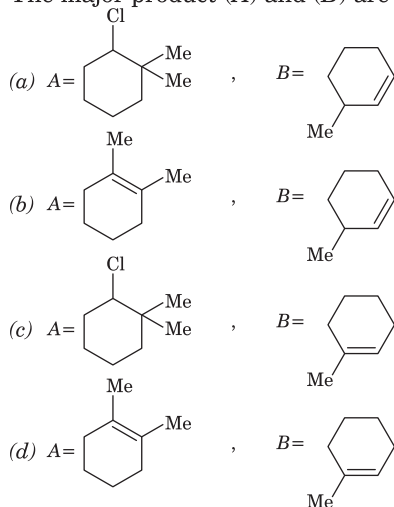
1. The preferred sites of protonation in the following compounds are [NSEC 2012]



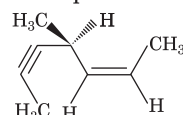
- (a) 1 and 3    (b) 2 and 4    (c) 1 and 4    (d) 2 and 3
2. The weight of water in grams per litre of air at 20°C and 45% relative humidity is (vapour pressure of water at 20°C is 17.55 mm Hg).  
 (a)  $5.61 \times 10^{-3}$  g/L    (b)  $5.24 \times 10^{-2}$  g/L  
 (c)  $6.21 \times 10^{-4}$  g/L    (d)  $7.74 \times 10^{-3}$  g/L



The major product (A) and (B) are respectively.

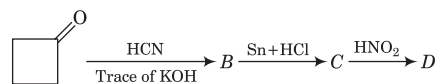


4. A mixture of acidified  $K_2Cr_2O_7$  and 10% KI is titrated against  $Na_2S_2O_3$  (sodium thiosulphate) solution using starch as indicator. The colour of the reaction mixture at the end point is [NSEC 2013]  
 (a) yellow    (b) blue  
 (c) green    (d) colourless
5. The solubilities of carbonates decreases downward in magnesium group due to a decrease in  
 (a) hydration energies of cations  
 (b) interionic attraction  
 (c) entropy of solution of formation  
 (d) lattice energies of the solids
6. Hydrogenation of the adjoining compound in the presence of poisoned palladium catalyst gives



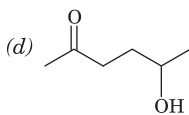
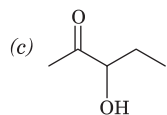
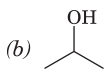
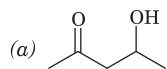
- (a) an optically active compound  
 (b) an optically inactive compound  
 (c) a racemic mixture  
 (d) a diastereomeric mixture
7. A gaseous reaction,  

$$A_2(g) \longrightarrow B(g) + \frac{1}{2}C(g)$$
 shows increase in pressure from 100 mm to 120 mm in 5 min. What is the rate of disappearance of  $A_2$ ?  
 (a) 8    (b) 6  
 (c) 10    (d) 12
8. Which one of the following statements is incorrect about the reaction given below?



- (a) The product D is cyclopentanone  
 (b) The product D is  $\alpha, \beta$ -unsaturated cyclopentanone  
 (c) Ring expansion takes place in conversion of C to D  
 (d) Conversion of B to C can also be carried out by using LAH

9. Which one of the following will be most easily dehydrated in acidic solution?



10. A cell is containing two hydrogen electrodes. The negative electrode is in contact with a solution of  $10^{-6}$  M  $H^+$  ion. The emf of the cell is 0.118 V at  $25^\circ C$ . Calculate  $[H^+]$  at positive electrode.

(a)  $10^{-1}$  M

(b)  $10^{-3}$  M

(c)  $10^{-2}$  M

(d)  $10^{-4}$  M

11. When potassium metal is added to 1, 3, 5, 7-cyclooctatetraene, a highly conducting salt is formed without evolution of  $H_2$  gas because

(a) reduction of cyclooctatetraene into anionic,  $C_8H_8^-$

(b) reduction of cyclooctatetraene into anionic,  $C_8H_8^{2-}$

(c) reduction of cyclooctatetraene into  $C_8H_{10}$

(d) oxidation of cyclooctatetraene into  $C_8H_8^{2+}$

12. The vapour density (hydrogen = 1) of a mixture containing  $NO_2$  and  $N_2O_4$  is 38.3 at  $26.7^\circ C$ . The number of moles of  $NO_2$  in 100 g of the mixture is

(a) 0.31 mol

(b) 0.43 mol

(c) 0.52 mol

(d) 0.26 mol

13. A metal surface was bombarded with two different lights of wavelength  $2300 \text{ \AA}$  and  $2000 \text{ \AA}$ , respectively. The bombardment resulted in the

production of electrons with kinetic energy in second case is two times more than the kinetic energy in first case. The work function of metal is

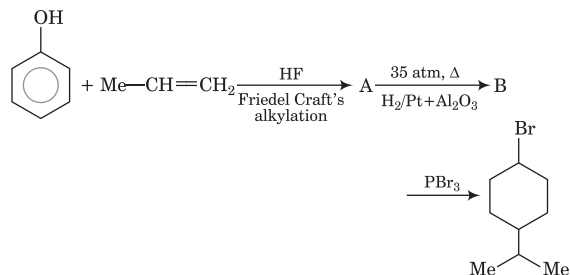
(a)  $6.14 \times 10^{-19}$  J

(b)  $7.34 \times 10^{-21}$  J

(c)  $7.34 \times 10^{-19}$  J

(d)  $6.14 \times 10^{-20}$  J

14. The number of electrons lost during the conversion of  $A \rightarrow B$  is



(a) 4

(b) 6

(c) 2

(d) 1

15. The temperature coefficient of the cell is  $\left(\frac{\delta E}{\delta T}\right)_p$ . Select the incorrect alternative.

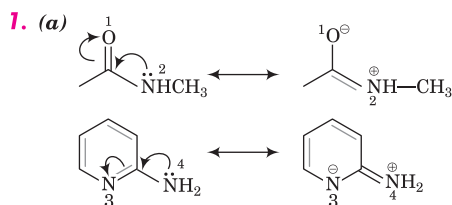
(a) When  $\left(\frac{\delta E}{\delta T}\right)_p < 0$ , then  $|nFE| > |\Delta H|$

(b) When  $\left(\frac{\delta E}{\delta T}\right)_p = 0$ , then  $\Delta H = -nFE$

(c) When  $\left(\frac{\delta E}{\delta T}\right)_p > 0$ , then  $|nFE| < |\Delta H|$ , i.e. exothermic reaction.

(d) When,  $\left(\frac{\delta E}{\delta T}\right)_p = 0$ , then  $|\Delta H| > |nFE|$ , i.e. endothermic reaction

## Answers with Explanation



Electron density on O-1 and N-3 increases due to resonance.

2. (d) % relative humidity

$$= \frac{\text{Partial pressure of } H_2O \text{ in air}}{\text{Vapour pressure of } H_2O \text{ at the same temp.}} \times 100$$

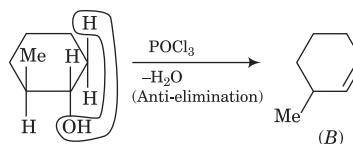
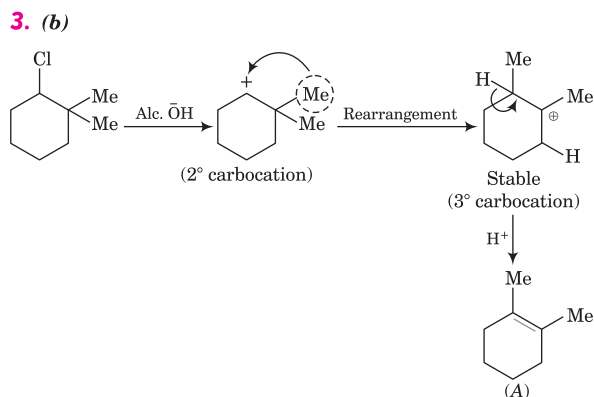
$$\therefore p_{H_2O} = \frac{45 \times 17.55}{100} = 7.8 \text{ mm} = 0.0104 \text{ atm}$$

Thus, for 1 L of air, mole of  $H_2O$  can be calculated as

$$n = \frac{pV}{RT} = \frac{0.0104 \times 1}{0.0821 \times 293} = 4.3 \times 10^{-4} \text{ mole}$$

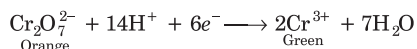
$$\therefore \text{Weight of } H_2O = 4.3 \times 10^{-4} \times 18$$

$$= 7.74 \times 10^{-3} \text{ g/L of air}$$



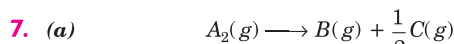
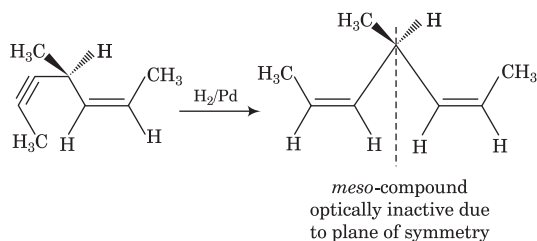
 BRAIN TEASERS

4. (c) The colour of the reaction mixture at the end point is green because  $\text{Cr}^{3+}$  ion is formed in the solution.



5. (a) With increase in size of  $\text{Mg}^{2+}$  ions from  $\text{Mg}^{2+}$  to  $\text{Ba}^{2+}$ , the hydration energy decreases significantly, while there is only a small change in lattice energy. This decreases the solubility significantly.

6. (b) *cis*-hydrogenation of alkyne occurs with poisoned Pd which does not affect double bonds.



At initial	$p$	0	0
At equilibrium	$p - x$	$x$	$\frac{x}{2}$

$$\text{Total pressure} = p - x + x + \frac{x}{2} = p + \frac{x}{2}$$

$$\text{Initial pressure } (p) = 100 \text{ mm}$$

$$\text{Final pressure} = \text{Total pressure} = 120 \text{ mm}$$

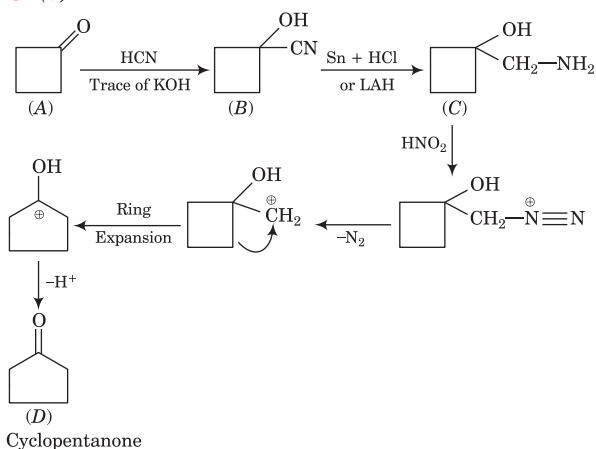
$$\therefore p + \frac{x}{2} = 120$$

$$100 + \frac{x}{2} = 120$$

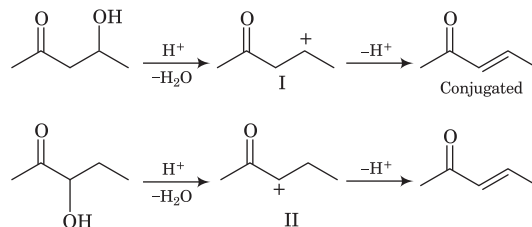
$$\Rightarrow x = 40 \text{ mm}$$

$$\frac{-d[A_2]}{dt} = \frac{40}{5} = 8 \text{ mm min}^{-1}$$

8. (b)

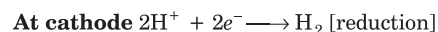


9. (a)



Although both reactions are giving the same product but carbocation I is more stable than II, so I is easily dehydrated.

10. (d) At anode  $\text{H}_2 \longrightarrow 2\text{H}^+ + 2\text{e}^-$  [oxidation]



$$\therefore E_{\text{cell}} = E_{\text{H}_2/\text{H}^+} + E_{\text{H}^+/\text{H}_2}$$

$$E_{\text{cell}} = E_{\text{H}_2/\text{H}^+}^\circ - \frac{0.059}{2} \log[\text{H}^+]_{\text{anode}}^2 + E_{\text{H}^+/\text{H}_2}^\circ + \frac{0.059}{2} \log[\text{H}^+]_{\text{cathode}}^2$$

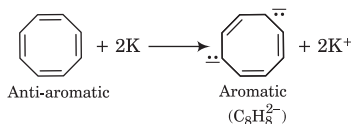
$$= \frac{0.059}{2} \log \frac{[\text{H}^+]_{\text{cathode}}^2}{[\text{H}^+]_{\text{anode}}^2}$$

$$\therefore 0.118 = \frac{0.059}{2} \log \frac{[\text{H}^+]_{\text{cathode}}^2}{(10^{-6})^2}$$

$$4 = \log \frac{[\text{H}^+]_{\text{cathode}}^2}{(10^{-6})^2}$$

$$[\text{H}^+]_{\text{cathode}} = 10^{-4} \text{ M}$$

11. (b)



12. (b)  $\text{N}_2\text{O}_4(g) \rightleftharpoons 2\text{NO}_2(g)$

$$\text{At equilibrium } (1-x) \quad 2x$$

$$\text{Degree of dissociation } (x) = \frac{D-d}{(n-1)d}$$

$$\text{Given, } d = 38.3,$$

$$D = \frac{\text{Molecular mass of } \text{N}_2\text{O}_4}{2} = \frac{92}{2} = 46, n = 2$$

$$\therefore x = \frac{46 - 38.3}{38.3} = 0.2$$

$$\text{At equilibrium, amount of } \text{N}_2\text{O}_4 = 1 - 0.2 = 0.8 \text{ mol}$$

$$\text{Amount of } \text{NO}_2 = 2 \times 0.2 = 0.4 \text{ mol}$$

$$\text{Mass of the mixture}$$

$$= 0.8 \times 92 + 0.4 \times 46$$

$$= 73.6 + 18.4 = 92 \text{ g}$$

$$\therefore 92 \text{ g of mixture} = 0.4 \text{ mol } \text{NO}_2$$

$$\therefore 100 \text{ g of mixture} = \frac{0.4 \times 100}{92} = 0.43 \text{ mol of } \text{NO}_2$$



13. (c) Applying Einstein photoelectric equation for the first bombardment.

Let the work function of the metal be  $\phi = h\nu_0$   
and kinetic energy of the released electron be  $KE_1$

$$\therefore \frac{hc}{\lambda_1} = KE_1 + \phi \quad \dots(i)$$

Similarly for the second bombardment,

$$\frac{hc}{\lambda_2} = KE_2 + \phi$$

Given,  $KE_2 = 2KE_1$

$$\text{Hence, } \frac{hc}{\lambda_2} = 2KE_1 + \phi \quad \dots(ii)$$

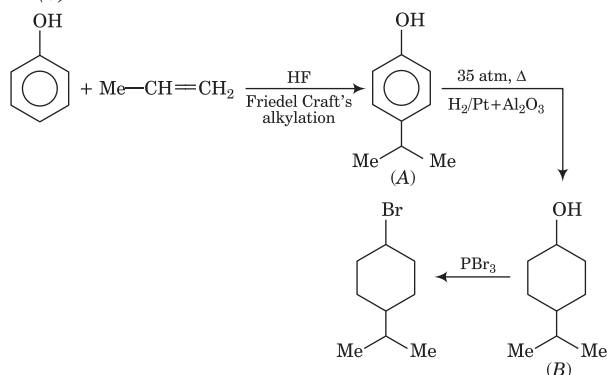
Subtracting Eq. (i) from Eq. (ii),

$$\begin{aligned} KE_1 &= hc \left[ \frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right] \\ &= 6.626 \times 10^{-34} \times 3 \times 10^8 \\ &\quad \left[ \frac{1}{2000} - \frac{1}{2300} \right] \times \frac{1}{10^{-10}} \\ &= 1.296 \times 10^{-19} \text{ J} \end{aligned}$$

Substitute the value of  $KE_1$  in Eq. (i), to calculate work function ( $\phi$ )

$$\begin{aligned} \phi &= \frac{hc}{\lambda_1} - KE_1 \\ &= 8.64 \times 10^{-19} \text{ J} - 1.296 \times 10^{-19} \text{ J} \\ &= 7.344 \times 10^{-19} \text{ J} \end{aligned}$$

14. (b)



Since, Lindlar's catalyst reduces  $\pi$ -bonds and forms (B) and there are  $6\pi$ -electrons in (A), so (A) will lose  $6\pi$  electrons to produce (B).

15. (d) We have the following thermodynamic relationship,

$$\Delta G = \Delta H + T \left( \frac{\delta G}{\delta T} \right)_p \quad \dots(i)$$

$$\Delta G = \Delta H + T \left[ \frac{\delta(-nFE)}{\delta T} \right]$$

$$-nFE = \Delta H - nFT \left[ \frac{\delta E}{\delta T} \right]_p$$

$$\left( \frac{\delta E}{\delta T} \right)_p = \frac{\Delta H + nFE}{nF}$$

$$\left( \frac{\delta E}{\delta T} \right)_p < 0 \text{ or } = 0 \text{ or } > 0$$

Continued from Page 74

43. Which of the following is magnetite?  
(a)  $Fe_2CO_3$  (b)  $Fe_2O_3$  (c)  $Fe_3O_4$  (d)  $Fe_2O_3 \cdot 3H_2O$
44. Identify the incorrect statement among the following.  
(a) *d*-block elements show irregular and erratic chemical properties among themselves  
(b) La and Lu have partially filled *d*-orbitals and no other partially filled orbitals  
(c) The chemistry of various lanthanoids is very similar  
(d) *4f*- and *5f*-orbitals are equally shielded
45. The point of dissimilarity between lanthanides and actinides is  
(a) three outermost shell are partially filled  
(b) they show oxidation state of + 3 (common)  
(c) they are called inner-transition elements  
(d) they are radioactive in nature
46. Lanthanoid contraction is caused due to  
(a) the appreciable shielding on outer electrons by *4f*-electrons from the nuclear charge  
(b) the appreciable shielding on outer electrons by *5d*-electrons from the nuclear charge  
(c) the same effective nuclear charge from Ce to Lu  
(d) the imperfect shielding on outer electrons by *4f*-electrons from the nuclear charge
47. Gadolinium belongs to *4f*-series. Its atomic number is 64. Which of the following is the correct electronic configuration of Gadolinium?  
(a)  $[Xe]4f^7 5d^1 6s^2$  (b)  $[Xe]4f^6 5d^2 6s^2$   
(c)  $[Xe]4f^8 6d^2$  (d)  $[Xe]4f^9 5s^1$
48. The lanthanoid contraction is responsible for the fact that  
(a) Zr and Y have about the same radius  
(b) Zr and Nb have similar oxidation state  
(c) Zr and Hf have not the same radius  
(d) Zr and Zn have the same oxidation state
49. On which factors, the stability of an oxidation state of lanthanoid elements depend?  
(a) Enthalpy  
(b) Internal energy  
(c) Combined effect of hydration energy and ionisation energy  
(d) Electronic configuration
50. Which of the following trivalent ion has the largest atomic radii in the lanthanide series?  
(a) Ce (b) Pm (c) La (d) Lu

Answers

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (a)  | 2. (a)  | 3. (b)  | 4. (b)  | 5. (b)  |
| 6. (b)  | 7. (c)  | 8. (b)  | 9. (a)  | 10. (a) |
| 11. (a) | 12. (a) | 13. (b) | 14. (b) | 15. (b) |
| 16. (d) | 17. (a) | 18. (a) | 19. (c) | 20. (c) |
| 21. (b) | 22. (c) | 23. (b) | 24. (d) | 25. (b) |
| 26. (b) | 27. (c) | 28. (a) | 29. (c) | 30. (a) |
| 31. (b) | 32. (c) | 33. (d) | 34. (b) | 35. (a) |
| 36. (c) | 37. (d) | 38. (a) | 39. (d) | 40. (c) |
| 41. (b) | 42. (c) | 43. (c) | 44. (d) | 45. (d) |
| 46. (d) | 47. (a) | 48. (c) | 49. (c) | 50. (c) |

 **TARGET CBSE 2017**

# TEST DRIVE

Comprehensive Simulator Test Series for Board Exams

# BOARD EXAM

## (PAPER ONE PREP UP)

**FULL  
TEST**
**5**
**(COMPLETE SYLLABUS)  
WITH SOLUTIONS**

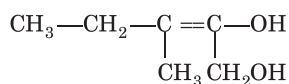
Typical Questions with Crispy Solutions

### INSTRUCTIONS

- All questions are compulsory.
- Questions number 1 to 5 are very short answer type questions and carry 1 mark each.
- Questions number 6 to 10 are short answer type I questions and carry 2 marks each.
- Questions number 11 to 22 are short answer type II questions and carry 3 marks each.
- Question number 23 is a value based type question and carry 4 marks.
- Questions number 24 to 26 are long answer type questions and carry 5 marks each.
- Use log tables, if necessary. Use of calculators is not allowed.

### Very Short Answer Type Questions [1 Mark]

1. Write the IUPAC name of the following compound:



2. How does the addition of alum purify water?
3. Out of  $\text{BaCl}_2$  and  $\text{KCl}$ , which one is more effective in causing coagulation of a negatively charged colloidal sol. Give reason. [Delhi 2015]
4. What is the product formed when benzene sulphonyl chloride is treated with ethylamine?
5. Why metals usually do not occur in nature as nitrates?

### Short Answer Type I Questions [2 Marks]

6. Calculate the volume of 80% (by mass) of  $\text{H}_2\text{SO}_4$  [density =  $1.8 \text{ gL}^{-1}$ ] required to prepare 1 L of 0.2 molar  $\text{H}_2\text{SO}_4$ .
7. Explain the following giving one example for each.
- Reimer-Tiemann reaction
  - Friedel-Craft's acetylation of anisole
8. Find out the molar conductivity of an aqueous solution of  $\text{BaCl}_2$  at infinite dilution when ionic conductances of  $\text{Ba}^{2+}$  and  $\text{Cl}^-$  ions are  $127.30 \text{ Scm}^2 \text{ mol}^{-1}$  and  $76.34 \text{ Scm}^2 \text{ mol}^{-1}$ , respectively.
9. When a coordination compound,  $\text{CoCl}_3 \cdot 6\text{NH}_3$  is mixed with  $\text{AgNO}_3$ , 3 moles of  $\text{AgCl}$  are precipitated per mole of the compound. Write [All India 2016]
- structural formula of the complex
  - IUPAC name of the complex

10. Write balanced chemical equation for the following.

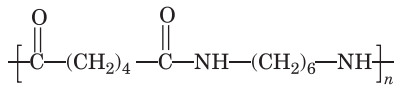
- Reaction of gold with aqua-regia
  - Reaction of chlorine with dry slaked lime
- Or

Draw the structure of the following compound

- Cyclotrimetaphosphoric acid,  $(\text{HPO}_3)_3$
- $\text{XeOF}_4$

### Short Answer Type II Questions [3 Marks]

11. How do you convert?
- Propene to propan-1-ol
  - Chloroform to ethyne
  - Ethyne to ethanol
12. Give the structures of products, A, B and C in the following reactions. [Delhi 2013]
- $\text{CH}_3\text{CH}_2\text{Br} \xrightarrow{\text{KCN}} \text{A} \xrightarrow{\text{LiAlH}_4} \text{B} \xrightarrow[0^\circ\text{C}]{\text{HNO}_2} \text{C}$
  - $\text{CH}_3\text{COOH} \xrightarrow[\Delta]{\text{NH}_3} \text{A} \xrightarrow{\text{NaOH} + \text{Br}_2} \text{B} \xrightarrow{\text{CHCl}_3 + \text{Alc. KOH}} \text{C}$
13. Account for the following
- Chlorine water has both oxidising and bleaching properties.
  - $\text{H}_3\text{PO}_2$  and  $\text{H}_3\text{PO}_3$  acts as good reducing agents while  $\text{H}_3\text{PO}_4$  does not.
  - On addition of ozone gas to KI solution, violet vapours are obtained.
14. (i) Why rubbers are elastomers?  
(ii) Identify the monomers in the following polymer.



- (iii) Arrange the following polymers in the increasing order of their intermolecular forces.

Nylon-6,6, buna-S, polythene

- 15.** For the first order thermal decomposition reaction, the following data were obtained.

Time/s	Total pressure/atm
0	0.30
300	0.50

Calculate the rate constant.

(Given,  $\log 2 = 0.301$ ,  $\log 3 = 0.4771$ ,  $\log 4 = 0.6021$ )

[All India 2016]

- 16.** Define the following by giving one example of each

- (i) Antiseptics (ii) Antioxidants  
(iii) Narcotic analgesics

- 17.** An element X with an atomic mass of  $60 \text{ g mol}^{-1}$  has density of  $6.23 \text{ g cm}^{-3}$ . If the edge length of its cubic unit cell is 400 pm, identify the type of cubic unit cell. Calculate the radius of an atom of this element.

Or

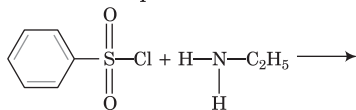
Aluminium crystallises in a cubic closed packed structure. Its metallic radius is 125 pm.

- (i) What is the length of the side of the unit cell?  
(ii) How many unit cells are there in  $100 \text{ cm}^3$  of aluminium?

- 18.** (i) Name the method of refining to obtain silicon of high purity.  
(ii) What is the role of  $\text{SiO}_2$  in the extraction of copper?  
(iii) What is the role of depressants in froth floatation process?

[All India 2015]

- 19.** (i) Write the main product of the following reaction.

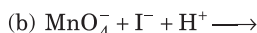
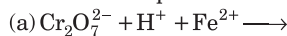


- (ii) Gabriel phthalimide synthesis is preferred for synthesising primary amines. Why?

- (iii) Arrange the following in increasing order of basic strength in gas phase.



- 20.** (i) Complete the following chemical equations for reactions in aqueous media.



- (ii) The transition metals and their compounds are found to be good catalysts in many processes. Explain.

- 21.** Explain the following terms with suitable examples:

- (i) Alcosol (ii) Aerosol (iii) Hydrosol

[Delhi 2009, All India 2010]

- 22.** An aqueous solution of sodium chloride is marked 10% (w/W) on the bottle. The density of solution is  $1.071 \text{ g mL}^{-1}$ . What is its molality and molarity? Also, what is the mole fraction of each component in the solution?

### Value Based Type Question [4 Marks]

- 23.** Pankaj is 50 yr old and has diabetes. He uses saccharine as sweetening agent in coffee and tea and sugar free in sweets. Uma too is diabetic person. She controls her sugar level in diet by using less sugar and exercising.

Answer the following questions based on above passage:

- (i) Who is able to handle diabetes better and why?  
(ii) What are harmful effects of artificial sweeteners?  
(iii) Write the structure of saccharine.  
(iv) What value do you get from this?

### Long Answer Type Questions [5 Marks]

- 24.** (i) Calculate the emf of the cell,  
 $\text{Mg(s)} | \text{Mg}^{2+} (0.1 \text{ M}) || \text{Cu}^{2+} (1 \times 10^{-3} \text{ M}) | \text{Cu(s)}$   
[Given,  $E_{\text{Cu}^{2+}/\text{Cu}}^0 = +0.34 \text{ V}$ ,  $E_{\text{Mg}^{2+}/\text{Mg}}^0 = -2.37 \text{ V}$ ]

- (ii) Explain with examples the terms weak and strong electrolytes. [Delhi 2007]

Or

- (i) State two advantages of  $\text{H}_2\text{---O}_2$  fuel cell over ordinary cell.  
(ii) Silver is electrodeposited on a metallic vessel of total surface area  $900 \text{ cm}^2$  by passing a current of 0.5A for 2 h. Calculate the thickness of silver deposited. [Given : Density of silver =  $10.5 \text{ g cm}^{-3}$ , Atomic mass of silver = 108 u,  $1\text{F} = 96500 \text{ C mol}^{-1}$ ]

[All India 2006]

- 25.** An organic compound (A) has characteristic odour. On treatment with NaOH, it forms compounds (B) and (C). Compound (B) has molecular formula,  $\text{C}_7\text{H}_8\text{O}$  which on oxidation gives back (A). The compound (C) is a sodium salt of an acid. When (C) is treated with soda lime, it yields an aromatic compound (D). Deduce the structures of (A) to (D). Write the sequence of reactions involved.

Or

- (i) Why sodium metal can be used for drying diethyl ether but not ethyl alcohol?  
(ii) Give the name of the alkyl halide and sodium alkoxide used for synthesis tert-butyl ethyl ether.  
(iii) A compound (A) having molecular formula,  $\text{C}_4\text{H}_{10}\text{O}$  is found to be soluble in conc.  $\text{H}_2\text{SO}_4$ . It does not react with sodium metal or  $\text{KMnO}_4$ . On heating with excess of HI, it gives a single alkyl halide. Deduce the structure of compound 'A'.

- 26.** (i) Write the formula of the following complexes:

- (a) Hexaammineplatinum (IV) chloride  
(b) Dichlorotetraamminecobalt (III) ion

- (ii) (a) Coordination compound,  $\text{CrCl}_3 \cdot 4\text{H}_2\text{O}$  precipitates AgCl when treated with  $\text{AgNO}_3$ . The molar conductance of its solution corresponds to a total of two ions. Write the structure and name of the complex compound.  
(b) Name a ligand which is bidentate.

Or

- (i) Using valence bond theory predict the geometry and magnetic behaviour of  $[\text{Cr}(\text{NH}_3)_6]^{3+}$  ion [Atomic number of Cr = 24]  
(ii) Write all the geometrical isomers of  $\text{Pt}(\text{NH}_3)(\text{Br})(\text{Cl})(\text{py})$  and how many of these will exhibit optical isomers?  
(iii) Why is CO a stronger ligand than  $\text{Cl}^-$ ?

To be Continued at Page 92

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# TEST DRIVE

Comprehensive Simulator Test Series for Board Exams

# BOARD EXAM

## (PAPER TWO SCALE UP)

**FULL  
TEST**

**6**

(COMPLETE SYLLABUS)  
UNSOLVED

Typical Questions without Solutions

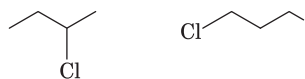
### INSTRUCTIONS

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- Question number 23 is a value based type question and carry 4 marks.
- Questions number 24 to 26 are long answer type questions and carry 5 marks each.
- Use log table, if necessary. Use of calculators is not allowed.

### Very Short Answer Type Questions

[1 Mark]

1. What would be the value of van't Hoff factor for a dilute solution of  $K_2SO_4$  in water?
2. Which of the 3rd series transition metals exhibits the largest number of oxidation states and why?  
[All India 2014]
3. How will you know whether a given  $-OH$  group is alcoholic or phenolic in nature?
4. Out of  $NH_3$  and  $N_2$ , which gas will be adsorbed more readily on the surface of charcoal and why?
5. Identify the chiral molecule in the following pair.  
[Delhi 2013]



### Short Answer Type I Questions

[2 Marks]

6. For the reaction,  $A + 2B \longrightarrow 3C + 2D$ , the rate of disappearance of  $B$  is  $1 \times 10^{-2} \text{ mol L}^{-1} \text{ s}^{-1}$ . What will be
  - (i) rate of the reaction
  - (ii) rate of change in concentration of  $A$  and  $C$ ?
7. What happens, when
  - (i)  $PCl_5$  is heated
  - (ii)  $H_3PO_3$  is heated?  
[Delhi 2013]
8. When fruits and vegetables that have dried are placed in water, they slowly swell and then return to the original form. Explain why?

9. A complex of the type,  $[M(AA)_2 X_2]^{n+}$  is known to be optically active. What does this indicate about the structure of complex? Give one example of such complex.

10. Give chemical tests to distinguish between compounds in each of the following pairs.

- (i) Butan-2-ol and 2-methylpropane-2-ol
- (ii) Phenol and benzyl alcohol.

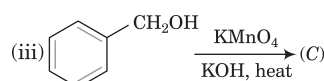
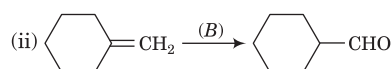
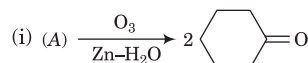
Or

Explain why sodium metal can be used for drying diethyl ether but not ethyl alcohol.

### Short Answer Type II Questions

[3 Marks]

11. (i) What change occurs when  $AgCl$  is doped with  $CdCl_2$ ?
- (ii) What type of semiconductor is produced when silicon is doped with boron?  
[All India 2013]
12. Complete the following reactions by replacing (A), (B) and (C).



Or

How do you convert?

- (i) Acetophenone to ethylbenzene
- (ii) Ethanal to 2-aminoethanoic acid
- (iii) Methyl chloride to ethanoic acid

- 13.** (i) Write the Zwitter ion structure of glycine.  
 (ii) What is meant by inversion of sugar?  
 (iii) Name the vitamin in each case whose deficiency causes,  
 (a) night blindness  
 (b) poor coagulation of blood

- 14.** (i) In reference to Freundlich adsorption isotherm, write the expression for adsorption of gases on solids in the form of an equation.  
 (ii) Write an important characteristic of lyophilic sols.  
 (iii) Based on the type of particles of dispersed phase, give one example each of associated colloid and multimolecular colloid. [All India 2014]

- 15.** Conductivity of 0.00241 M acetic acid is  $7.896 \times 10^{-5} \text{ S cm}^{-1}$ . Calculate its molar conductivity. If  $\wedge_m^\circ$  for acetic acid is  $390.5 \text{ S cm}^2 \text{ mol}^{-1}$ , what is its dissociation constant?

- 16.** Write the IUPAC name of the following coordination compounds.

- (i)  $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$
- (ii)  $\text{K}_3[\text{Fe}(\text{CN})_6]$
- (iii)  $[\text{CoBr}_2(\text{en})_2]^+$ , (en = ethylenediamine)

[Delhi 2013]

- 17.** Write balanced chemical equations for the following reactions.

- (i) Thermal decomposition of ammonium dichromate.
- (ii) Reaction of  $\text{Cl}_2$  with cold and dilute NaOH.
- (iii) When phosphine is passed through mercuric chloride solution.

- 18.** Giving an example of each by describing the following reactions.

- (i) Hofmann's bromamide reaction
- (ii) Gatterman reaction
- (iii) Coupling reaction

- 19.** An element  $X$  with an atomic mass of  $2.7 \times 10^{-2} \text{ g/mol}$  has density of  $2.7 \times 10^3 \text{ g/cm}^3$ . If the edge length of its cubic unit cell is 405 pm, identify the type of cubic unit cell. Calculate the radius of an atom of this element.

- 20.** Write the names of monomer(s) of the following polymers and classify them as addition or condensation polymers.

- (i) Teflon
- (ii) Bakelite
- (iii) Natural rubber

- 21.** (i) Name the method of refining of nickel.  
 (ii) What is the role of cryolite in the extraction of aluminium?  
 (iii) What is the role of limestone in the extraction of iron from its oxides? [All India 2016]

- 22.** A molal freezing point depression constant of benzene ( $\text{C}_6\text{H}_6$ ) is  $4.90 \text{ K kg mol}^{-1}$ . Selenium exists as a polymer of the type  $\text{Se}_x$ . When 3.26g of selenium is dissolved in 226g of benzene, the observed freezing point is  $0.112^\circ\text{C}$  lower than for pure benzene. Deduce the molecular formula of selenium ( $\text{Se}_x$ ) [Atomic mass of Se =  $78.8 \text{ g mol}^{-1}$ ].

**Value Based Type Question**

[4 Marks]

- 23.** Sudhir heard a lot of noise and weeping in nearby jhuggis. He took courage and went to enquire what had happened. He found that some people had taken spurious alcohol containing methanol and were crying with pain and were complaining of loss of eye sight. He immediately hired an autorickshaw and packed it with four persons who had consumed spurious alcohol.

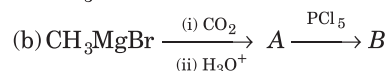
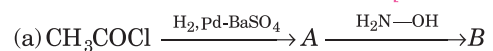
Answer the following question by reading above passage.

- (i) How does methanol in drinking alcohol cause problem?
- (ii) What treatment might the doctors have undertaken to save the patients?
- (iii) What values are shown by Sudhir?

**Long Answer Type Questions**

[5 Marks]

- 24.** (i) Write the structures of  $A$  and  $B$  in the following reactions. [All India 2016]

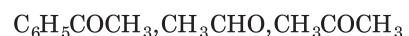


- (ii) Distinguish between  
 (a)  $\text{C}_6\text{H}_5\text{COCH}_3$  and  $\text{C}_6\text{H}_5\text{CHO}$   
 (b)  $\text{CH}_3\text{COOH}$  and  $\text{HCOOH}$   
 (iii) Arrange the following in the increasing order of their boiling points.



Or

- (i) Write the chemical reaction involved in Wolff-Kishner reduction.
- (ii) Arrange the following in the increasing order of their reactivity towards nucleophilic addition reactions.



- (iii) Why carboxylic acids do not give reactions of carbonyl group?

 TARGET CBSE 2017

- (iv) Allyl chloride is hydrolysed more readily than *n*-propyl chloride. Why?
- (v) *A* and *B* are two functional isomers of compound  $C_3H_6O$ . On heating with  $NaOH$  and  $I_2$ , isomer *B* forms yellow precipitate of iodoform whereas isomer *A* does not form any precipitate. Write the formulae of *A* and *B*.

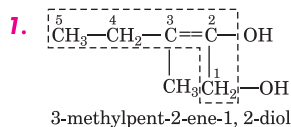
- 25.** (i) Explain the following terms;
- Order of reaction
  - Molecularity of a reaction
- (ii) The rate of a reaction increases four times when the temperature changes from 300 K to 320 K. Calculate the energy of activation of the reaction, assuming that it does not change with temperature. [ $R = 8.314 \text{ JK}^{-1} \text{ mol}^{-1}$ ]
- Or
- Illustrate graphically the effect of catalyst on activation energy.
  - Catalyst have no effect on equilibrium constant. Why?

- (iii) The decomposition of *A* into product has value of  $K$  as  $4.5 \times 10^3 \text{ s}^{-1}$  at  $10^\circ \text{C}$  and activation energy as  $60 \text{ kJ mol}^{-1}$ . Calculate the temperature at which the value of  $k$  (J) be  $1.5 \times 10^4 \text{ s}^{-1}$ .

- 26.** (i) (a) Which is stronger reducing agent  $Cr^{2+}$  or  $Fe^{2+}$  and why?
- (b) Explain why  $Cu^+$  ion is not stable in aqueous solutions.
- (c) Why  $Ce^{4+}$  is a strong oxidising agent.
- (ii) Describe the oxidising property of  $KMnO_4$  in neutral or faintly alkaline medium for its reaction with iodide ions and thiosulphate ions.
- Or
- (i) Complete the following chemical equations.
- $MnO_4^-(aq) + S_2O_3^{2-}(aq) + H_2O(l) \longrightarrow$
  - $Cr_2O_7^{2-}(aq) + Fe^{2+}(aq) + H^+(aq) \longrightarrow$
- (ii) Write the steps involved in the preparation of
- $K_2Cr_2O_7$  from  $Na_2CrO_4$
  - $KMnO_4$  from  $K_2MnO_4$

## Continued from Page 89

## Answers with Explanation



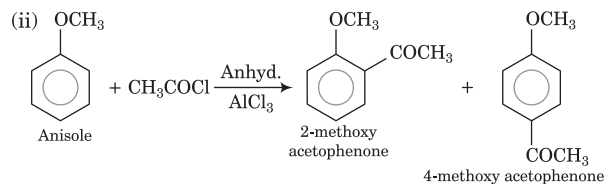
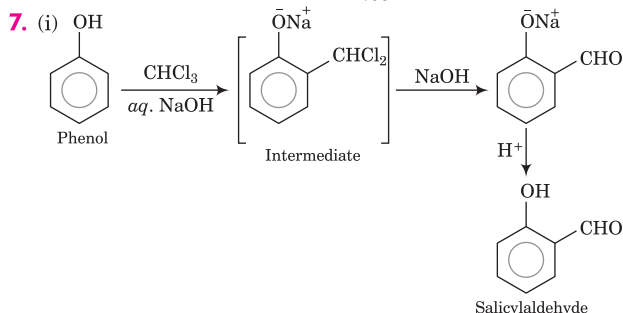
- 2.** Alum is an electrolyte. It coagulates colloidal muddy particles and helps in purification of water.
- 3.** According to Hardy-Schulze rule, greater the valency of the flocculating ion added to the colloid, greater is its power to cause coagulation.
- 4.**  $C_6H_5SO_2Cl + C_2H_5NH_2 \longrightarrow C_6H_5SO_2NHC_2H_5 + HCl$   
N-ethylbenzene sulphonamide
- 5.** Nitrates of all metals are soluble in water. Hence, if metal nitrates were present in the earth's crust, these would be slowly and gradually washed by rain water into the sea.

**6.** Molarity =  $\frac{\text{Percentage by mass} \times 10 \times \text{density}}{\text{Molar mass}}$

$$= \frac{80 \times 10 \times 1.8}{98} = 14.69 \text{ mol L}^{-1}$$

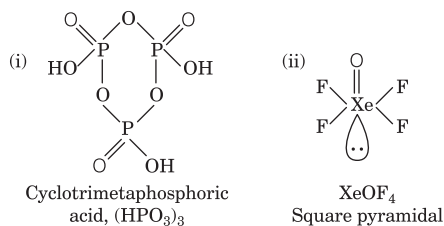
Using molarity equation,

$$M_1 V_1 = M_2 V_2, \quad V_1 = \frac{0.2 \times 1000}{14.69} = 13.6 \text{ mL}$$



- 8.** By applying Kohlrausch law,
- $$\begin{aligned} \Lambda_m^0(\text{BaCl}_2) &= \lambda_{\text{Ba}^{2+}}^0 + 2\lambda_{\text{Cl}^-}^0 \\ &= 127.30 \text{ Scm}^2 \text{ mol}^{-1} + 2 \times 76.34 \text{ Scm}^2 \text{ mol}^{-1} \\ &= 279.98 \text{ Scm}^2 \text{ mol}^{-1} \end{aligned}$$
- 9.** (i) Structural formula of the complex =  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$
- $$[\text{Co}(\text{NH}_3)_6]\text{Cl}_3 \xrightarrow{3\text{AgNO}_3} [\text{Co}(\text{NH}_3)_6]^{3+} + 3\text{NO}_3^- + 3\text{AgCl}$$
- (ii)  $[\text{Co}(\text{NH}_3)_6]\text{Cl}_3$  - Hexaamminecobalt (III) chloride.
- 10.** (i)  $\text{Au} + 4\text{H}^+ + \text{NO}_3^- + 4\text{Cl}^- \longrightarrow \text{AuCl}_4^- + \text{NO} + 2\text{H}_2\text{O}$
- (ii)  $2\text{Ca}(\text{OH})_2 + 2\text{Cl}_2 \longrightarrow \text{Ca}(\text{OCl})_2 + 2\text{CaCl} + 2\text{H}_2\text{O}$

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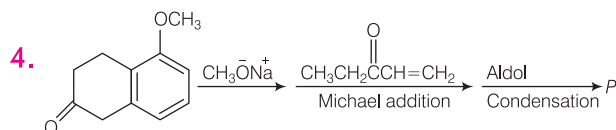
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1. The painkiller ibuprofen has a single chiral centre. The *S* enantiomer acts as a painkiller while the *R* enantiomer is ineffective but it is sold as a racemic mixture of *R* and *S* enantiomers. How?

2. Mercury, with a freezing point of  $-39^{\circ}\text{C}$  is the only metal that is liquid at room temperature. How much thermal energy must be transferred to its surroundings if 1 mL of the mercury is cooled from room temperature of  $23^{\circ}\text{C}$  to  $-39^{\circ}\text{C}$  and then frozen to a solid? The density, specific heat capacity and enthalpy of fusion of liquid are  $13.6\text{ g/cm}^3$ ,  $0.138\text{ Jg}^{-1}\text{C}^{-1}$  and  $11\text{ J/g}$ , respectively.

3. Contact lenses are cleaned in a solution that is buffered. Why?



Identify the product 'P'

5. Compound (X) on reduction with  $\text{LiAlH}_4$  gives a hydride (Y) containing 21.72% hydrogen along with other products. The compound (Y) reacts with air explosively resulting in the formation of boron trioxide. Identify, compound (X) and (Y).

### Fill in the Blanks

6. An isolated diene present in rose, lemongrass and other flowers is \_\_\_\_\_.

7. Glycerol may improve the performance of endurance athletes and body-builders by \_\_\_\_\_ in the body.

8. In bananas, the sweet fruity odour of \_\_\_\_\_ attracts numerous feeders from fruit flies to fruit bats and monkeys.

9. \_\_\_\_\_ is a potent poison that is found in the puffer fish.

10. Micas are amphiboles which are made up of sheets of \_\_\_\_\_ tetrahedra.



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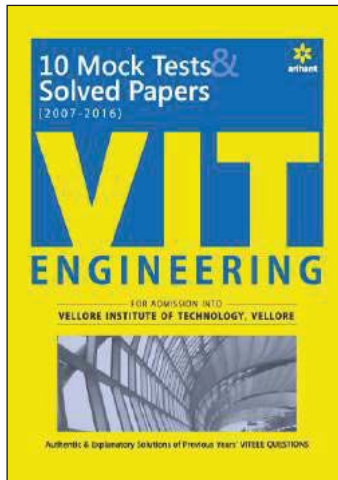
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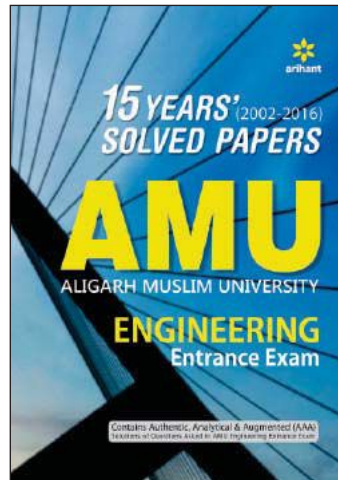
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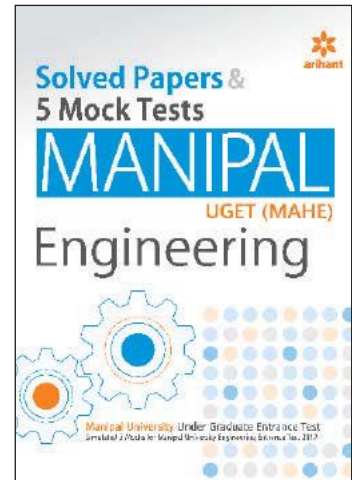
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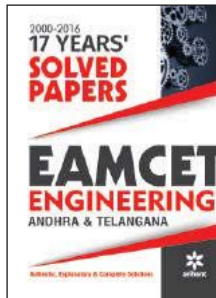


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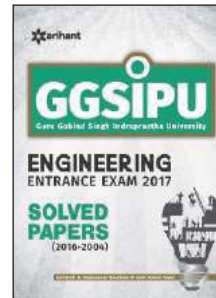
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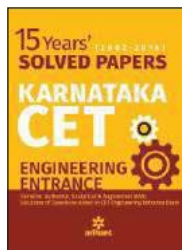
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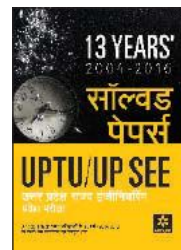
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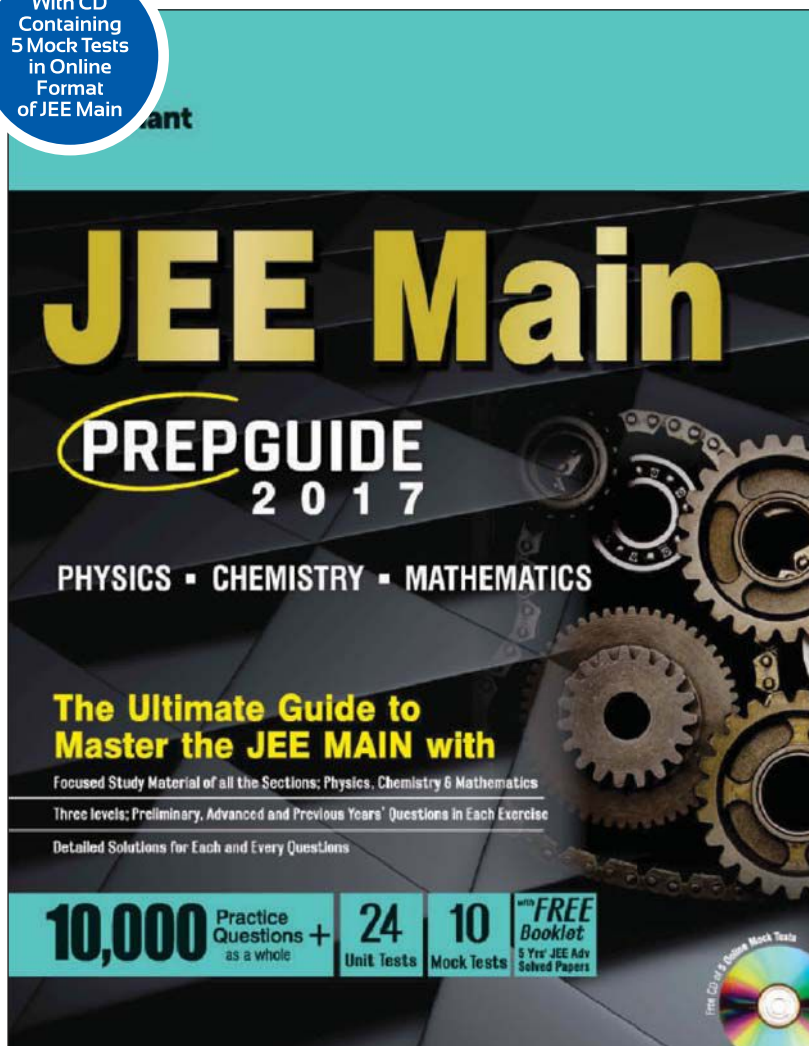
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