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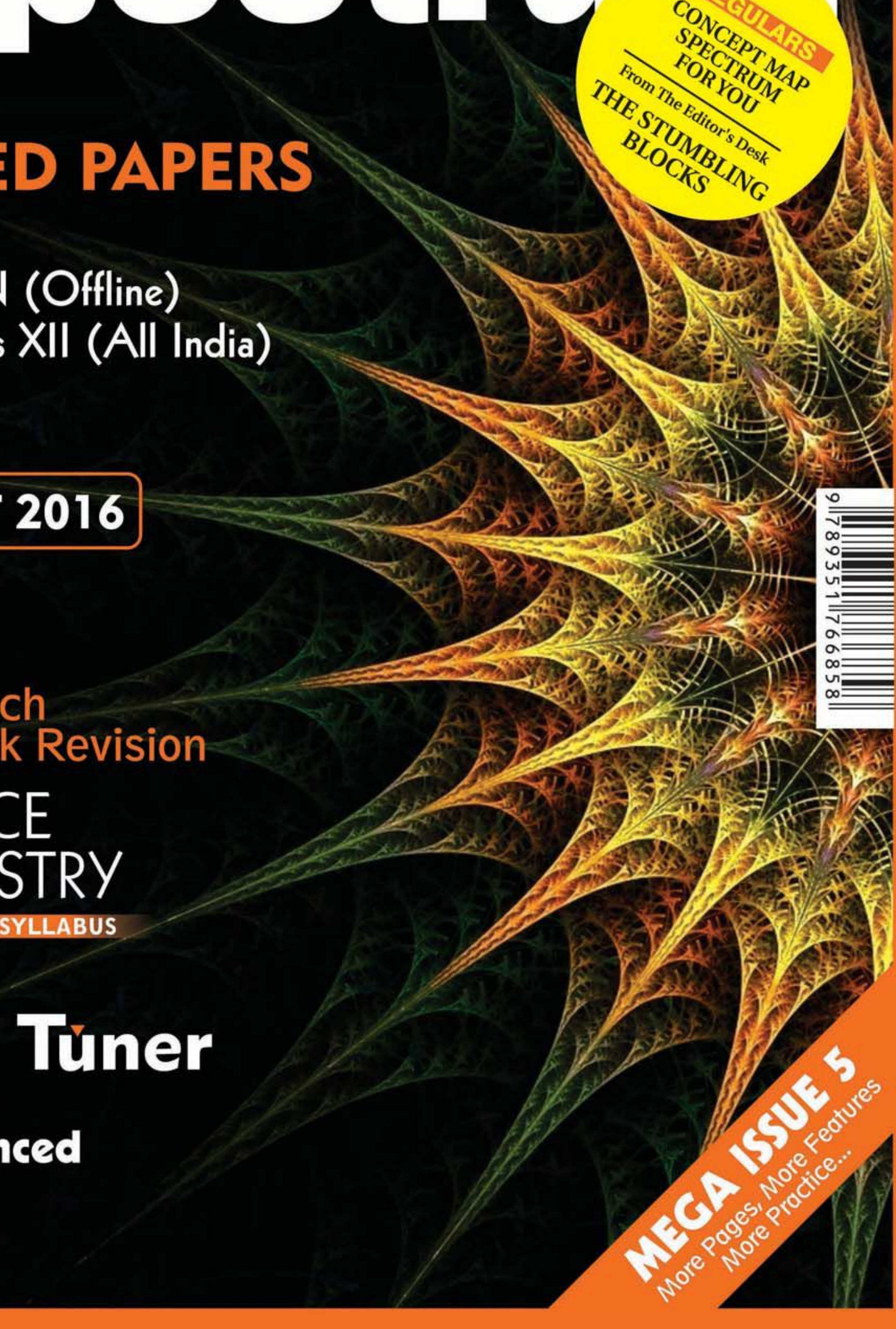

REGULARS

CONCEPT MAP
SPECTRUM
FOR YOU

From The Editor's Desk
THE STUMBLING BLOCKS

SOLVED PAPERS 2016

JEE MAIN (Offline)
CBSE Class XII (All India)

TARGET 2016

JEE

Final Touch
Fast Track Revision

SURFACE
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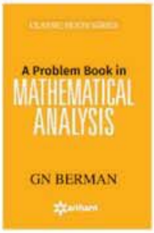
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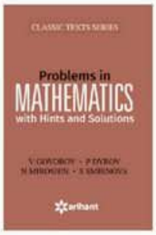
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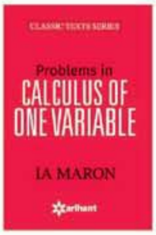
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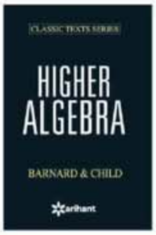
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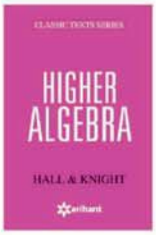
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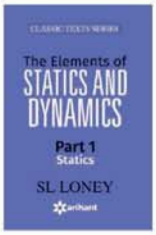
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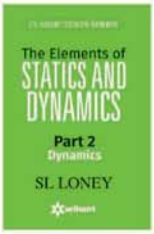
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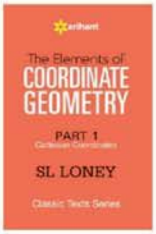
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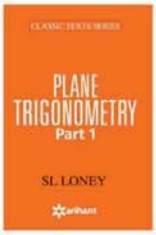
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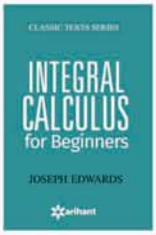
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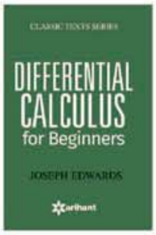
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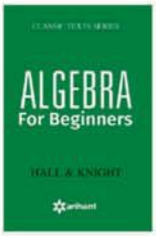
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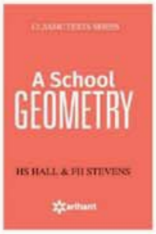
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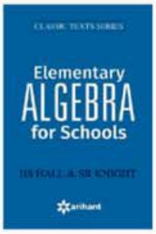
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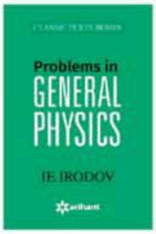
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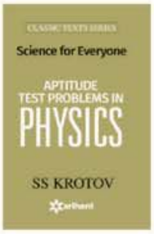
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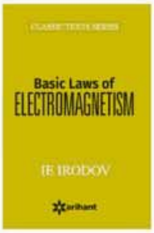
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FROM THE EDITOR'S DESK

THE STUMBLING BLOCKS

All of us are/were television, internet or computer games addicts at some point of times in our lives. It is up to us to convert this kind of addiction into distraction or a utility e.g., I was a TV addict during early days of my life, but today it is more or less a utility for me. I use TV, Movies etc., for recreation purposes when I am mentally tired. Infact these two elements (TV shows and Movies) work as energy boosters for my body.

Scientifically frames in a movie or a TV show change faster that the functioning rate of our brain. That's why our real thinking power decreases up to a large extent while watching these. Actually our brain works only over those directions reaching to it *via* our eyes while watching a movie or a TV show. Thus, keeping other portions of our brain at minimum functional level, this in turn provides relief up to a large extent to our tired functional brain. On the other hand, watching TV and Movies may affect our body in negative manner also. Their over exposure is always hazardous to our eyes and other body parts.

The journey to IIT is too long. It seems like walking on the top of a moving object which is rough, slippery and narrow too. Walking on such an object's top requires ultimate skills, courage, consistency and determination as key players. One 'slip' can easily deviate you from the track. The word **'slip'** here signifies **'Distraction'**. There will be all kinds of things like *TV, movies, internet, phone, friends, 'Bad' habits* (smoking, drinking etc.,), *crushes/infatuations, the pressure of looking good, the desire of being noticed in social circle* etc., which can be categorised to distractions or stumbling block for your progress. Sometimes, a mode of recreation also becomes a distraction.

THE REAL STUMBLING BLOCKS

From the example given above, it must be clear in your mind *that controlled exposure to gadgets like TV, internet etc., may not distract you, but uncontrolled exposure certainly distract you just like a hydrogen bomb which demolished your studies completely*. Hence, I strongly suggest every JEE aspirant to analyse and remove from his path such stumbling blocks which can be one of the following or something else

TELEVISION

Let's begin with TV, 'DOORDARSHAN' which have the capability of converting a normal human being into 'Buddhu' or an 'idiot'. That's why some of us also call it 'Buddhu Baksa' or 'idiot box'. For one kind of people this can be the source of entertainment through reality shows, serials etc., while for others it provides entertainment through games like IPL, IHL, FIFA, Grand slams, ICC world cups etc.

Thus, something or the other always visible on the screen and pulling you away from your books just like spider webs. For a person like my son, it was even a bigger problem because he (and many more like him) equally fits in both the categories. Likewise his younger cousin says that he used to be glued to the television every time Virat stepped out to bat, just like a normal cricket fan. First watching a match and then the guilt of wasting time is a great distraction for him.

To overcome this kind of problem, you really need to have burning desire to hit your target. Once you are involved with such attractions, it will be hard to come back. Suppose you decided to sit for an hour in front of the TV and ended up watching a 3 hour T20 match. This in turn followed by wasting another hour in discussing the outcomes of match or feeling guilty.

Everybody understands the fact that it is almost impossible to be passive emotionally during this tenure of 2 years. There will be ups and downs signifying good and bad times during this tenure. These up and downs are in fact the 'Testing Times' for us. *I consider these times as the eliminators as these are the indicators of our success and failures*. What would give you more happiness – *a **good rank in JEE** or India lifting the World Cup 2015 in cricket?* Think about this question and your heart would give good rank in JEE as the answer.

You can, or rather should, surely watch programs of your interest but it is better to fix up a time for TV and try to follow it honestly. Be stiff with yourself. Build the road map of your priorities in such a way to get maximum help from it in ensuring your success.

INTERNET

Internet entered in our life as a time saving connecting tool which provides manifold help in increasing our exposure towards the real world. Although internet has something for everybody, but amazingly everyone among us is using it for the same purpose i.e. Social Networking means everybody is running towards social networking through many apps like Facebook, Twitter, Instagram etc., including you, your parents, your siblings and even your pets may have an account. Your worth is judged by the number of friends or followers you have. You are called COOL, if you have a good collection of songs or movies else you stand nowhere. For most people, social networking is not a requirement, but just an addiction.

I realised it when I lost my account for a month due to some reason. In real sense, when you don't have anything to post, you don't even expect a comment also. Just try to deactivate your account once, then only you will realise the worth of life without such social networking. In real sense it is much – much better than the one you are living with Facebook or Instagram. In a very recent research, this was disclosed that addiction of this kind of social media is more prone in those persons, which have some sort of insecurities in their relations. The solution of these kinds of distractions lies in your determination and commitment for success. So, *I prefer the usage of internet could be the best, if students use it for*

- The purpose of clearing their study related doubts
- For online tutorials/classes
- For reading e-books
- For exploring new horizons in different fields etc.

Likewise, if their parents use it for

- Office automation,
- Accounting purposes,
- Financial operations like bank accounts,
- Online shopping i.e., e–commerce, and
- So many other useful things.

MOBILE PHONE

I consider it a dragon that always stays in your pocket and literally grabs the peace of your life. I always prefer its limited usage as it left me unnecessarily exhausted. It is suggestive to switch off your mobiles when you are studying. Try to avoid its use in your 'relaxation time' too i.e., your **own time** in which

- You can have a chat with your family members or
- You can play some outdoor games, or
- You can take a walk in the park to rejuvenate your exhausted body
- You can listen to some music to re-energize yourself.

Simply, this means the time of your personal usage, which must be used for constructive purposes. Some of you may be of the opinion that the usage of mobile phone is necessary to increase and maintain their social circle. But as per my understanding an increase in 'social circle' does not necessarily means an increase in number of 'friends'. Likewise, its size has inverse relation with your success.

REMEMBER!

The day you compromise with your success for them, they will compromise on their 'friendship' for you. In simple words, they are not your true friends rather they want to gain something from your success. Hence, when you make compromises with your success they may leave you. So limit your social circle only to the people, who know the worth of your time.

CRUSHES AND INFATUATIONS

Crushes and infatuations are the part of every adolescent's life. Attraction to opposite sex at this age is very common, but at the same time its proper incorporation in life is essential. At such times, when each minute has its own value and requires proper planning, don't even think of having a girlfriend or a boyfriend for time pass. Their presence is acceptable only if, they do not deviate you from what you are supposed to do? Crushes may keep on changing every month i.e., you can fall in love 24 times or more in these 2 years, but you won't allowed to appear 24 times to crack JEE. *So you have two options i.e., either learn to handle both the things simultaneously or become a saint until you crack the JEE.*

In my opinion the second option is better as at your age nobody is mature enough to handle both the things simultaneously.

ATTENTION SEEKERS

Seeking attention may also be considered as a distraction. See, if looking good makes you feel 'confident', then it is fine, but if it makes you feel 'acceptable', then it is wrong. Try to please everyone with your result and not with your so called personality. My perception is, in your age personality keeps on changing in days or weeks. Accept yourself as a future star, who can do much more than the rest without following their ways. Love yourself and respect your uniqueness. Let people judge you, but what you think about yourself matters the most. Just decide what appeals you the most - a 'show man' or a 'show stopper'.

All the above written distractions are those common factors which everyone among us faces or faced in his/her life. You are not alone the only victim of these.

REMEMBER!

For clearing JEE, you need not at all isolate yourself from your friends, family or any modes of recreation. Rather, it is very necessary to give them the time they deserve. **Play for half an hour or talk to your parents or play with your siblings or watch TV, chat, dance, sing, sketch** etc., in short, do whatever, which makes you forget that you are up for a job, but with a restriction. In the early days of my career, I had a student who was very fond of cricket. He got his selection to IIT with a marvelous rank of 325. Just imagine, he was playing a cricket match 4 days before his IIT-JEE, in which he got this rank. This was a lesson for me regarding distractions. If we analyse this incident properly, we can easily understand the difference between stumbling blocks and utilisation of above written distractions with focused approach. That's why I mentioned above, do whatever you like, but be focused in your approach. See how beautifully **Abraham Lincoln** connected these distractions with destiny

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

@CLASS XII SYLLABUS

JEE Final Touch

Fast Track Revision

Surface Chemistry

ADSORPTION

- The accumulation/adhesion of atoms/ions/molecules of gas, liquid or solid (adsorbate) at the surface rather than the whole mass of a substance (adsorbent) is called adsorption.
- It proceeds with a negative value of ΔH (exothermic), ΔS (decrease in entropy) and ΔG (spontaneous).

Distinction between Adsorption and Absorption

Adsorption	Absorption
It implies concentration at the surface only.	It implies penetration into the body of the solid.
It is a rapid process and equilibrium is maintained in a short time.	In this, the equilibrium is reached slowly.

Note Both adsorption and absorption often take place side by side and it is difficult to distinguish between these two processes.

- Mc Bain introduced the general term sorption, which includes both the processes.

Characteristics of Adsorption

- It is a specific and selective phenomenon, refers to the existence of a higher concentration of any particular component at the surface of a liquid or a solid phase.
- For adsorption, $\Delta G < 0$, $\Delta S < 0$ and $\Delta H < 0$. Hence, the adsorption is associated with decrease in enthalpy of the system. Thus, adsorption is always an exothermic process.
- The atoms or molecules of a solid surface have unbalanced or residual attractive forces on the surface, which can hold adsorbate particles together. Thus, the adsorbed atoms or molecules can be held on the surface of a metal by physical van der Waals' forces or chemical forces due to residual valence bond.
- All solids adsorb gases to some extent. Adsorption is not very pronounced unless an adsorbent possesses a large surface area for a given mass.

Types of Adsorption

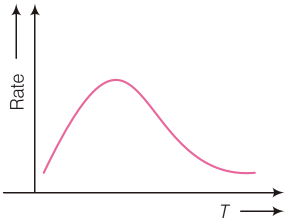
Physisorption

The adsorbate and adsorbent are held together by weak van der Waals' forces of attraction.

- It is reversible and not specific in nature.
- Rate of physisorption is directly proportional to ease of liquefaction of adsorbate. Also, it increases with increase in surface area of adsorbent.
- Rate of physisorption increases with increase in pressure upto a certain extent and decreases with increase in temperature.

Chemisorption

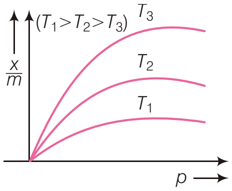
- The adsorbate and adsorbent are held together by chemical bond. It is irreversible and highly specific. It increases with increase in surface area of adsorbent.
- Rate of chemisorption increases with increase in temperature till the activation energy is achieved.

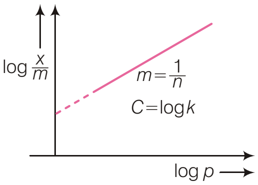


Isotherms Related to Adsorption

(I) Freundlich Adsorption Isotherm

It gives the variation of rate of adsorption with pressure, $\frac{x}{m} = kp^{1/n}$; $(n > 1)$ or $\log\frac{x}{m} = \log k + \frac{1}{n}\log p$



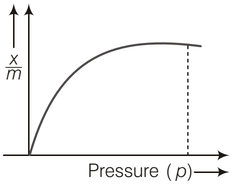


When $\frac{1}{n} = 0$, $\frac{x}{m}$ = constant (i.e. independent of pressure). When $\frac{1}{n} = 1$, $\frac{x}{m} = kp$ (rate of adsorption is directly proportional to pressure)

- It fails at high pressure.
- It is also applicable to adsorption by a solid in solution, in which pressure is replaced by concentration (C).

$$\frac{x}{m} = kC^{1/n} \quad \text{or} \quad \log\frac{x}{m} = \log k + \frac{1}{n}\log C$$

(II) Langmuir Adsorption Isotherm



Langmuir derived an adsorption isotherm on theoretical considerations based on kinetic theory of gases. The Langmuir adsorption isotherm is represented by the relation.

$$\frac{x}{m} = \frac{ap}{1 + bp} \quad (a \text{ and } b \text{ are two Langmuir parameters})$$

At high pressure, $\frac{x}{m} = \frac{a}{p}$. At low pressure, $\frac{x}{m} = ap$

At low pressure, x/m linearly increases with p. At high pressure, x/m becomes constant, i.e. the surface is fully covered and change in pressure has no effect and no further adsorption takes place.

Applications of Adsorption

- Adsorbents like silica and aluminium gels are used to remove moisture to control humidity.
- Noble gases are separated by adsorbing them on coconut charcoal at different temperatures due to different degree of adsorption of noble gases.
- Coloured impurities are removed from a solution by adsorbing them with the help of animal charcoal.
- Froth floatation process for the concentration of sulphide ores is based on adsorption.
- In the creation of completely vacuum space etc.

Best Practice SHOTS

1. The area of interface depends upon the

I. size of the particles of bulk phase.
II. size of the particles of other than bulk phase.
III. shape of the particles of bulk phase.

Which of the above statements is/are correct?

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

2. If $\frac{x}{m}$ is the mass of adsorbate adsorbed per unit mass of adsorbent, p is the pressure of the adsorbate gas and a and b are constants, which of the following represents 'Langmuir adsorption isotherm'?

(a) $\log\left(\frac{x}{m}\right) = \log\left(\frac{a}{b}\right) + \frac{1}{a}\log p$ (b) $\frac{x}{m} = \frac{1}{ap} + \frac{b}{a}$

(c) $\frac{1}{\left(\frac{x}{m}\right)} = \frac{a}{b} + \frac{p}{a}$ (d) $\frac{1}{\left(\frac{x}{m}\right)} = \frac{b}{a} + \frac{1}{ap}$

3. The characteristics of an adsorption process are given below.

I. It is an exothermic process.
II. Adsorption increases with increasing temperature.
III. The bond involved in the chemisorption process may be covalent or ionic.
IV. The material on the surface of which adsorption takes place is called adsorbate.

Which of the above statements are correct?

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

4. Freundlich adsorption isotherm is given by the expression $\frac{x}{m} = k \cdot p^{1/n}$. Some conclusions that can be drawn from this expression are given below.

I. When $\frac{1}{n} = 0$, the adsorption is independent of pressure.

II. When $\frac{1}{n} = 0$, the adsorption is directly proportional to pressure.

III. When $\frac{1}{n} = 0$, $\frac{x}{m}$ *versus* p graph is a line parallel to x-axis.

IV. When $\frac{1}{n} = 0$, plot of $\frac{x}{m}$ *versus* p is a logarithmic type curve.

Which of the above statements are correct?

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

5. Plot of $\log \frac{x}{m}$ against $\log p$ is a straight line inclined at an angle of 45°. When the pressure is 0.5 atm and Freundlich parameter, k is 10, the amount of solute adsorbed per gram of adsorbent will be ($\log 5 = 0.6990$)

(a) 1 g *(b)* 2 g
(c) 5 g *(d)* 2.5 g

6. Which among the following statements are correct with respect to adsorption of gases on a solid?

I. The extent of adsorption is equal to Kp^n according to Freundlich isotherm.

II. The extent of adsorption is equal to $\frac{(1+bp)}{ap}$ according to Langmuir isotherm.

III. The extent of adsorption is equal to $\frac{ap}{(1+bp)}$ according to Langmuir isotherm.

IV. The extent of adsorption is equal to $Kp^{1/n}$ according to Freundlich isotherm.

V. Freundlich adsorption isotherm fails at low pressure.

where, K, a and b are constants and p is pressure.

Choose the correct option.

(a) I and III *(b)* III and IV
(c) II and III *(d)* II and IV

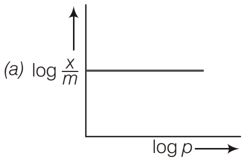
7. Match the Column I with Column II and select the correct option from the codes given below.

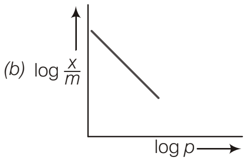
Column I	Column II
A. Adsorption	p. ΔH always negative
B. Freundlich isotherm	q. High specificity
C. Chemisorption	r. $\frac{x}{m} = K \cdot p^{1/n} (n > 1)$
D. Adsorption at equilibrium	s. $\Delta H = T\Delta S$

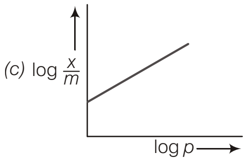
Codes

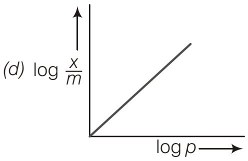
	A	B	C	D
(a)	p	q	r	s
(b)	p	s	q	r
(c)	q	p	r	s
(d)	p	r	q	s

8. Which one of the following graphs represents Freundlich adsorption isotherm?









9. At the equilibrium position for the process of adsorption, the correct relation is

(a) $\Delta H > 0$
(b) $\Delta H = T\Delta S$
(c) $\Delta H > T\Delta S$
(d) $\Delta H < T\Delta S$

Hint At equilibrium, $\Delta G = 0$

$$\Delta H - T\Delta S = 0, \Delta H = T\Delta S.$$

10. 1 g of charcoal is placed in 100 mL of 0.5 M CH_3COOH to form an adsorbed monolayer of acetic acid molecule and thereby, the molarity of CH_3COOH reduces to 0.49. Surface area of charcoal $= 3.01 \times 10^2$ m^2/g. The surface area of charcoal adsorbed by each molecule of acetic acid is

(a) 5×10^{-9} m^2
(b) 4×10^{-9} m^2
(c) 5×10^{-19} m^2
(d) 6×10^{-19} m^2

Hint Number of acetic acid molecules adsorbed

$$= 1 \times 10^{-3} \times 6.023 \times 10^{23}$$

$$= 6.023 \times 10^{20}$$

∴ Area of 1 molecule of acetic acid

$$= \frac{3.01 \times 10^2}{6.023 \times 10^{20}}$$

$$= 5 \times 10^{-19} \text{ m}^2$$

11. Which is not correct regarding the adsorption of a gas on surface of a solid?

(a) Enthalpy and entropy change is negative
(b) Adsorption is more for some specific substance
(c) On increasing temperature, adsorption increases progressively
(d) It is a reversible reaction

Hint Adsorption decreases with increasing temperature.

CATALYSIS

A substance that alters the rate of a reaction without being consumed in the reaction is called catalyst and the phenomenon is known as catalysis.

Types of Catalysis

(a) **Homogeneous catalysis** Both reactants and the catalyst are in same phase.

e.g. $2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$ [Catalyst–NO(*g*)]

(b) **Heterogeneous catalysis** The reactants and the catalyst are in different phase.

e.g. $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$ [Catalyst– Fe(*s*)]

$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$ [Catalyst– Pt(*s*)]

(c) **Positive catalysis** When a catalyst increases the rate of reaction.

e.g. $2H_2 + O_2 \xrightarrow{\text{Pt (s)}} 2H_2O$ [Catalyst - Pt(*s*)]

(d) **Negative catalysis** When a catalyst decreases the rate of reaction, e.g.

$2Na_2SO_3(s) + O_2(g) \xrightarrow{\text{Alcohol}(l)} 2Na_2SO_4(s)$

[Catalyst-alcohol]

(e) **Auto-catalysis** Sometimes during a reaction either of the products acts as catalyst and this phenomenon in which a chemical reaction is catalysed by product of the reaction is known as auto-catalysis.

e.g. $CH_3COOC_2H_5 + H_2O \longrightarrow CH_3COOH + C_2H_5OH$

[Auto-catalyst-CH_3COOH]

Adsorption Theory of Heterogeneous Catalysis

It is based on theory of intermediate complex formation and involves the following continuous steps:

***Step* I** Reactant molecules are diffused to the surface of the catalyst.

***Step* II** Reactant molecules are adsorbed at the surface of the catalyst.

***Step* III** Chemical reaction occurred at the surface of catalyst through the formation of intermediate.

***Step* IV** Products formed are desorbed making the surface available for new reaction.

Shape Selective Catalysis (Zeolites)

The catalytic reaction depends on size of reactants, products and pore sizes of catalysts.

e.g. Zeolites (microporous aluminosilicates in which some Si-atoms are replaced by Al-atoms). ZSM-5, a zeolite directly converts alcohol to gasoline.

Enzyme catalysis Enzymes are biochemical catalysts and catalyse a specific chemical reaction in plants and animals.

An enzyme is a protein molecule and forms colloidal solution in water.

- Enzymes are highly efficient, highly specific, highly active under optimum temperature range (298-310 K), highly active under optimum pH (5-7).
- Enzyme activity is increased in the presence of activators and coenzymes and it decreases in the presence of inhibitors or poisons.
- Enzyme catalysis proceeds through the formation of enzyme-substrate complex according to lock and key mechanism, in which the substrate acts as the closed lock and enzyme acts as the key.

$$\underset{\text{Enzyme}}{E} + \underset{\text{Substrate}}{S} \rightleftharpoons \underset{\substack{\text{(Concept of its}\\ \text{existence was proposed}\\ \text{by Charles A. Wurtz in 1880)}}}{E\text{-}S \text{ complex}}$$

$$\rightleftharpoons E\text{-}P \text{ complex} \rightleftharpoons E + P$$

Applications of Catalysis in Industry

S.No.	Industrial process	Catalyst used
1.	Acetic acid from acetaldehyde by oxidation with air	V_2O_5
2.	Bosch process for the manufacture of H_2	$Fe_2O_3 + Cr_2O_3$
3.	Contact process for the manufacture of H_2SO_4	V_2O_5, Pt
4.	Deacon's process for the manufacture of Cl_2	$CuCl_2$
5.	Dehydrogenation of alcohol to aldehyde	Cu
6.	Haber's process for the synthesis of NH_3	Fe_2O_3 or Fe + Mo
7.	Lead chamber process for the manufacture of H_2SO_4	NO
8.	Manufacture of vegetable ghee	Ni
9.	Methanol from water gas and H_2	ZnO, Cr_2O_3
10.	Ostwald's process for the manufacture of HNO_3	Pt gauze
11.	Polymerisation of alkenes	H_3PO_4 on kieselguhr
12.	Preparation of O_2 from $KClO_3$	MnO_2
13.	Synthetic petrol from coal (Bergius process)	Iron oxalate

Best Practice SHOTS

12. The steps of adsorption mechanism are given below.

I. Adsorption of reactant molecules on the surface of catalyst.
II. Diffusion of reactant at the surface of catalyst.
III. Desorption of reaction products from the catalyst surface.
IV. Occurrence of chemical reaction on the catalyst's surface through the formation of an intermediate.

Arrange the steps in the correct order and choose the correct option.

(a) I, III, IV, II *(b)* II, I, IV, III *(c)* I, II, IV, III *(d)* I, II, III, IV

13. Match the reactions given in Column I with Column II representing corresponding processes and select the correct option from the codes given below.

Column I	Column II
A. $4NH_3(g) + 5O_2(g) \xrightarrow{Pt(s)} 4NO(g) + 6H_2O(g)$	p. Homogeneous catalysis
B. $N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$	q. Haber's process
C. $2SO_2(s) + O_2(g) \xrightarrow{NO(s)} 2SO_3(g)$	r. Ostwald's process

Codes

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

14. Which of the following statements are true about zeolite?

I. They are microporous structure of aluminosilicates.
II. Catalytic activity depends upon the pores and cavities of the zeolites.
III. Zeolites are not found in nature.
IV. ZSM-5 is a zeolite.

Identify the correct option.

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

15. Which reaction characteristics are changing by the addition of a catalyst to a reaction at constant temperature?

I. Activation energy II. Equilibrium constant
III. Reaction entropy IV. Reaction enthalpy

(a) Only I *(b)* Only II
(c) I and II *(d)* All of these

16. Identify the correct statement regarding enzymes.

(a) Enzymes are specific biological catalysts that can normally function at very high temperatures ($T \sim 1000$ K)
(b) Enzymes are normally heterogeneous catalysts that are very specific in their action
(c) Enzymes are specific biological catalysts that cannot be poisoned
(d) Enzymes are specific biological catalysts that possess well defined active sites

17. Consider the following statements. Identify the true (T) or false (F) statements and choose the correct option given below.

I. A catalyst remains unchanged chemically and physically at the end of the reaction.
II. The activity of enzymes is increased in the presence of certain substances known as coenzymes or activators.
III. Acetic acid formed during hydrolysis of ester acts as an induced catalyst.
IV. Combination of N_2 and H_2 in the presence of Fe as a catalyst is an example of heterogeneous catalysts.

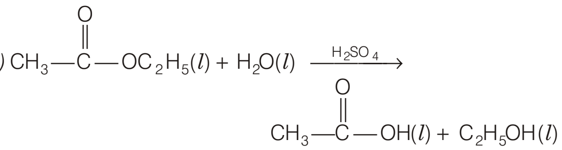
Codes

	I	II	III	IV
(a)	T	F	T	F
(b)	F	F	T	T
(c)	F	T	F	T
(d)	T	T	F	F

18. Which of the following reactions is an example of heterogeneous catalysis?

(a) $O_3(g) + O(g) \xrightarrow{Cl} 2O_2(g)$ (gas phase)

(b) $2CO(g) + O_2(g) \xrightarrow{NO} 2CO_2(g)$

(c)


$$CH_3-\overset{\overset{\large O}{\|}}{C}-OC_2H_5(l) + H_2O(l) \xrightarrow{H_2SO_4} CH_3-\overset{\overset{\large O}{\|}}{C}-OH(l) + C_2H_5OH(l)$$

(d) $CO(g) + 2H_2(g) \xrightarrow{Cu,\ ZnO\text{-}Cr_2O_3} CH_3OH(l)$

19. On the basis of data given below, predict which of the following gases show least adsorption on a definite amount of charcoal?

Gas	CO_2	SO_2	CH_4	H_2
Critical temp./K	304	630	190	33

(a) CO_2 *(b)* SO_2 *(c)* CH_4 *(d)* H_2

Hint Lesser the value of critical temperature of gases, lesser will be the extent of adsorption.

20. In which of the following reactions, heterogeneous catalysis is involved?

I. $2SO_2(g) + O_2(g) \xrightarrow{NO(g)} 2SO_3(g)$
II. $2SO_2(g) \xrightarrow{Pt(s)} 2SO_3(g)$
III. $N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$
IV. $CH_3COOCH_3(l) + H_2O(l) \xrightarrow{HCl(l)} CH_3COOH(aq) + CH_3OH(aq)$

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

21. Which one of the following is an example of homogeneous catalysis?

(a) Manufacture of sulphuric acid by contact process
(b) Manufacture of ammonia by Haber's process
(c) Hydrolysis of sucrose in the presence of dilute hydrochloric acid
(d) Hydrogenation of oil

CLASSIFICATION OF COLLOIDS AND COLLOIDS AROUND US

Colloidal state is a state in which a substance is dispersed in another medium in the form of very small particles having size in the range 1-100 nm.

Classification of Colloids

Based on the nature of interaction between the dispersed phase and the dispersion medium, colloidal solutions are classified as:

(a) **Lyophilic colloids** These are liquid loving colloids and are formed directly by mixing substances like gelatin, starch, etc. These are more stable and cannot be easily coagulated.

(b) **Lyophobic colloids** These are liquid hating colloids and are usually formed by metals, metal sulphides etc.

- These are prepared by special methods like chemical methods, Bredig's arc method etc.
- These are also called irreversible sols because once they are precipitated, it is difficult to convert them back to colloidal solution.

Classification of Colloids based on Types of Particles of Dispersed Phase

(a) **Multimolecular colloids** A large number of atoms/molecules/ions aggregate together to form colloids, e.g. gold sol, sulphur sol.

(b) **Macromolecular colloids** Macromolecules like protein, starch, enzymes etc., form colloidal solution.

(c) **Associated colloids** (micelles) These colloids behave as strong electrolyte at low concentration but behave as colloids at high concentration due to association of particles called micelles.

- Micelles are formed only at a particular temperature called **Kraft temperature** (T_K) and concentration called **Critical Micelle Concentration** (CMC), e.g. cleansing action of soap.

Methods of Preparation of Colloids

(a) **Chemical methods** In these methods, chemical reactions are carried out and products formed associated leading to the formation of colloidal solution, e.g.

$$As_2O_3 + 3H_2S \longrightarrow As_2S_3\,(sol) + 3H_2O$$

(b) **Bredig's arc method** Colloidal solution of metals like Au, Ag, Pt etc., are prepared by this method. Metal electrodes are dipped in dispersion medium and high voltage is provided. Metal atoms are vaporised due to intense heat, which are then condensed to form colloidal solution.

(c) **Peptisation** Precipitates are converted back to colloidal solution by shaking it in dispersion medium with the help of a small amount of electrolyte.

Gold Number

Gold number of a protective colloid is the minimum weight of it in milligrams which must be added to 10 mL of a substance (red gold sol) so that no coagulation of the gold sol takes place when 1 mL of 10% sodium chloride solution is rapidly added to it.

or

Weight of the dried protective agent in milligrams, which, when added to 10 mL of a standard gold sol (0.0053 to 0.0058%), is just sufficient to prevent a colour change from red to blue on the addition of 1 mL of 10% sodium chloride solution, is equal to the gold number of protective colloid. Protective power $\propto \dfrac{1}{\text{Gold number}}$

Note Gold number is a practical value, it cannot be obtained theoretically.

Properties of Colloidal Solution

(a) **Tyndall effect** Colloidal solutions show Tyndall effect due to scattering of light by colloidal particles in all directions in space.

- Tyndall effect is observed only under the following conditions:
  - (i) The diameter of the colloids should not be much smaller than the wavelength of light used.
  - (ii) The refractive indices of the dispersed phase and the dispersion medium should differ greatly in magnitude.

(b) **Colour** The colour of colloidal solution depends on wavelength of light scattered by dispersed particles, size and nature of colloidal particles and direction of observation.

(c) **Brownian movement** Colloidal particles show a continuous *zig-zag* motion which is independent of nature of particles but small sized particles show faster movement.

(d) **Charge on colloidal particles** Each colloidal particle of a solution is either positively or negatively charged, the reason for this charge is best explained by preferential adsorption of ions from solution.

- **Positively charged sols** Sols of haemoglobin, hydrated metallic oxides like $Al_2O_3 \cdot xH_2O$, $CrO_3 \cdot xH_2O$, $Fe_2O_3 \cdot xH_2O$ etc., basic dye like methylene blue, oxides like TiO_2 etc.
- **Negatively charged sols** Sols of starch, gum, gelatin, clay, charcoal, acid dyes like eosin, congo red sols etc. Metals like Cu, Ag, Au etc., metallic sulphides like As_2S_3, Sb_2S_3, CdS etc.

Cleansing Action of Soap

The hydrophobic part (hydrocarbon) of soap is attached to dirt particles, while the hydrophilic part is projected towards water forming micelles. Now, the micelle along with dirt particle is pulled away towards water due to emulsification and washed away.

Theory of preferential adsorption of ions When two or more ions are present in the dispersion medium, the colloidal particles prefer to adsorb the ion common among them, e.g.

$$FeCl_3 + H_2O\,(hot) \longrightarrow \underset{\text{(Positively charged)}}{Fe_2O_3 \cdot xH_2O/Fe^{3+}}$$

$$FeCl_3 + NaOH \longrightarrow \underset{\text{(Negatively charged)}}{Fe_2O_3 \cdot xH_2O/OH^-}$$

Helmholtz electrical double layer The charged colloidal particles layer after preferential adsorption, further attracts oppositely charged ions from dispersion medium forming a second layer called Helmholtz electrical double layer. e.g.

$$\underset{\text{(Layer-1, fixed layer)}}{[AgI]\ I^-} \quad \underset{\text{(Layer-2, diffused layer)}}{K^+}$$

- The potential difference between the fixed layer and diffused layer is called electrokinetic potential or zeta potential.

Coagulation (Precipitation) of Colloidal Particles

Coagulation of lyophobic sols These are coagulated by electrophoresis, mixing two oppositively charged sols, boiling or persistent dialysis etc.

- A positively charged ion causes the precipitation of a negatively charged sol and *vice-versa*.

Hardy-Schulze rule According to this rule, higher the charge on the flocculating ion added for coagulation, higher is the coagulating power of the ion.

- For the coagulation of a positively charged sol, the coagulation power of different negatively charged ions is $[Fe(CN)_6]^{4-} > PO_4^{3-} > SO_4^{2-} > NO_3^-$
- For the coagulation of a negatively charged sol, the coagulation power of different positively charged ions is $Al^{3+} > Ba^{2+} > Na^+$.

Coagulation of lyophilic sols These sols having high solvation energy and charge are more stable than lyophobic sols.

- These are coagulated by adding an electrolyte and a suitable solvent like alcohol, acetone etc.

Emulsions (Liquid-Liquid Colloidal System)

When two immiscible or partially miscible liquids are mixed and shaken together, one liquid is dispersed over another forming a colloidal system called emulsions. Emulsions are of two types such as:

(a) **Oil dispersed in water** (O/W) **type** Here, water acts as a dispersion medium, e.g. milk.

(b) **Water dispersed in oil** (W/O) **type** Here, oil acts as a dispersion medium. e.g. butter, cream etc.

Emulsifying Agents

Due to lyophobic nature, oil in water type of emulsion is unstable and requires an emulsifying agent for their stabilisation. e.g. proteins, gums, long chain alcohols, heavy metal salts, fatty acids, soaps etc.

Applications of Colloids

Colloids have many important applications such as:

- Electrical precipitation of pollutants present in smoke.
- Purification of drinking water by coagulating suspended particles.
- Colloidal medicines are more effective due to the large surface area of colloids in dispersion medium.
- Cleansing action of soaps and detergents are due to micelle formation.

Photographic film is an emulsion of light sensitive AgBr in gelatin.

Best Practice SHOTS

22. Some statements are given below.

I. Soap molecules form micelle around the oil droplet.
II. Polar groups of soap molecules interact with water.
III. The negatively charged sheath around the micelles prevent further aggregation.
IV. Hydrophobic group of the soap molecule interact with water.

Which of the above statements are true?

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

23. In an electric field, the particles of a colloidal system move towards cathode. The coagulation of the same sol is studied using K_2SO_4 (I), Na_3PO_4 (II), $K_4[Fe(CN)_6]$ (III) and NaCl (IV). Their coagulating power should be

(a) I > II > III > IV *(b)* III > II > I > IV
(c) III > I > II > IV *(d)* IV > I > II > III

Hint According to Hardy-Schulze rule, greater the valency of coagulating ion added, the greater is its power to cause coagulation.

$$\underset{\text{III}}{[Fe(CN)_6]^{4-}} > \underset{\text{II}}{PO_4^{3-}} > \underset{\text{I}}{SO_4^{2-}} > \underset{\text{IV}}{Cl^-}$$

24. A freshly formed precipitate of SnO_2 is peptised by a small amount of NaOH. Their colloidal particles may be represented as

(a) $[SnO_2]\ SnO_3^{2-};\ 2Na^+$ *(b)* $[SnO_2]\ Sn^{4+};\ O^{2-}$
(c) $[SnO_2]\ Na^+;\ OH^-$ *(d)* $[SnO_2]\ Sn^{4+};\ OH^-$

25. The volume of colloidal particle, V_C as compared to the volume of a solute particle in a true solution V_S, could be

(a) $\frac{V_C}{V_S} \approx 10^3$ *(b)* $\frac{V_C}{V_S} \approx 10^{-3}$ *(c)* $\frac{V_C}{V_S} \approx 10^{23}$ *(d)* $\frac{V_C}{V_S} \approx 1$

26. Consider the following statements.

I. The collodion is 4% solution of nitrocellulose in a mixture of alcohol and ether.
II. Colloidal solution shows colligative properties.
III. The coagulation power of Na^+ is more than Ba^{2+}.
IV. Detergents with high CMC are more economical to use.

Which of the above statements are correct?

(a) I and III *(b)* I and II
(c) I and IV *(d)* II and IV

27. Match the Column I with the Column II and select the correct option from the codes given below.

Column I	Column II
A. Micelles	p. 10^{-4} to 10^{-3} mol L^{-1}
B. CMC of soaps	q. Kraft temperature
C. Lyophilic	r. Sulphur sol
D. Multimolecular colloid	s. Liquid loving

Codes

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

28. The amount of electrolytes required to coagulate the given amount of AgI colloidal solution (negative charge) will be in the order

(a) $NaNO_3 > Al_2(NO_3)_3 > Ba(NO_3)_2$
(b) $Al_2(NO_3)_3 > Ba(NO_3)_2 > NaNO_3$
(c) $Al_2(NO_3)_3 > NaNO_3 > Ba(NO_3)_2$
(d) $NaNO_3 > Ba(NO_3)_2 > Al_2(NO_3)_3$

29. Consider the following statements.

I. Micelle formation by soap in aqueous solution is possible at all temperatures.
II. Micelle formation by soap in aqueous solution occurs above a particular concentration.
III. On dilution of soap solution, micelles may revert to individual ions.
IV. Soap solution behaves as a normal strong electrolyte at all concentrations.

Which of the above statements are correct?

(a) I and II *(b)* II and III
(c) III and IV *(d)* II and IV

Hint When soap is mixed with water above the critical micelle concentration (CMC), micelles are formed, i.e. colloids are associated.

30. The gold numbers of a few protective colloids are given below

x 0.005, y 3.5, z 40

The protective nature of these colloidal solutions follows the order

(a) $z > x > y$ *(b)* $x < y > z$ *(c)* $z > y > x$ *(d)* $x > y > z$

31. Among the following, the surfactant that will form micelles in aqueous solution at the lowest molar concentration at ambient conditions is

(a) $CH_3(CH_2)_{15}N^+(CH_3)_3Br^-$ *(b)* $CH_3(CH_2)_{11}OSO_3^- Na^+$
(c) $CH_3(CH_2)_6COO^- Na^+$ *(d)* $CH_3(CH_2)_{11}N^+(CH_3)_3Br^-$

32. Pick out the statements, which are relevant in the discussion of colloids.

I. Sodium aluminium silicate is used in the softening of hard water.
II. Potash alum is used in shaving wounds and as a styptic in medicines.
III. Artificial rain is caused by throwing electrified sand on the clouds from an aeroplane.
IV. Deltas are formed at a place where the river pours its water into the sea.

Choose the correct option.

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

Hint In the softening of hard water, simple chemical substitution of calcium salt with zeolite occurs so that calcium zeolite precipitates out and hardness of water removes.

33. The dispersed phase in colloidal iron (III) hydroxide and colloidal gold is positively and negatively charged respectively. Which of the following statement(s) is/are not correct?

I. Coagulation in both sols can be brought about by electrophoresis.
II. Mixing of sols cause no effect.
III. Sodium sulphate solution causes coagulation in both sols.
IV. Magnesium chloride solution coagulates the gold sol more readily than the iron (III) hydroxide sol.

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

34. Bleeding due to a cut can be stopped by applying ferric chloride solution in the laboratory. This is due to

(a) coagulation of negatively charged blood particles by Fe^{3+} ions
(b) coagulation of positively charged blood particles by Cl^- ions
(c) reaction taking place between ferric ions and the haemoglobin forming a complex
(d) common element, iron, in both $FeCl_3$ and haemoglobin

Answers

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

MASTER STROKE

1. Match the Column I with Column II. Select an appropriate answer from the codes given below.

Column I	Column II
A. Placing silica gel in water vapour.	p. Enzymatic catalysis
B. Placing anhyd. $CaCl_2$ in water vapour.	q. Occlusion
C. Placing finely divided nickel in a closed vessel containing H_2 gas.	r. Adsorption
D. Shaking dil.KCl solution with blood charcoal.	s. Absorption
E. Conversion of proteins into amino acids.	t. Negative adsorption

Codes

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

2. Which of the following is/are application(s) of adsorption?

I. Deionisation of water.
II. Gas masks.
III. Hygroscopic nature of $CaCl_2$.
IV. Heterogeneous catalysis.

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

3. Which of the following is/are not correctly matched?

I. Emulsion - Curd
II. Foam - Mist
III. Aerosol - Smoke
IV. Solid sol - Cake

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

Hint Smoke is an aerosol (solid carbon particles dispersed in air).

4. Match Column I with Column II and select the correct option from the codes given below.

Column I	Column II
A. Argyrol	p. Kala-azar
B. Antimony	q. Intramuscular injection
C. Colloidal gold	r. Stomach disorder
D. Milk of magnesia	s. Eye lotion

Codes

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

5. In an adsorption experiment, a graph between $\log\left(\frac{x}{m}\right)$ *versus* $\log p$ was found to be linear with a slope of 45°. The intercept on the $\log\left(\frac{x}{m}\right)$ axis was found to be 0.3010. The amount of the gas adsorbed per gram of charcoal under a pressure of 0.5 atm is

(a) 1.0 *(b)* 1.5 *(c)* 2 *(d)* 2.5

6. Consider the following statements for the electro-osmosis process of $Fe(OH)_3$ sol.

I. Sol particles move towards anode.
II. Sol particles move towards cathode.
III. The dispersion medium move towards anode.
IV. The sol particles do not move in either direction.

Which of the above statements are true?

(a) III and IV *(b)* I and II *(c)* I and III *(d)* I and IV

Hint In electro-osmosis, the sol particles are prevented from migration whereas the dispersion medium migrates in the direction opposite to those of particles. Here, the medium is negatively charged.

7. Match the following reactions given in Column I with the conditions given in the Column II and select the correct option from the codes given below.

Column I	Column II
A. Haber's process for the manufacture of ammonia $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	p. Platinised asbestos, at 573 K
B. Ostwald's process for the manufacture of nitric acid, $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(s) + 6H_2O(g)$ $2NO(g) + O_2(g) \longrightarrow 2NO_2(g)$ $4NO_2(g) + 2H_2O + O_2(g) \longrightarrow 4HNO_3(aq)$	q. Platinised asbestos or vanadium pentoxide (V_2O_5) at 673-723 K
C. Contact process for the manufacture of sulphuric acid $2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$ $SO_3(g) + H_2SO_4(l) \longrightarrow H_2S_2O_7(aq)$ $H_2S_2O_7(aq) + H_2O(l) \longrightarrow 2H_2SO_4(aq)$	r. Finely divided iron, molybdenum as promoter; at 200 bar pressure and 723-773 K temperature

Codes

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

8. Methylene blue, from its aqueous solution, is adsorbed on activated charcoal at 25°C. For this process, the correct statement is

(a) The adsorption requires activation at 25°C
(b) The adsorption is accompanied by a decrease in enthalpy

(c) The adsorption increases with increase of temperature
(d) The adsorption is irreversible

Hint Physical adsorption takes place with decrease in enthalpy, thus exothermic process occurs. Being physical adsorption, $\Delta H < 0$.

9. When a beam of light is passed through a colloidal solution, it is

(a) reflected *(b)* scattered *(c)* transmitted *(d)* absorbed

Hint When a beam of light is passed through a colloidal solution, it is scattered.

10. 20% surface sites have adsorbed N_2. On heating, N_2 gas is evolved from sites and were collected at 0.001 atm and 298 K in a container of volume 2.46 cm^3. Density of surface sites is 6.023×10^{14} molecules/cm^3 and surface area is 1000 cm^2. The number of surface sites occupied per molecule of N_2 are

(a) 12.046×10^{16} *(b)* 13.046×10^{16}
(c) 15.046×10^{16} *(d)* 12.046×10^{6}

Hint Number of moles of $N_2 = \frac{pV}{RT} = \frac{0.001 \times 2.46 \times 10^{-3}}{0.0821 \times 298}$

$$= 1.0 \times 10^{-7}$$

Molecules of adsorbed $N_2 = 6.023 \times 10^{23} \times 1.0 \times 10^{-7}$

$$= 6.023 \times 10^{16}$$

Total surface sites available = Number of sites/cm^2 × area

$$= 6.023 \times 10^{14} \times 1000 = 6.023 \times 10^{17}$$

Surface sites at which N_2 was adsorbed

$$= \frac{20}{100} \times 6.023 \times 10^{17} = 12.046 \times 10^{16}$$

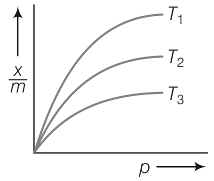
11. The gold number of some colloidal solutions are given below

Colloidal solution	Gold number
A	0.01
B	2.5
C	20

The protective nature of these colloidal solutions follow the order

(a) $C > B > A$ *(b)* $A > B > C$ *(c)* $A = B = C$ *(d)* $B > A > C$

12. Freundlich adsorption isotherm is represented at temperatures T_1, T_2 and T_3,



Arrange the temperature in the increasing order as shown in the graph.

(a) $T_1 < T_2 < T_3$ *(b)* $T_3 < T_2 < T_1$
(c) $T_2 < T_3 < T_1$ *(d)* $T_3 > T_1 < T_2$

13. Which of the following statements are correct?

I. Mixing two oppositely charged sols neutralises their charges and stabilises the colloid.
II. Presence of equal and similar charges on colloidal particles provides stability to the colloids.
III. Any amount of dispersed liquid can be added to emulsion without destabilising it.
IV. Brownian movement stabilises sols.

Choose the correct option.

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

14. Which of the following factors are responsible for the increase in the rate of surface catalysed reaction?

I. A catalyst provides proper orientation for the reactant molecules to react.
II. Heat of adsorption of reactants on a catalyst helps reactant molecules to overcome activation energy.
III. The catalyst increases the activation energy of the reaction.
IV. Adsorption increases the local concentration of reactant molecules on the surface of the catalyst.

Select the correct option.

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

15. 10^{-4} g of gelatin is required to be added to 100 cm^3 of a standard gold solution to just prevent its precipitation by the addition of 1 cm^3 of 10% NaCl solution to it. Hence, the gold number of gelatin in mg is

(a) 10 *(b)* 1.0
(c) 0.1 *(d)* 0.01

Hint NaCl solution prevents coagulation when gelatin is added

$$= \frac{10^{-4}}{100} \times 10 = 10^{-5} \text{ g}$$

So, gold number of gelatin in milligram

$$= 10^{-5} \times 1000 = 10^{-2} = 0.01$$

16. Match the Column I with Column II.

Column I (Catalyst)	Column II (Industrial product)
A. V_2O_5	p. High density polyethylene
B. *Ziegler-Natta*	q. Polyacrylonitrile
C. Peroxide	r. NH_3
D. Finely divided Fe	s. H_2SO_4

Codes

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

Answers

1. (c) **2.** (c) **3.** (c) **4.** (b) **5.** (a) **6.** (a) **7.** (b) **8.** (b) **9.** (b) **10.** (a)
11. (b) **12.** (b) **13.** (c) **14.** (c) **15.** (d) **16.** (c)

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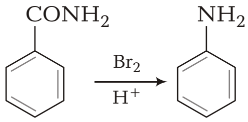
Mock Questions with Complete Solutions

Paper 1

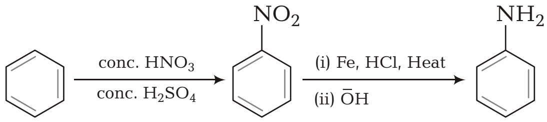
Integer Type Questions

1. Consider the following reaction sequences,

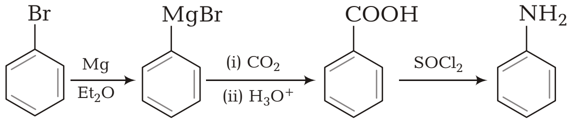
I.



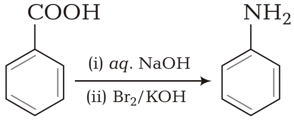
II.



III.



IV.



Among the above, how many reaction sequence(s) is/are correct for the synthesis of amines?

2. Phenol associates in benzene to a certain extent to form dimers. A solution containing 2.0×10^{-2} kg of phenol in 1.0 g of benzene has its freezing point decreased by 0.69 K. Calculate the degree of association of phenol and approximate it to the nearest integer value.

(K_f for benzene = 5.12 K molal^{-1})

3. A hydrated metallic salt *A* is light green in colour. On careful heating, it gives a white anhydrous residue *B*. *B* is soluble in water and its aqueous solution reacts with NO to give a dark brown compound *C*. *B* on heating, produces a mixture of products. How many products are formed?

4. A C_9H_{20} hydrocarbon (linear molecule), on monochlorination, gives a mixture of products. The optically active products formed in the reaction is

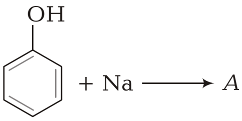
5. The mass of an electron is 9.1×10^{-31} kg. If its kinetic energy is 3.0×10^{-25} J and wavelength in metre is 8.9×10^{-x}, find the value of x.

6. The following reaction is non-spontaneous at 25°C,

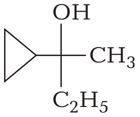
$$Cu_2O(s) \rightleftharpoons 2Cu(s) + \frac{1}{2}O_2(g);\ \Delta_r G^\circ = 141\ \text{kJ}$$

If $\Delta_r S^\circ = 75.18\ \text{JK}^{-1}$ and above $(2170 + x)$ K, the reaction becomes spontaneous. Calculate the value of x.

7. The number of resonance structure(s) for *A* is

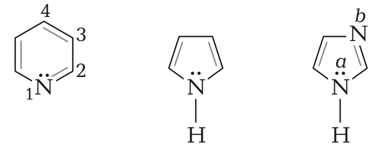


8. How many different Grignard reagents can be directly used to prepare the following alcohol alongwith other suitable compounds?



One or More than One Options Correct Type

9. Consider the following molecules,



Pyridine (I) Pyrrole (II) Imidazole (III)

Which one of the following statement(s) is/are correct?

(a) (I) and (III) are modest Bronsted bases whereas (II) is not

(b) In (III), N^a is more basic than N^b

(c) When (III) is protonated in the presence of a strong acid, protonation occurs at C-2

(d) All the nitrogen present in (I), (II) and (III) are sp^2 hybridised

10. Consider the following reactions,

$$\text{I.}\quad \underset{A}{\text{Me}-\!\equiv\!-\text{Me}} \xrightarrow[\text{Pd+BaSO}_4]{\text{H}_2} B \xrightarrow{\text{D}_2/\text{Pd/C}} C$$

$$\text{II.}\quad \underset{A}{\text{Me}-\!\equiv\!-\text{Me}} \xrightarrow[\text{(ii) EtOH}]{\text{(i) Na+liq. NH}_3} D \xrightarrow{\text{D}_2/\text{Pd/C}} E$$

Which of the following statements is/are correct?

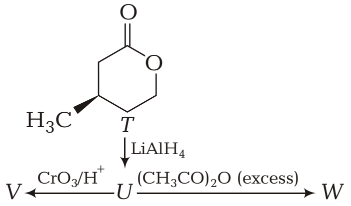
(a) *B* is *cis*-but-2-ene and *D* is *trans*-but-2-ene

(b) *B* is *trans*-but-2-ene and *D* is *cis*-but-2-ene

(c) *C* is *meso* form and *E* is racemic forms

(d) *C* is racemic forms and *E* is *meso* form

11. With reference to the scheme given below, which of the given statements about *T*, *U*, *V* and *W* is/are correct?



(a) *T* is soluble in hot *aq.* NaOH

(b) *U* is optically active

(c) Molecular formula of *W* is $C_{10}H_{18}O_4$

(d) *V* gives effervescence on treatment with *aq.*$NaHCO_3$

12. Which of the following statements is/are correct about the given reaction?

$$\text{MeCHO} + [\text{Ag(NH}_3)_2]^+ + \bar{\text{O}}\text{H} \longrightarrow \text{MeCOO}^- + \text{Ag}$$

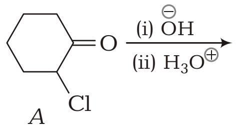
(a) The equivalent weight of MeCHO is 22

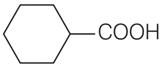
(b) Three moles of $\bar{\text{O}}\text{H}$ are required in the above reaction

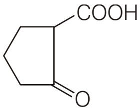
(c) MeCHO acts as an oxidising agent

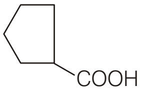
(d) $[\text{Ag(NH}_3)_2]^+$ gets reduced

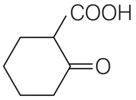
13. The major product of the following reaction is



(a) 

(b) 

(c) 

(d) 

14. Consider the following reaction steps,

$$\text{CuS} \xrightarrow[\text{in air}]{\text{Roasting}} A \xrightarrow[\text{air}]{\text{Roast without}} B$$

Which of the following statements is correct regarding the above reaction steps?

(a) It is a self reduction process

(b) It involves disproportionation, $Cu_2S \longrightarrow Cu + CuS$

(c) *A* is a mixture of Cu_2O and SO_2 and *B* is a mixture of Cu and SO_2

(d) *A* is a mixture of Cu and SO_2 and *B* is $CuSO_4$

15. Ti^{3+}, V^{3+}, Fe^{3+} and Co^{2+} afford a large number of tetrahedral complexes while Cr^{3+} never. The correct reason for this is

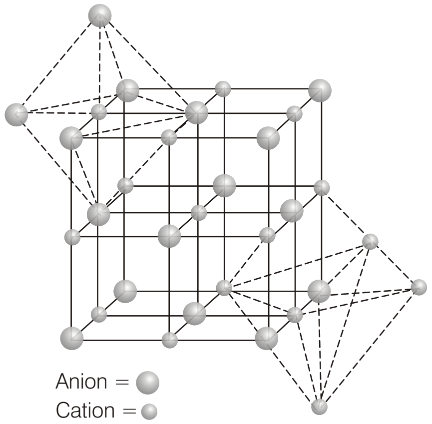
(a) Cr^{3+} imparts high crystal field splitting with different ligands

(b) In Cr^{3+} system, crystal field stabilisation energy plays a deciding role for the formation of tetrahedral or octahedral complexes

(c) The ionic radius of Cr^{3+} is the largest among the other M^{3+} ions mentioned in the problem

(d) Electronegativity of Cr^{3+} is the largest among these trivalent 3*d*-metal ions, hence, chromium prefers to be associated with as many ligands as its ionic radius permits

16. Consider the following structure,



Which of the following statements is/are correct about tetrahedral voids in the given unit cell?

(a) Number of tetrahedral voids per unit cell is 2

(b) Number of tetrahedral voids per unit cell is 8

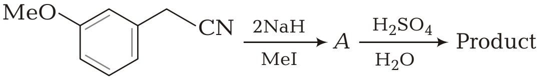
(c) Number of tetrahedral voids is twice the number of atoms in the given unit cell

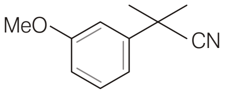
(d) Number of tetrahedral voids is equal to the number of atoms in the fcc unit cell

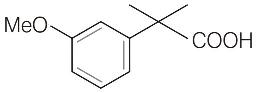
17. When HCN reacts with chlorine, it gives A. On further reaction with HCl, it readily forms B. B when reacts with KNH_2, gives $(RNHCN)(ClCN)_2$ and $R\,NH_3^+Cl^-$.
Using the above information, select the correct statements about molecule B.

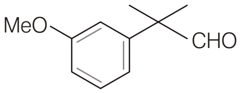
(a) It is a cyclic molecule
(b) Geometry at carbon is triangular planar with sp^2 hybridisation of carbon
(c) Geometry at nitrogen is triangular planar with sp^2 hybridisation of N
(d) Ratio of electrons $\alpha : \pi : lp$ is 3 : 1 : 4

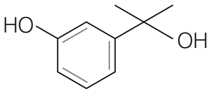
18. Identify the final product from the following transformation.



(a)


(b)


(c)


(d)


Matching Type Questions

19. Match the complex with its geometry/magnetic property.

	Column I		Column II
A.	$[Ni(CO)_4]$	p.	Square planar
B.	$[Ni(CN)_4]^{2-}$	q.	Tetrahedral
C.	$[Cu(NH_3)_4]^{2+}$	r.	Paramagnetic
D.	$[FeCl_4]^{2-}$	s.	Diamagnetic

Codes

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

20. Match the Column I with Column II.

	Column I		Column II
A.	Conversion of proteins into amino acids	p.	Shape selective catalysis
B.	Conversion of alcohols into gasoline	q.	Enzymatic catalysis
C.	Polymerisation of ethylene	r.	*Zeiglar-Natta* catalyst
D.	Manufacture of margarine	s.	Heterogeneous catalysis

Codes

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

Paper 2

Integer Type Questions

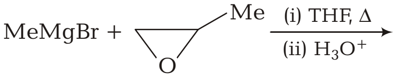
1. The total number of isomers produced by prismane on bromination.

2. Among the following, the number of reaction(s) that produce(s) alcohol is/are

I. $H{-}C{\equiv}N + C_2H_5MgBr \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) THF, } \Delta}$

II. $CH_2{=}O + PhMgBr \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) THF, } \Delta}$

III.


IV.


3. When a trisubstituted unsymmetric benzene gets converted into tetrasubstituted compound, then how many derivatives can be obtained?

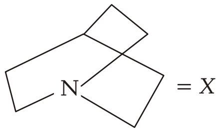
4. A piece of aluminium weighing 2.7g is titrated with 75.0 mL of H_2SO_4 (specific gravity 1.18 g mL^{-1} and 24.7% H_2SO_4 by weight). After the metal is completely dissolved, the solution is diluted to 400 mL. Calculate the molarity of free H_2SO_4 solution. If actual molarity is twenty times of calculated molarity, then what is actual molarity?

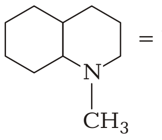
5. NaCl structure has a lattice parameter $a = 400$ pm. The molar volume (in mL) of the lattice including all the empty space is

6. Phosphorus belongs to nitrogen family. It has eight electrons in the penultimate shell. It exists in X form. When this X combines with oxygen, it readily forms Y which is a waxy solid having white colour. The number of P—O—P bonds in the Y is/are

7. x and y are the number of times of HEM takes place to open the chain of the compounds X and Y respectively.

(HEM = Hofmann Exhaustive Methylation)





Sum of x + y =

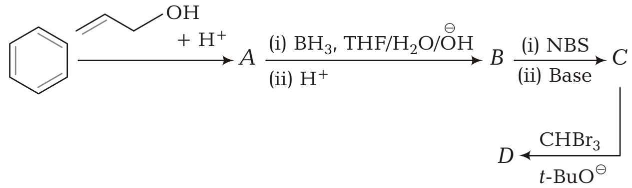
8. What is the theoretical value of bond length in H—F, if r_H and r_F are 0.37Å and 0.72Å respectively? Electronegativities of F and H are 4.0 and 2.1 respectively. If experimentally bond length of HF, 0.08 Å, is also increased, what is the total value in term of Angstrom?

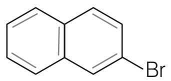
One or More than One Options Correct Type

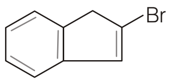
9. Which among the following is aromatic in nature?

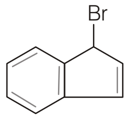
(a) Azulene
(b) Furan
(c) Cyclohepta-1, 3, 5-trienyl anion
(d) Borazine

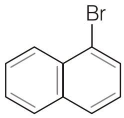
10. What is the end product (D) of the following reaction?

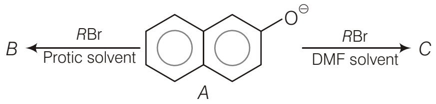


(a) 

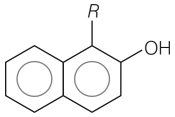
(b) 

(c) 

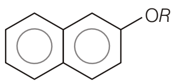
(d) 

11. 

The compounds given are



I



II

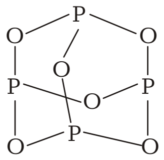
Which of the following statements is/are correct?

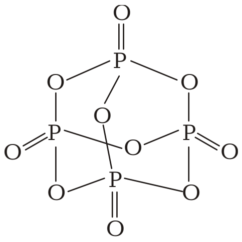
(a) The compound B is I
(b) The compound B is II
(c) The compound C is I
(d) The compound C is II

12. The correct statement(s) regarding PH_3, AsH_3, NH_3, SbH_3 and BiH_3 is (are)

(a) Phosphine (PH_3) has the highest boiling point
(b) The compounds given are as we move from PH_3 to BiH_3, the molecular mass increases. As a result, the van der Waals' forces of attraction decreases
(c) The boiling point of NH_3 is higher than those of PH_3 and AsH_3
(d) NH_3 and PH_3 also act as a Lewis base

13. Consider the following two important oxides of phosphorus.

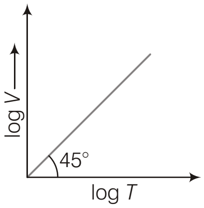


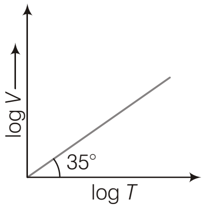


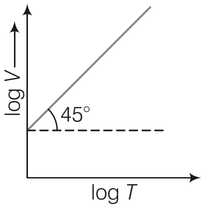
Which of the following statements is/are correct?

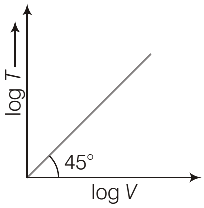
(a) P_4O_6 is formed by burning phosphorus in a limited supply of air
(b) P_4O_{10} absorbs water from the air and becomes sticky
(c) P_4O_6 is basic and hydrolyses in water
(d) All of the above

14. For a closed (not rigid) container containing 10 moles of an ideal gas fitted with movable, frictionless and weightless piston operating such that pressure of gas remains constant at 0.821 atm. Which graph represents correct variation of log V *versus* log T where, V is in litre and T in kelvin?

(a) 

(b) 

(c) 

(d) 

15. The wave function of 2s electron is given by

$$\psi_{2s} = \frac{1}{4\sqrt{2\pi}}\left(\frac{1}{a_0}\right)^{3/2}\left(2 - \frac{r}{a_0}\right)e^{-r/a_0}$$

It has a node at $r = r_0$. What is the relation between r_0 and a?

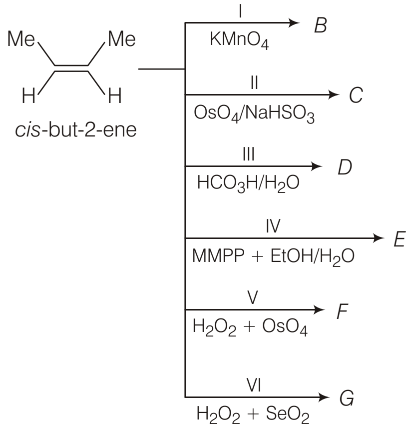
(a) $r_0 = 2a_0$
(b) $r_0 = a/2$
(c) $r_0 = 6a_0$
(d) $r_0 = \sqrt{2}a$

16. The dissociation constants of aniline, acetic acid and water at 25°C are, respectively, 3.83×10^{-10}, 1.75×10^{-5} and 1.008×10^{-14}. Calculate the percentage hydrolysis of aniline acetate in a decimolar solution.

(a) 55.62%
(b) 50.00%
(c) 45.62%
(d) 54.95%

Paragraph I

Consider the following reactions,



(MMPP= Magnesium monoperoxyphthalate)

17. Which of the following are regioselective reactions?

(a) I, II and IV

(b) III, IV and VI

(c) I, II and IV

(d) III, IV and V

18. *Anti*-addition takes place in

(a) I, II and IV *(b)* III, IV and VI

(c) I, II and IV *(d)* III, IV and V

Paragraph II

A mixture of CO and CO_2 when treated with I_2O_5 gives I_2 vapours according to the following equation,

$$5CO + I_2O_5 \longrightarrow 5CO_2 + I_2$$

I_2 vapour was separated and treated with $HClO_4$ and the resultant HIO_4 required 0.001 mole of glycerol for complete oxidation.

After treatment with I_2O_5 and removal of I_2, the mixture was treated with excess of 0.01 N NaOH solution and finally this solution required 20 mL of 1N HCl to reach end-point using phenolphthalein as an indicator, followed by methyl orange as an indicator after the first end-point, 10 mL of further HCl was consumed.

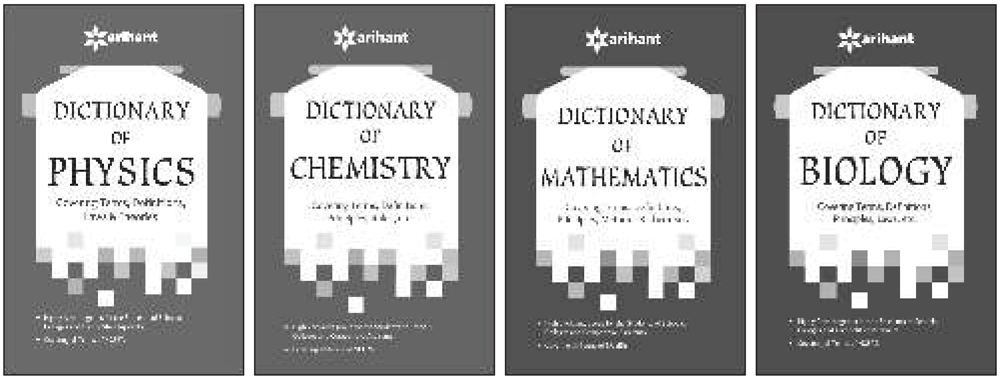
19. The number of moles of CO present initially was

(a) 0.001 *(b)* 0.002 *(c)* 0.005 *(d)* 0.01

20. The total volume of NaOH used in the problem was

(a) 30 mL *(b)* 300 mL

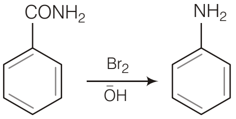
(c) 60 mL *(d)* 600 mL

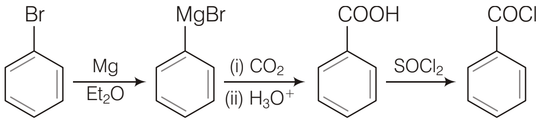


Answers *with* Explanation

Paper 1

1. **(2)** II and IV are the correct reaction sequences for the synthesis of amines but reaction (i) and (ii) not correct.

(I)


(II)


2. **(1)** Mass of phenol, $W_2 = 2.0 \times 10^{-2}$ kg; $K_f = 5.12$ K molal^{-1};
Mass of benzene, $W_1 = 1.0$ kg; $\Delta T_f = 0.69$ K
Therefore, according to the equation,

$$M_2 \text{ (observed)} = \frac{1000\, K_f\, W_2}{W_1\, \Delta T_f}$$

$$= \frac{1000 \text{ kg}^{-1} \times 5.12 \text{ K kg mol}^{-1} \times 2.0 \times 10^{-2} \text{ kg}}{1.0 \text{ kg} \times 0.69 \text{ K}}$$

$$= \frac{10.240 \times 10^{-2}}{0.69} = 14840.58 \times 10^{-2} = 148.4 \text{ g mol}^{-1}$$

Also, M_2 (calculated) for
$C_6H_5OH = 12 \times 6 + 1 \times 5 + 16 + 1 = 94$ g mol^{-1}

Therefore, $i = \dfrac{M_2 \text{ (calculated)}}{M_2 \text{ (observed)}} = \dfrac{94 \text{gmol}^{-1}}{148.4 \text{gmol}^{-1}} = 0.633$

	$2C_6H_5OH \rightleftharpoons$	$(C_6H_5OH)_2$
Initial moles	1 mol	0
Moles after dissociation	$1-\alpha$	$\alpha/2$

Total moles after dissociation $= 1 - \alpha + \dfrac{\alpha}{2} = 1 - \dfrac{\alpha}{2}$

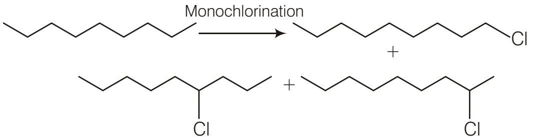
Therefore, $i = \dfrac{1-(\alpha/2)}{1}$

$$\alpha = 2(1-i) = 2(1-0.633) = 0.734 \simeq 1$$

3. **(3)** $\underset{\substack{A \\ \text{(Light green)}}}{FeSO_4 \cdot 7H_2O} \xrightarrow{\Delta} \underset{\substack{B \\ \text{(Soluble in water)}}}{FeSO_4}$

$$FeSO_4(aq) + NO \longrightarrow \underset{C}{FeSO_4 \cdot NO\,(aq)}$$

$$\underset{B}{2FeSO_4} \xrightarrow{\Delta} \underbrace{Fe_2O_3 + SO_2 + SO_3}_{\text{Three products are obtained}}$$

4. **(3)**


There are three optically active products obtained from the chlorination of *n*-nonane.

5. **(7)** The kinetic energy (E_K) is expressed as

$$E_K = \frac{1}{2} mv^2$$

Given that, $E_K = 3 \times 10^{-25}$ J and $m_e = 9.1 \times 10^{-31}$ kg

Substituting these values, we get

$$3 \times 10^{-25} = \frac{1}{2} \times 9.1 \times 10^{-31} \times v^2$$

or $$v = \left(\frac{2 \times 3 \times 10^{-25}}{9.1 \times 10^{-31}}\right)^{1/2} = 8.12 \times 10^2 \text{ ms}^{-1}$$

Using de-Broglie relationship, we get

$$\lambda = \frac{h}{m_e v} = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 8.12 \times 10^2}$$

$$= 8.932 \times 10^{-7} \text{ m}$$

6. **(6)** At $T = 25°C = 298$ K, we have

$$\Delta G = \Delta H - T\Delta S$$
$$141 = \Delta H - 298 \times 0.0758$$
$$\Delta H = 141 + 298 \times 0.0758 = 163.6 \text{ kJ}$$

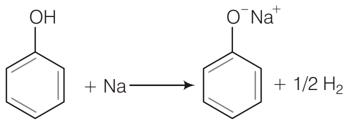
The temperature above which the reaction becomes spontaneous under standard conditions corresponds to $\Delta G = 0$ and is given by

$$T = \frac{\Delta H}{\Delta S}$$

Substituting the values of ΔH and ΔS, it gives

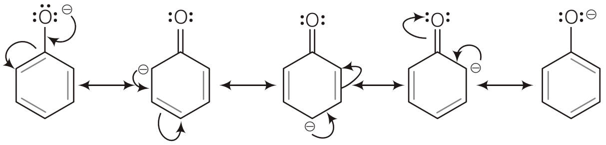
$$T = \frac{163.6 \times 10^3 \text{ J}}{75.18 \text{ JK}^{-1}} = 2176 \text{ K}$$

Above 2176 K, the reaction will become spontaneous.
As $T = 2176$ K
So, $x = 6$ or $T = (2170 + 6)$ K
Hence, $x = 6$

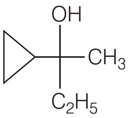
7. **(5)**


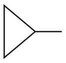
Sodium phenoxide

Phenoxide ion undergoes resonance and get stabilised.

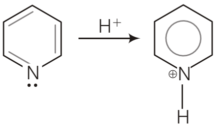


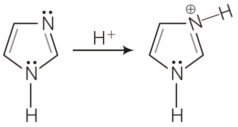
8. **(3)** Three Grignard reagents are used to prepare as there are three different alkyl groups



, — CH_3 and —C_2H_5, respectively.

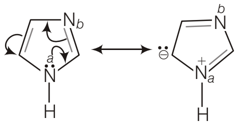
9. **(a,c,d)**

(I)


(III)


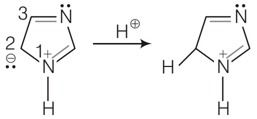
But (II) is not protonated, hence the statement (a) is true.

In (III) :



So, N^b is more basic due to the presence of lone pair of electron. Hence, the statement (b) is wrong.

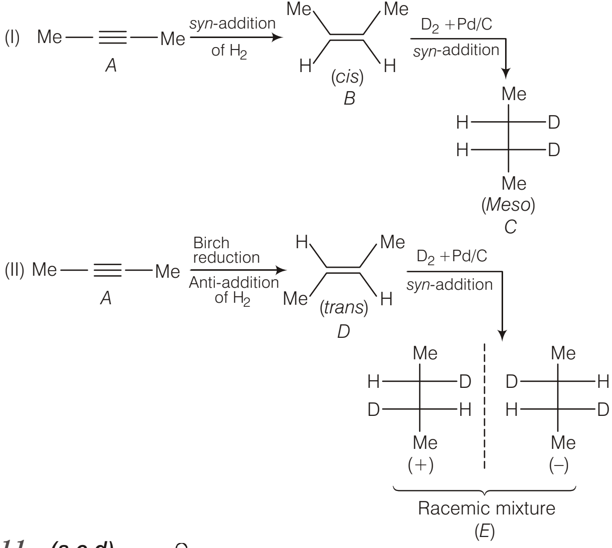
Statement (c) :



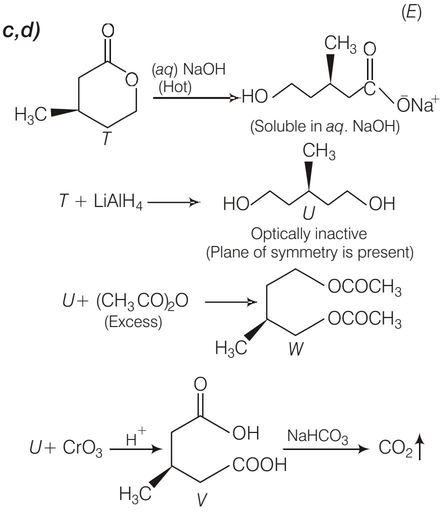
Statement (c) is true.

Statement (d) : Due to resonance, all the N in I, II and III are sp^2 hybridised and hence, the statement (d) is true.

10. **(a,c)**



11. **(a,c,d)**



12. **(a,b,d)** **Oxidation** $CH_3CHO + 3\bar{O}H \longrightarrow$

$$CH_3COO^- + 2e^- + 2H_2O$$

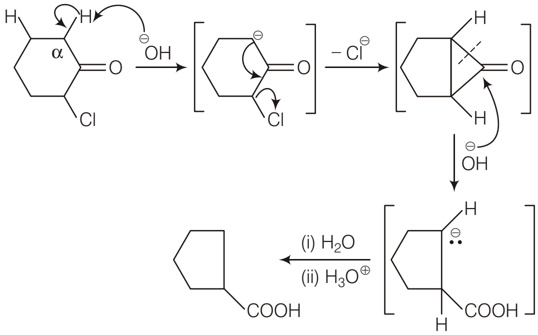
Reduction $[Ag(NH_3)_2]^+ + e^- \longrightarrow Ag + 2NH_3] \times 2$

$$CH_3CHO + 2[Ag(NH_3)_2]^+ + 3\bar{O}H \longrightarrow CH_3CO\bar{O} + 2H_2O + 2Ag + 4NH_3$$

Molecular mass (M) of $CH_3CHO = 44\,g\,mol^{-1}$

Equivalent weight $(EW) = \dfrac{M}{n\text{-factor}} = \dfrac{44}{2} = 22\,g\,mol^{-1}$

13. **(c)** It is an example of favorskii rearrangement reaction, since the compound (A) is an α-haloketone. Base abstracts acidic α-H atom, followed by S_N2 displacement of Cl^- to give a bicycloketone. Ring opening followed by acidification, gives cyclopentane carboxylic acid.



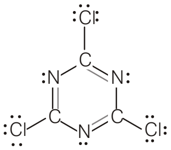
14. **(a,c)** $CuS \xrightarrow[\text{in air}]{\text{Roasting}} \underset{(A)}{Cu_2O} + SO_2 \xrightarrow[\text{without air}]{\text{Roast}} \underset{(B)}{6Cu} + SO_2$

It is a self reduction process. Oxides of unreactive metals (like those of Hg, Pb, Cu etc) are reduced by air/anion of ore. Here, no external reducing agent is added.

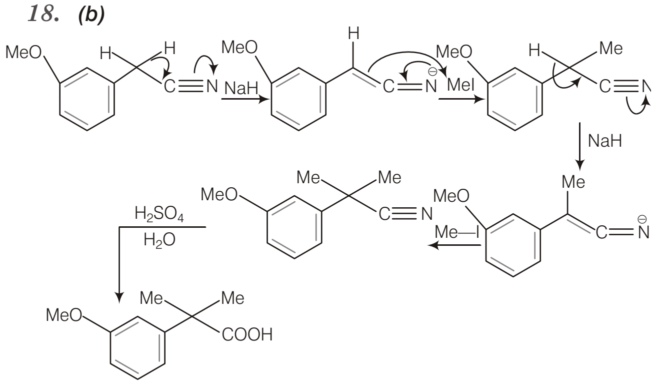
15. **(b)**

16. **(b,c)**

17. **(a,b,d)**

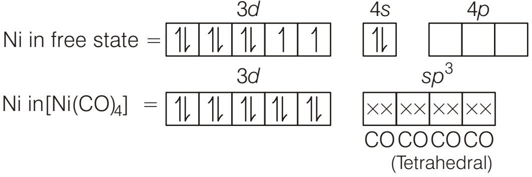


18. **(b)**



19. **(b)** $[Ni(CO)_4]$

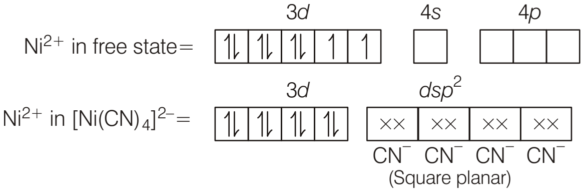
$Ni = [Ar]3d^8 4s^2$



It is diamagnetic in nature as all the electrons are paired.

$[Ni(CN)_4]^{2-}$

Ni = $[Ar]\,3d^8 4s^2$; $Ni^{2+} = [Ar]\,3d^8$

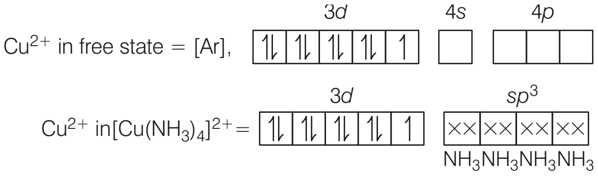


It is diamagnetic in nature as all the electrons are paired.

$[Cu(NH_3)_4]^{2+}$

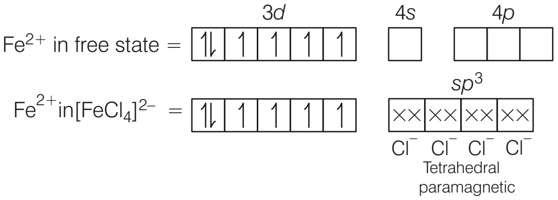
Cu = $[Ar]\,3d^{10}, 4s^1$

$Cu^{2+} = [Ar]\,3d^9$



$[FeCl_4]^{2-}$

Fe = $[Ar]\,3d^6 4s^2$; $Fe^{2+} = [Ar]\,3d^6$

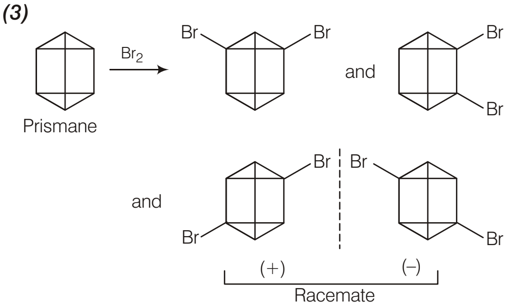


20. **(c)** A - q, B - p,s, C - r,s, D - s

Conversion of proteins into amino acids is an enzymatic catalysis. Conversion of alcohols into gasoline is a shape selective catalysis. It is also an example of heterogeneous catalysis. *Zeigler-Natta* catalyst is used in the polymerisation of ethylene which is an example of heterogeneous catalysis. Manufacture of margarine is an example of heterogeneous catalysis.

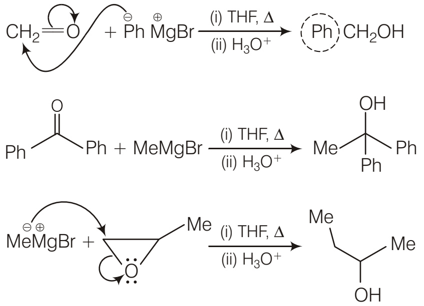
Paper 2

1. **(3)**

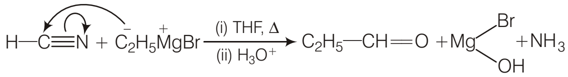


There are three isomers produced by prismane on bromination. However, one of them is chiral and exists as a pair of enantiomers.

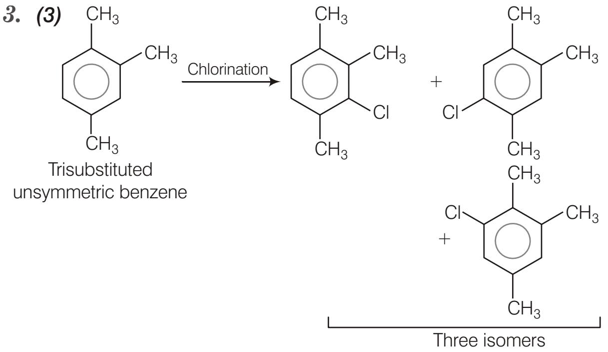
2. **(3)** II, III and IV reactions produce alcohols.



In reaction I, aldehyde is produced.



3. **(3)**



4. **(4)** Milliequivalent of Al = milliequivalent of H_2SO_4 reacted

$$\text{Milliequivalent of Al} = \frac{2.7}{9} \times 1000 = 300$$

$$\left[\text{Equivalent weight (EW) of Al} = \frac{\text{Molecular weight}}{3} = \frac{27}{3} = 9\text{g}\right]$$

$$(Al \longrightarrow Al^{3+} + 3e^-)$$

$$\underset{(N)}{\text{Normality of } H_2SO_4} = \frac{\%\text{ by weight} \times 10 \times d}{EW_2} = \frac{24.7 \times 10 \times 1.18}{98/2}$$

$$= 5.95$$

Milliequivalent of H_2SO_4 = N × volume in mL

= 5.95 × 75 = 446.25

Milliequivalent of Al added = 300

Milliequivalent of H_2SO_4 left after reaction = 446.25 − 300

= 146.25

Solution is diluted to 400 mL

$$\therefore N_{H_2SO_4}\text{ left} = \frac{\text{Milliequivalent left after reaction}}{\text{Volume of solution after dilution (mL)}}$$

$$= \frac{146.25}{400} = 0.367\text{ N}$$

$$M_{H_2SO_4}\text{ left} = \frac{N}{n} = \frac{0.367}{2} = 0.183\text{ M}$$

∴ Actual molarity = 20 × 0.183 = 3.660 ≃ 4 M

5. **(9)** As it is NaCl structure. So, it exists in fcc lattice.

Number of atoms = N_A

$$\text{Number of unit cells} = \frac{N_A}{4} \qquad [\because 4 \text{ atoms in each unit cell}]$$

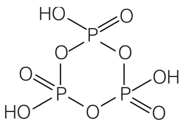
Volume of 1mole lattice $= \dfrac{N_A}{4} \times$ volume of unit cell

$$= \frac{6.023 \times 10^{23}}{4} \times (400 \times 10^{-10})^3\ \text{cm}^3 = 9.6\ \text{mL} \simeq 9\ \text{mL}$$

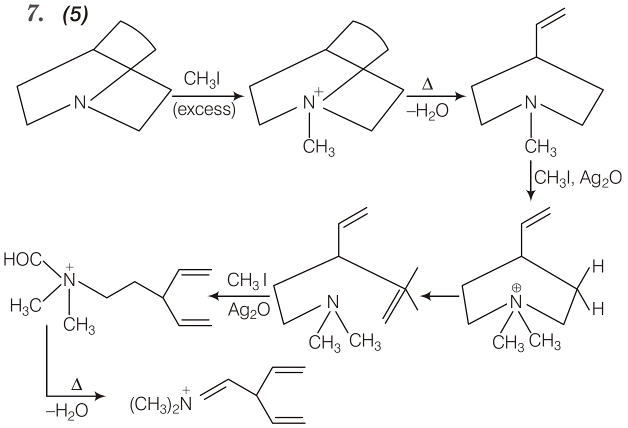
6. ***(3)*** There are three P—O—P bonds in the *Y* molecule.

$$P_4 + 5O_2 \xrightarrow{\Delta} P_4O_{10}$$

It is cyclic metaphosphoric acid,

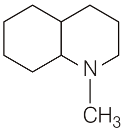


7. ***(5)***



So, $x = 3$

Similarly, 2 times HEM occur in case of



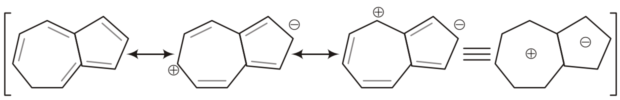
So, $y = 2$

Total $x + y = 3 + 2 = 5$

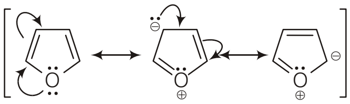
8. ***(1)*** Given, $r_H = 0.37$ Å, $r_F = 0.72$ Å; $\chi_F = 4.0$; $\chi_H = 2.1$

$$d_{A-B} = r_H + r_F - 0.09\,(\chi_F - \chi_H)$$
$$= 0.37 + 0.72 - 0.09\,(4.0 - 2.1) = 0.92\ \text{Å}$$
$$d_{A-B} = 0.92\ \text{Å} + 0.08\ \text{Å} = 1\ \text{Å}$$

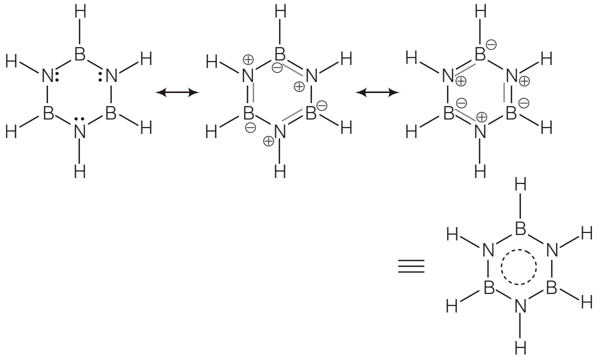
9. ***(a,b,d)*** Azulene is aromatic as resonance structure bears a positive charge in the seven-membered ring, while the five membered ring bears a negative charge making it similar to the aromatic cyclopentadienyl anion. It is cyclic, planar with 10π electron system.



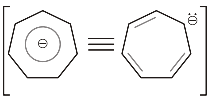
Furan is cyclic, planar and has 6π-electron system.



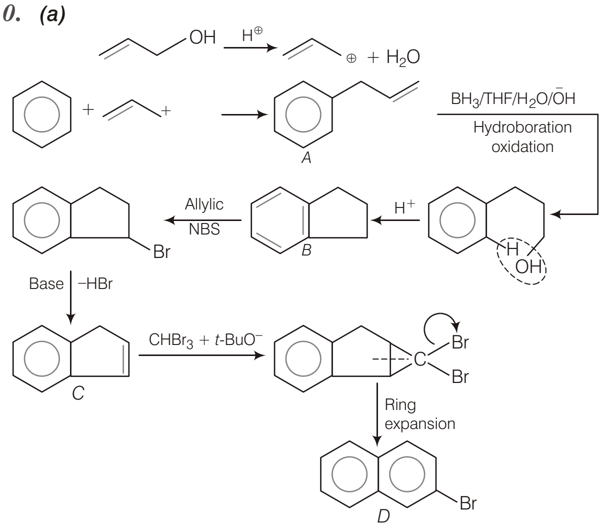
Borazine is cyclic, planar and both N and B are sp^2 hybridised. Each N has two non-bonding electrons in a *p*-orbital and each B has an emply *p*-orbital giving a total number of six delocalised π-electrons, hence aromatic.



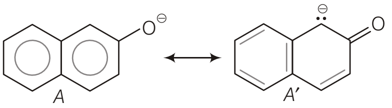
whereas cyclohepta-1, 3, 5-trienyl anion is an anti-aromatic compound. It is cyclic, planar and 8π-electron system follows 4*n* π-electron rule.



10. ***(a)***



11. ***(a,d)*** The resonance structure of 2-naphthoxide ion (*A*) is



A is an ambident nucleophile and a better nucleophile than *A′* because negative charge is on more electronegative oxygen atom. In the presence of polar non-protic solvent (DMF, dimethyl formamide), alkylation on oxygen atom is favoured to give product II (C).

In the presence of protic solvent, hydrogen bonding with the O-atom occurs, thus reducing the nucleophilicity of oxygen. Therefore, C-alkylation is favoured to give product (*B*).

12. ***(c,d)*** Phosphine (PH_3) has lowest boiling point. As we move from PH_3 to BiH_3, the molecular mass increases. As a result, the van der Waals' forces of attraction increases and the boiling point increases regularly from PH_3 to BiH_3.
However, the boiling point of NH_3 is higher than those of PH_3 and AsH_3 due to intermolecular hydrogen bonding in ammonia but boiling point of NH_3 is lower than those of SbH_3 and BiH_3 because higher van der Waals' forces of attraction in SbH_3 and BiH_3 compensate the increase in boiling point of NH_3.
Thus, the boiling points of hydrides of group 15 elements follow the order.

$$PH_3 < AsH_3 < NH_3 < SbH_3 < BiH_3$$

13. ***(a,b)*** P_4O_6 is formed by burning phosphorus in a limited supply of air.

$$P_4 + 3O_2 \xrightarrow[\text{air}]{\text{Limited supply of}} P_4O_6$$

P_4O_6 is acidic and hydrolyses in water, forming phosphorous acid. P_4O_{10} absorbs water from the air or from other compounds and becomes sticky.

$$P_4O_{10} + 6H_2O \longrightarrow 4H_3PO_4$$

14. ***(c)***

15. ***(a)*** The wave function of $2s$ electron is

$$\psi_{2s} = \frac{1}{4\sqrt{2}\,\pi}\left(\frac{1}{a_0}\right)^{3/2}\left(2 - \frac{r}{a_0}\right)e^{-r/a_0}$$

Thus, the probability of finding of $2s$ electron at a point is

$$\psi_{2s} = \left[\frac{1}{4\sqrt{2}\,\pi}\left(\frac{1}{a_0}\right)^{3/2}\left(2 - \frac{r}{a_0}\right)e^{-r/a_0}\right]^2$$

$$= \frac{1}{32\,\pi}\left(\frac{1}{a_0}\right)^{3}\left(2 - \frac{r}{a_0}\right)^{2}e^{-2r/a_0}$$

Node is the point at which the probability of finding an electron is zero. It means the value of ψ_{2s} is zero when $r = r_0$.

So, $\frac{1}{32\,\pi}\left(\frac{1}{a_0}\right)^{3}\left(2 - \frac{r_0}{a_0}\right)^{2}e^{-2r_0/a_0} = 0 \Rightarrow 2 - \frac{r_0}{a_0} = 0$

$\therefore \qquad r_0 = 2a_0$

16. ***(d)*** The degree of hydrolysis (x) of a salt of weak acid and a weak base is given by

$$x = \sqrt{\frac{K_w}{K_a \times K_b}} = \sqrt{\frac{1.008 \times 10^{-14}}{1.75 \times 10^{-5} \times 3.83 \times 10^{-10}}} = 1.219$$

But, x cannot be greater than 1. This indicates that the degree of hydrolysis in this case is very large and therefore, the above formula, which is based on the assumption that x is small, is not applicable.

In the present case, we have to calculate x as follows:

$$K_h = \frac{K_w}{K_a \times K_b};\ K_h = \frac{x^2}{(1-x)^2}$$

$$\frac{x}{1-x} = \sqrt{\frac{K_w}{K_a \times K_b}} = 1.219 \text{ or } x = 0.5495$$

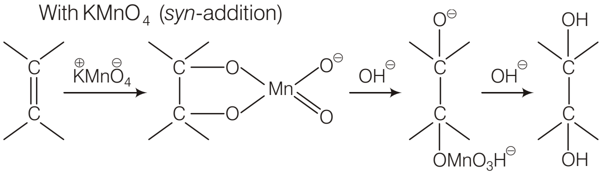
i.e. per cent hydrolysis = 54.95%

17. ***(a)*** All the reactions are hydroxylation reactions. All of them are stereospecific, but if one product is formed they are regioselective. If more than one product is formed in major amount, then they are non-regioselective.

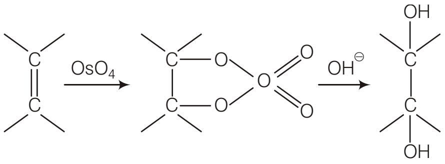
18. ***(b)*** *Syn*-hydroxylation occurs in reactions I, II and V, whereas *anti*-hydroxylation occurs in reactions III, IV and VI.

Mechanism of these reactions are:

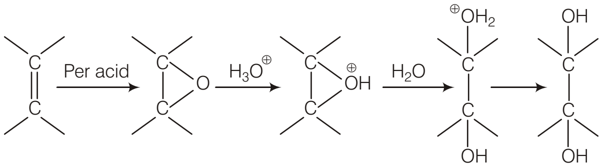
With $KMnO_4$ (*syn*-addition)



With OsO_4 (*syn*-addition)

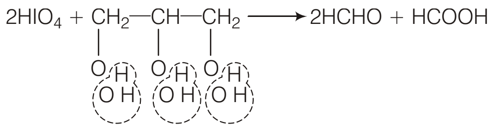


with peracid (*trans*-addition)



19. ***(c)*** $5CO + I_2O_5 \longrightarrow 5CO_2 + I_2$

$$I_2 + 2HClO_4 \longrightarrow 2HIO_4 + Cl_2$$



$$2HIO_4 + \underset{\substack{|\\ OH}}{CH_2}-\underset{\substack{|\\ OH}}{CH}-\underset{\substack{|\\ OH}}{CH_2} \longrightarrow 2HCHO + HCOOH$$

Number of moles of HIO_4 required = 2 × 0.001 = 0.002

$\underset{(0.002)}{2 \text{ moles of } HIO_4} = \underset{(0.001)}{1 \text{ mole of } I_2} = \underset{(0.001 \times 5 = 0.005)}{5 \text{ moles of CO}}$

Number of moles of CO present initially = 0.005

20. ***(b)*** In the beginning, mixture of CO and CO_2 was given and 5 moles of CO_2 was formed by the reaction of 5 moles of CO with I_2O_5.

Let the number of mmol of CO_2 initially = n

$\therefore$ Number of mmol of CO_2 = (n + 5)

$$\underset{(n+5)}{CO_2} + 2NaOH \longrightarrow \underset{(n+5)}{Na_2CO_3} + H_2O$$

Let the mmoles of NaOH = b

mmoles of NaOH left = $b - 2(n + 5)$

When phenolphthalein is used

$$b - 2(n + 5) + (n + 5) = 20$$

$$b - (n + 5) = 10 \qquad \text{... (i)}$$

When methyl orange is used, $(n + 5) = 10$ ... (ii)

From Eqs. (i) and (ii), we get

$$n = 5$$

$\Rightarrow$ mmol of CO_2 = 5

$\therefore \qquad b = 30$

$\Rightarrow$ mmol of NaOH = 30

Thus, mmol of NaOH taken = 30

Volume of NaOH, $\quad 30 = 0.1 \times V$

$$V = 300 \text{ mL}$$

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Mock Questions with Complete Solutions

Paper 1

One or More than One Options Correct Type

1. Beryllium chloride exists in vapour as well as in solid phase, choose the correct option for solid phase beryllium chloride.

(a) Beryllium chloride has zero dipole moment
(b) Lone pairs present on Cl - atoms are used for bonding with vacant orbitals of the Be-atoms
(c) It exists in dimeric form of $BeCl_2$
(d) It functions as a Lewis acid

2. Choose the correct feature(s) about *ortho*-phosphoric acid from the following.

(a) It is tribasic acid
(b) It is syrupy liquid
(c) Trisodium salts of this acid show basic nature in water
(d) Phosphate ion is square pyramidal in shape

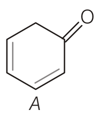
3. One mole of an ideal gas expands against a constant external pressure of 1 atm from a volume of 10 dm^3 to a volume of 30 dm^3. What would be the work done by the gas in joules?

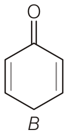
(a) – 2026 J (b) –2.026 J (c) 1648 J (d) –1947 J

4. Choose the correct statement(s) from the following options.

(a) Fluorine is the strongest oxidising agent
(b) If negative valencies of a species increase after reaction, it is known as reduction process
(c) Conversion of glucose into CO_2 is an exothermic process
(d) Hypo prefix in hypophosphorous acid indicates it will act as an oxidising agent

5. Consider the two structures *A* and *B*,


A


B

and choose the correct options from the following.

(a) *A* is more stable than *B*
(b) Both *A* and *B* show 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

6. Consider the statements, 'hydrolysis of NCl_3 gives ammonia but hydrolysis of PCl_3 gives phosphoric acid' and choose the correct option from the following.

(a) Because N is more electronegative than phosphorus
(b) Chlorine is more electronegative than phosphorus
(c) Phosphorus has vacant 3*d*-orbitals
(d) N-atom in NCl_3 has spare orbital to accept lone pair of electrons of O-atom of water molecule

7. The molar conductances at infinite dilution of HCl, NaCl and Na Z (sodium crotonate) are 425×10^{-4}, 125×10^{-4} and $80 \times 10^{-4}\ Sm^2 mol^{-1}$, respectively. The specific-conductance of 0.001 M aqueous solution of crotonic acid is $3.8 \times 10^{-3}\ Sm^{-1}$. What would be the dissociation constant of the acid?

(a) 1.11 mol dm^{-3}
(b) 1.11×10^{-5} mol dm^{-3}
(c) 121×10^{-3} mol dm^{-3}
(d) 0.11×10^{-5} mol dm^{-3}

8. Consider the reactions given below,

$$\text{I. } BCl_3 \xrightarrow{Zn,\ 900\,°C} P$$

$$\text{II. } B \xrightarrow{O_2} Q$$

$$\text{III. } KBF_4 \xrightarrow[800\,°C]{\text{Electrolysis}} R$$

Identify *P*, *Q* and *R* in the option given below.

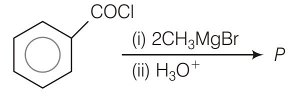
	P	*Q*	*R*
(a)	B	B_2O_3	B
(b)	B_2O_3	B	B
(c)	BH_3	B	B_2O_3
(d)	BH_3	H_3BO_3	B

9. Phenol undergoes Reimer-Tiemann reaction to give salicylaldehyde. What will happen, when 4-nitrophenol is taken instead of phenol in this reaction?

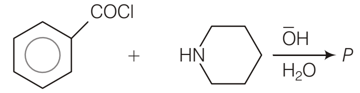
(a) Rate of reaction becomes slower
(b) Product formed in this reaction becomes highly electrophilic
(c) Product formed in this reaction becomes highly nucleophilic
(d) Rate of reaction becomes faster

10. Which of the following reaction/s may give tertiary alcohol as a product *P*?

(a)



(b)



(c) $CH_3COCl + \text{urea} \longrightarrow P$

(d) $CH_3CH(CH_3)CH_2Br \xrightarrow[H_2O]{} P$

Integer Type Questions

11. The energy corresponding to one of the lines in the Paschen series for H-atom is 18.16×10^{-20} J. What should be the quantum number for the transition which produces this line?

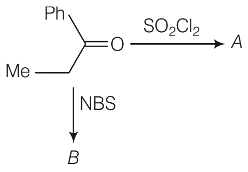
12. The compound $HOOC—(CHOH)_2—COOH$ is a chiral compound. Calculate the number of optical isomers exhibited by this compound.

13. Consider the following reactions,

I. $2S(l) + Cl_2(g) \longrightarrow P(l)$
II. $SO_2 + PCl_5 \longrightarrow P + Q$
III. $Fe(OH)_3 + 3SOCl_2 \longrightarrow P + Q + R$
IV. $CH_3COOH + SOCl_2 \longrightarrow P + Q + R$

How many of these reactions produce SO_2 as byproduct?

14. Consider the following sequence of the reaction,



Sum of the active hydrogen atoms present in *A* and *B* is

15. The complex compound $K_4[Fe(CN)_6]$ is 45% dissociated in 0.1 M aqueous solution at 27°C. The osmotic pressure of the solution approximately is

16. A dipeptide on hydrolysis gives two amino acids, which are $NH_2CH(R)COOH$ *A* and $H_2NCH(R')COOH(B)$. This dipeptide is also hydrolysed by leucine amino peptidase enzyme to give only *(B)*. How many asymmetrical carbon atom(s) is/are present in the structure of dipeptide?

17. Consider the following transition metal complex compounds, $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, $[Co(NH_3)_6]^{3+}$, $NiCl_3(PMe_3)_2$, $[Co(CN)_6]^{3-}$

How many of them show diamagnetic behaviour?

18. 0.45 g of pure crystal of $Na_2C_2O_4 \cdot xH_2O$ was dissolved in water and diluted to 100 mL. A 25 mL portion of this solution required 10 mL of a 0.05 M H_2SO_4 solution to reach the end point. The value of x in the salt is?

19. What would be the pressure in atm that exerted by one mole of CO_2 gas at 40°C, confined to a volume of 0.107 dm^3? Assuming that the $V_c = 0.0957$ dm^3, $T_c = 304$ K and $p_c = 7$ atm

20. How many inorganic compounds among the following exhibit octahedral geometry?

IF_7, SeF_6, BrF_5, BCl_3, XeF_4, SF_4

Paper 2

1. The rate of the homogeneous gaseous reaction, $2NO(g) + Cl_2(g) \longrightarrow 2NOCl(g)$ is doubled, when the chlorine concentration is doubled but increases by a factor of eight, when the concentration of both the reactants are doubled. Overall order of the reaction is

(a) one
(b) two
(c) three
(d) zero

2. When xenon hexafluoride is treated with water a product *P* is obtained with biproduct HF. Select the correct option regarding the product *P*.

(a) It oxidises Pu^{2+} to Pu^{4+} in presence of acid
(b) It forms xenate ion on reaction with aqueous alkali
(c) Both (a) and (b)
(d) None of the above

3. Consider the reaction,

$$CHCl_3 \xrightarrow[HF]{SbF_3} CHF_2Cl \xrightarrow{1070K} A + 2HCl,$$

Product *A* is

(a) $F_2C{=}CF_2$
(b) $ClFC{=}CFCl$
(c) $F_2C{=}CFCl$
(d) $F_2C{=}CCl_2$

4. Choose the correct choice for the reaction,

$$Na_2CrO_4 + H_2SO_4 \longrightarrow P + H_2O$$

(a) It is a redox reaction in which green solution of $[Cr(H_2O)_6]^{3+}$ is produced
(b) Product *P* obtained in reaction has trigonal planar structure
(c) Product *P* is dimeric bridged tetrahedral ion
(d) Dark blue colour is obtained in reaction

5. For a reaction, $A \rightleftharpoons B$, k values at 40°C and 60°C are 0.86 and 0.35, respectively. Choose the correct prediction about this reaction.

- (a) The reaction is non-spontaneous at 27°C
- (b) The reaction is spontaneous at 27°C
- (c) The reaction does not favour at lower temperature than 27°C
- (d) None of the above

6. Oxalic acid $\xrightarrow{\Delta} X(g) + Y(g) + Z(g)$, Y and Z, both are polar and neutral, X is non-polar and acidic. Z gas is condensed and formed liquid having pH $=7$. The hybridisation states of X, Y and Z respectively are

- (a) sp, sp^2, sp^3
- (b) sp^2, sp^3, sp^3d
- (c) sp, sp, sp^3
- (d) sp^2, sp^2, sp^3

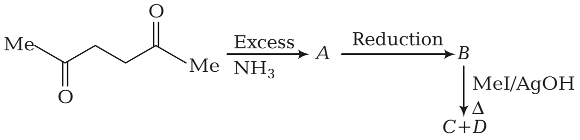
7. Choose the correct option regarding the characteristics of sodium peroxide.

- (a) It liberates O_2 with cold water
- (b) It turns into white colour on exposure to moist air
- (c) It reduces chromic compounds to chromate
- (d) All of the above

8. When 2-butene reacts with peroxy acids, the possible product(s) may be respectively.

- (a) *Meso*, racemate
- (b) Racemate, *meso*
- (c) *d*, *l*-pair, *Z*-isomer
- (d) Both (a) and (b)

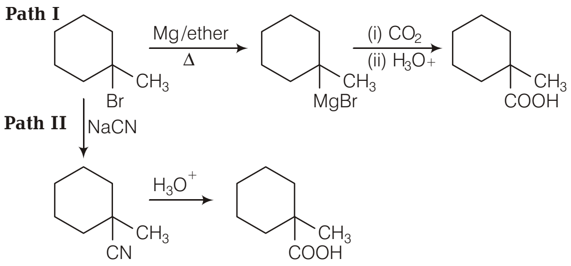
9. Consider the reaction,



Choose the correct option.

- (a) *A* is an aromatic compound
- (b) *B* is an antiaromatic compound
- (c) *D* is a Lewis acid
- (d) None of the above

10. In the following reaction, the final product can be prepared by two paths I and II.



According to the above reactions, which option is correct?

- (a) Path I is facile
- (b) Path II is facile
- (c) Both paths are facile
- (d) Neither I nor II is facile

Paragraph Type

Paragraph I

In a unit cell, atoms A are present at all corners of lattice, B atoms are present at alternate faces and all edge centres. Atoms C are present at face centres left from B and at each body diagonal at a distance of 1/4th of the body diagonal from corner.

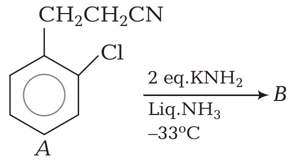
11. A tetrad axis is passed from the given unit cell and all the atoms touching the axis are removed. The possible formula of the compound left is

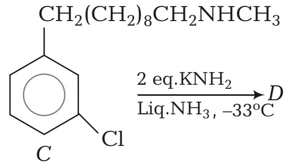
- (a) AB_3C_6 and AB_4C_5
- (b) $A_3B_6C_7$ and $A_3B_6C_5$
- (c) $A_4B_5C_8$ and $A_4B_5C_7$
- (d) AB_2C and ABC_2

12. Total fraction of voids occupied is

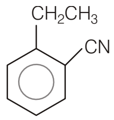
- (a) 0.58
- (b) 0.25
- (c) 0.48
- (d) 0.86

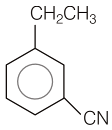
Paragraph II

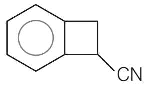


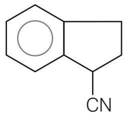


13. The product B of the reaction would be

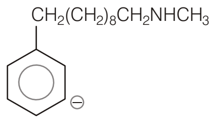
(a)


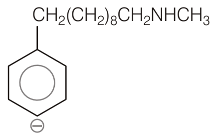
(b)


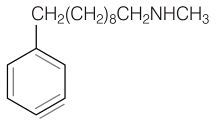
(c)


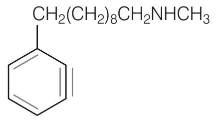
(d)


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

(a)


(b)


(c)


(d)


Passage III

Boron forms many compounds like boric acid, borax, and inorganic graphite etc. Orthoboric acid contains triangular BO_3^{3-} units. In the solid, the $B(OH)_3$ units are bonded through hydrogen bonding into 2D sheets with almost hexagonal symmetry. Borax is used in borax bead test.

15. The number of the H-atoms replaced from boric acid, when it is dissolved in water is
(a) two *(b)* one
(c) three *(d)* zero

16. Boric acid can behave as a strong acid in the presence of
(a) anhyd. H_2SO_4 *(b)* glycerol
(c) mannitol *(d)* All of these

Matching Type Questions

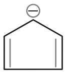
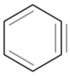
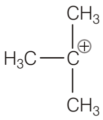
17. The complex given in Column I shows missing digit in its formula, which is given in Column II. Match the Column I with Column II.

Column I	Column II
A. $K_n[Fe(CN)_6]$ diamagnetic	p. $n = 2$
B. $[Ag(CN)_n]^-$	q. $n = 3$
C. Facial $-[PtCl_3Br_n]^{2-}$	r. $n = 4$
D. $[Pt(NH_3)_n]Cl_4$ (octahedral)	s. $n = 6$

Codes

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

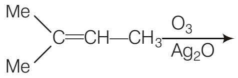
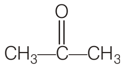
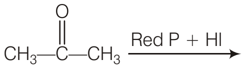
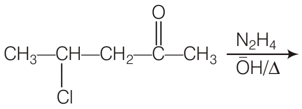
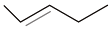
18. Match the Column I with Column II.

Column I	Column II
A. 	p. Hyperconjugation
B. 	q. All C-atoms are sp^2-hybridised
C. 	r. Aromatic
D.  $(CH_3)_3C^{\oplus}$	s. Diamagnetic

Codes

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

19. Match the Column I with Column II.

Column I	Column II
A. 	p. Reduction
B. $CH_3-CH\equiv CH \xrightarrow[Ag_2O]{Hg^{2+},\ H_2SO_4}$	q.  $CH_3-\overset{O}{\overset{\|\|}{C}}-CH_3$
C.  $CH_3-\overset{O}{\overset{\|\|}{C}}-CH_3 \xrightarrow{\text{Red P + HI}}$	r. Oxidation reaction
D.  $CH_3-\underset{Cl}{\underset{\|}{CH}}-CH_2-\overset{O}{\overset{\|\|}{C}}-CH_3 \xrightarrow[\bar{O}H/\Delta]{N_2H_4}$	s. 

Codes

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

20. Match Column I with Column II and select correct code for your answer.
(M = Central metal atom of molecule)

Column I (Molecule)	Column II (Property)
A. H_2O	p. Largest M—H length
B. H_2S	q. Largest H—M—H bond angle
C. H_2Se	r. Lowest boiling point
D. H_2Te	s. Two lone pairs

Codes

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

AMAZING REALITIES

According to their multi-scale analyses, a single ion has an influence on millions of water molecules, i.e. 10,000 times more than previously thought.

Answers *with* Explanation

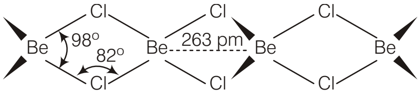
Paper 1

1. **(b,c)** Beryllium chloride exists in vapour as well as in solid phase.

In vapour phase, it exists in monomeric form

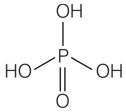
$$Cl-Be-Cl$$

While in solid phase, it exists in dimeric form.

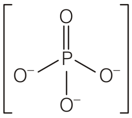


In this chain structure, the lone pairs present on Cl-atoms participate in bonding with empty *p*-orbitals of Be-atom. Vapour phase $BeCl_2$ acts as a Lewis acid because Be has vacant *p*-orbitals to accept the lone pair of electrons.

2. **(a,b,c)** The structure of *ortho*-phosphoric acid is



Due to the presence of three replaceable H-atoms, it is tribasic in nature. Also, trisodium salts of it show three polarised negative ions in water hence it is basic too. In aqueous solution, H-bonding predominates which gives it syrupyness.
Structure of phosphate ion shows it is tetrahedral in shape.



3. **(a)** We know that,

$$w = -\int_{V_1}^{V_2} p\,dV = -p(V_2 - V_1)$$

$$= -(1\text{ atm})(30\text{ dm}^3 - 10\text{dm}^3) = -20\text{ dm}^3\text{ atm}$$

But we have to get the result in Joules

As $\quad R = 8.314\text{ JK}^{-1}\text{mol}^{-1} = 0.08206\text{ dm}^3\text{atm K}^{-1}\text{mol}^{-1}$

$$1\text{ atm} = \frac{8.314\text{ JK}^{-1}\text{ mol}^{-1}}{0.08206\text{ dm}^3\text{K}^{-1}\text{ mol}^{-1}}$$

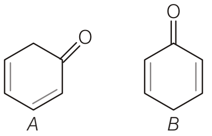
$$\therefore \quad w = -20\text{ dm}^3\text{ atm} = -20\text{ dm}^3 \times \frac{8.314\text{ JK}^{-1}\text{mol}^{-1}}{0.08206\text{dm}^3\text{K}^{-1}\text{mol}^{-1}}$$

$$-2026.36\text{ J}$$

4. **(a,b,c)**

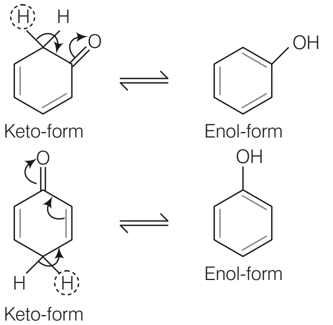
- Fluorine is the strongest oxidising agent because it has the tendency to accept an electron to gain noble gas configuration.
- $[Fe(CN)_6]^{3-} \longrightarrow [Fe(CN)_6]^{4-}$, negative valency increases, which means, oxidation state decreases and hence, it is a reduction process.
- During conversion of glucose into CO_2, a huge amount of energy get released, so it is an exothermic process.
  $C_6H_{12}O_6\,(aq) + O_2(g) \longrightarrow 6CO_2(g) + 6H_2O\,(l) + \text{Energy}$
- Hypo prefix indicates that central atom of compound has the minimum oxidation state, so it will act as a reducing agent.

5. **(a,d)**

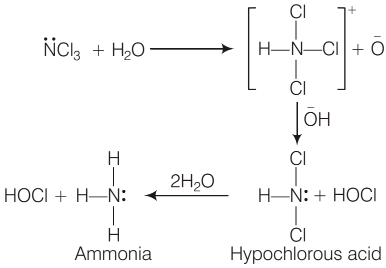


Due to the presence of α-hydrogen, they show tautomerism, i.e. show keto-enol tautomerism.

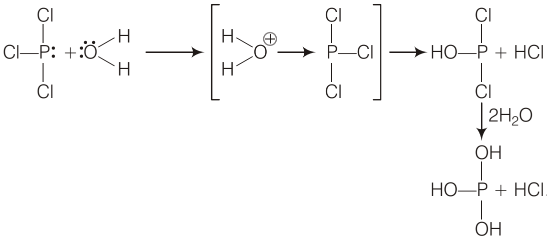
Enol form of both *A* and *B* have an aromatic ring. So, they are more stable than their respective keto-forms.



6. **(b,c)** In NCl_3, nitrogen is more electronegative than chlorine. Furthermore, nitrogen, in NCl_3 does not have any spare orbital to accept lone pair of electrons of O-atom of water molecule. So, in the presence of H_2O, reaction looks like



On the other hand, in PCl_3, phosphorus has available vacant 3*d*-orbitals to accept lone pair of electrons of O-atom of water. Furthermore, Cl is far more electronegative than phosphorous. Hence, hydrolysis takes place as



7. **(b)** Crotonic acid is formed as follows

$$HCl + NaZ \longrightarrow NaCl + \underset{\text{Crotonic acid}}{HZ}$$

where, Z = Crotonate ion

Since, crotonic acid is a weak organic acid and HCl, NaZ and NaCl are strong electrolytes. Hence, we use Kohlrausch's law of independent migration of ions.

$$\Lambda^\circ_m(HZ) = \Lambda^\circ_m(HCl) + \Lambda^\circ_m(NaZ) - \Lambda^\circ_m(NaCl)$$
$$= (425 + 80 - 125) \times 10^{-4}\ Sm^2\ mol^{-1}$$
$$= 380 \times 10^{-4}\ Sm^2\ mol^{-1}$$

Also, at the given concentration of crotonic acid

$$\Lambda_m = \frac{\kappa}{C} = \frac{3.8 \times 10^{-3} Sm^{-1}}{0.001 \times 10^3 mol\ m^{-3}}$$
$$= 38.0 \times 10^{-4} Sm^2 mol^{-1}$$
$$\alpha = \frac{\Lambda_m}{\Lambda^\circ_m} = \frac{38.0 \times 10^{-4} Sm^2 mol^{-1}}{380 \times 10^{-4}\ Sm^2 mol^{-1}} = 0.1$$

Using the Ostwald's dilution law,

$$K_a = \frac{C\alpha^2}{1-\alpha} = \frac{(1.0 \times 10^{-3} mol\ dm^{-3})\ (0.10)^2}{(1-0.10)}$$
$$= 1.11 \times 10^{-5}\ mol\ dm^{-3}.$$

8. ***(a)*** I. BCl_3 when reacts with zinc at very high temperature, i.e. at 900°C is reduced into Boron (B) forms.

$$BCl_3 \xrightarrow[900°C]{Zn} \underset{P}{B}$$

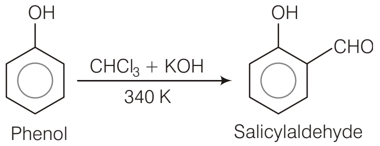
II. Boron after reaction with O_2 gives B_2O_3

$$4B \xrightarrow{3O_2} \underset{Q}{2B_2O_3}$$

III. Electrolytic reduction of fused tetrafluoro borate in molten KCl/KF at 800°C gives 95% pure boron

$$KBF_4 \xrightarrow[800°C]{Electrolysis} \underset{R}{\underset{(95\%\ pure)}{B}}.$$

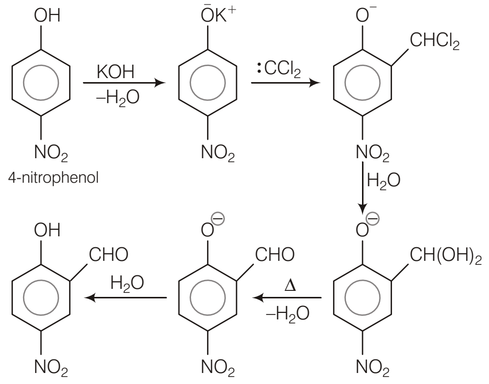
9. ***(a,b)***



But, when we use 4-nitrophenol as a substrate in this reaction, the rate of Reimer-Tiemann reaction becomes slower due to the presence of strong electron withdrawing —NO_2 group which reduces the electron density of benzene ring and slow down the rate of electrophilic reaction.

Reimer-Tiemann reaction

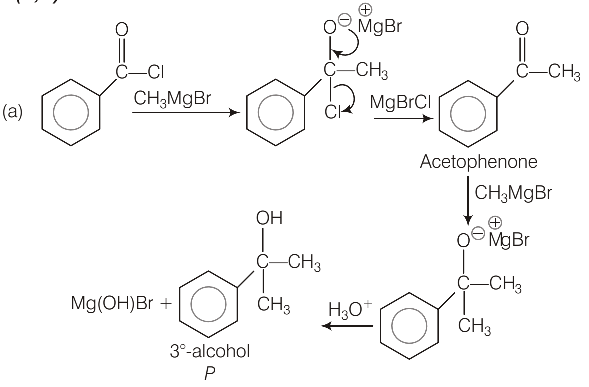
$$CHCl_3 + \bar{O}H \rightleftharpoons \bar{C}Cl_3 + H_2O$$
$$\bar{C}Cl_3 \longrightarrow \underset{\text{Dichlorocarbene}}{:CCl_2} + Cl^-$$

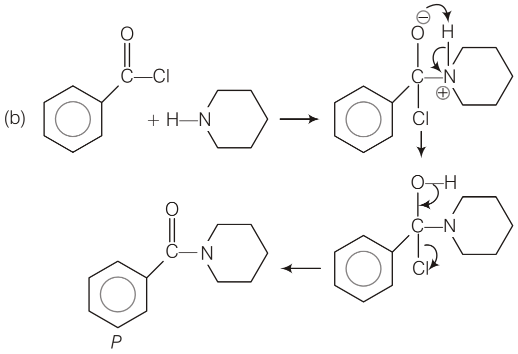


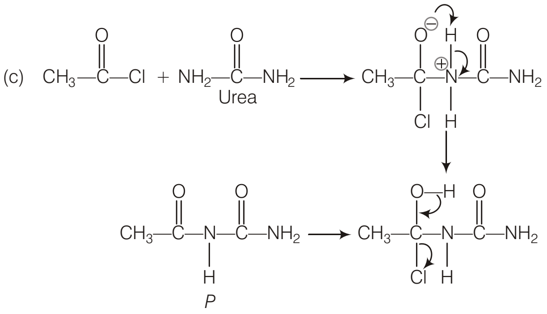
Final product

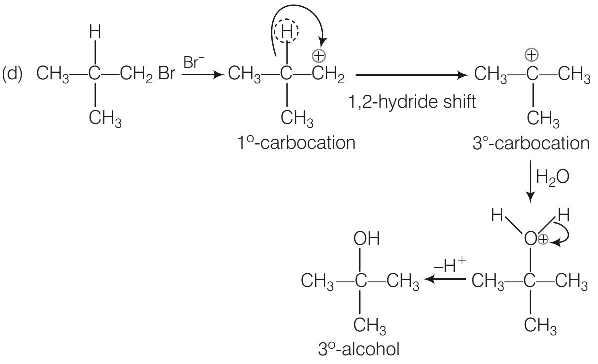
Due to the presence of two powerful electron withdrawing groups, i.e. —CHO and —NO_2 in the product, it is highly electrophilic in nature.

10. ***(a,d)***









11. ***(6)*** In the Paschen series, lower quantum number (n_1) is fixed which is '3'.

Given, $\Delta E = 18.16 \times 10^{-20}$ J.

Let, the higher quantum number (n_2) be n.

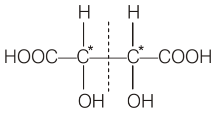
Then,

$$\Delta E = 2.18 \times 10^{-18} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \text{J}$$

$$\Rightarrow \quad 18.16 \times 10^{-20} \text{ J} = 2.18 \times 10^{-18} \left(\frac{1}{9} - \frac{1}{n^2} \right) \text{J}$$

On solving this quadratic equation for n, we get $n = 6$.

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



There are two asymmetric atoms present in this compound.

$\therefore \quad n = 2$

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)

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

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

$$= 2^{\left(\frac{2}{2}-1\right)} = 1$$

$\therefore$ Total number of optical isomers

$$= a + m = 2 + 1 = 3.$$

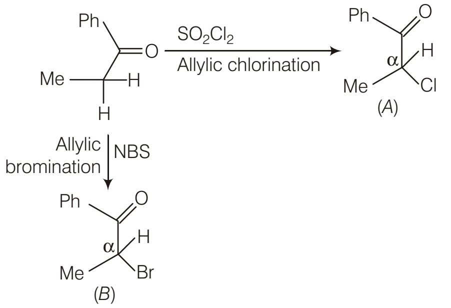
13. ***(2)*** I. $2S\,(l) + Cl_2(g) \longrightarrow \underset{P}{S_2Cl_2}\,(l)$

II. $SO_2 + PCl_5 \longrightarrow \underset{P}{SOCl_2} + \underset{Q}{POCl_3}$

III. $Fe(OH)_3 + 3SOCl_2 \longrightarrow \underset{P}{3SO_2} + \underset{Q}{3HCl} + \underset{R}{FeCl_3}$

IV. $CH_3COOH + SOCl_2 \longrightarrow \underset{P}{CH_3COCl} + \underset{Q}{SO_2} + \underset{R}{HCl}$

14. ***(2)*** Halogenation occurs at the α-position of the carbonyl group (C $=$ O) *via* free radical mechanism.



Hence, sum of active hydrogen in A and B is $1 + 1 = 2$.

15. ***(7)*** If the complex $K_4[Fe(CN)_6]$ had not been dissociated, its normal osmotic pressure would have been given by the van't Hoff equation.

$$\pi = CRT \qquad \ldots(i)$$

where, π = osmotic pressure

C = concentration of the solution

R = gas constant

T = temperature of the solution

$\therefore$ From Eq. (i)

$$\pi = (0.1 \text{ mol dm}^{-3})(0.08206 \text{ dm}^3 \text{ atm K}^{-1}\text{mol}^{-1})(300\text{K})$$

$$= 2.4618 \text{ atm}$$

or

The complex is dissociated in aqueous solution. If α be the degree of dissociation, then the dissociation reaction can be represented as,

$$\underset{1-\alpha}{K_4[Fe(CN)_6]} \rightleftharpoons \underset{4\alpha}{4K^+} + \underset{\alpha}{[Fe(CN)_6]^{4-}}$$

Total number of moles after dissociation

$$= 1 - \alpha + 4\alpha + \alpha = 1 + 4\alpha$$

and number of moles without dissociation = 1

Since, osmotic pressure is directly proportional to the number of moles,

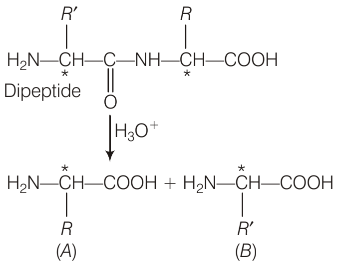
$$\text{Hence, } \frac{\pi_{\text{observed}}}{\pi_{\text{normal}}} = \frac{1 + 4\alpha}{1}$$

$$\therefore \pi_{\text{observed}} = 2.4618 \times \frac{(1 + 4 \times 0.45)}{1} \qquad (\alpha = 0.45)$$

$$= 6.89304 \approx 7 \text{ atm.}$$

16. ***(2)*** The enzyme leucine amino peptidase hydrolyses N-terminal amino acid.

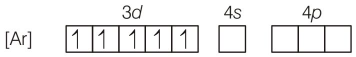
So, (B) is N-terminal and (A) is C-terminal amino acids. Therefore, the structure of dipeptide is



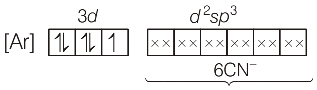
Hence, there are two asymmetric C-atoms present in dipeptide.

17. ***(3)*** In $[Fe(CN)_6]^{3-}$, Fe is in $+3$ oxidation state.

Valence shell electronic configuration (VSEC) of Fe^{3+} is



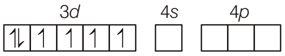
VSEC of Fe^{3+} in $[Fe(CN)_6]^{3-}$ =



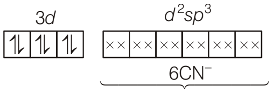
Number of unpaired electron (n) = 1; Complex is paramagnetic

In $[Fe(CN)_6]^{4-}$, Fe is in +2 oxidation state

VSEC of Fe^{2+} = [Ar]



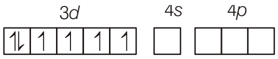
Fe^{2+} in $[Fe(CN)_6]^{4-}$ = [Ar]



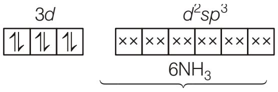
$n = 0$; complex is diamagnetic

In $[Co(NH_3)_6]^{3+}$ Co is in +3 oxidation state

VSEC of Co^{3+} = [Ar]



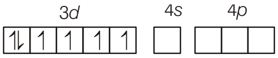
Co^{3+} in $[Co(NH_3)]^{3+}$ =



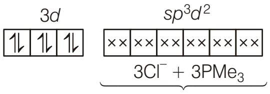
$n = 0$; complex is diamagnetic

In $[NiCl_3(PMe_3)_2]$ Ni is in +3 oxidation state

VSEC of Ni^{3+} = [Ar]



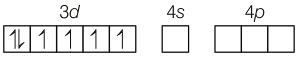
Ni^{3+} in $[NiCl_3(PMe_3)_2]$ = [Ar]



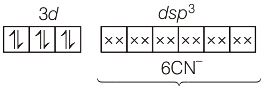
$n = 3$; complex is paramagnetic

In $[Co(CN)_6]^{3-}$; Co is in + 3 oxidation state

VSEC of Co^{3+}; [Ar]



Co^{3+} in $[Co(CN)_6]^{3-}$ = [Ar]



$n = 0$; complex is diamagnetic

18. **(5)** mmol of $H_2SO_4 = 10 \times 0.05 = 0.50$

Total mmol of $Na_2C_2O_4 . x\ H_2O = 0.50 \times 4$

$= 2$ (Both have same n-factor)

Now, molar mass of pure crystal

$$= \frac{0.45}{2} \times 1000$$

$$= 225$$

$$\Rightarrow \text{Moles of } H_2O = \frac{225 - 135}{18} = 5$$

∴ Formula of pure crystal $= Na_2C_2O_4 \cdot 5H_2O$.

19. **(8)** According to the law of corresponding states,

$$p_r = \frac{8T_r}{3V_{r-1}} - \frac{3}{V_r^2}$$

$$= \frac{8\,(T/T_c)}{3(V_m/V_{m,c}) - 1} - \frac{3}{(V_m/V_{m,c})^2} \quad \ldots(i)$$

where, p_r and T_r are reduced pressure and temperature respectively.

and $p/p_C = p_r$, $V_m/V_{m,c} = V_r$, $T/T_c = T_r$

p_c, V_c, T_c = Critical constants for pressure volume and temperature, respectively.

So, from Eq. (i)

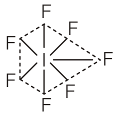
$$p_r = \frac{8\,(313/304)}{3(0.107/0.0957) - 1} - \frac{3}{(0.107/0.0957)^2}$$

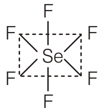
$$= \frac{8 \times 1.03}{(3 \times 1.18) - 1} - \frac{3}{(1.1)^2} = 3.51 - 2.40 = 1.11$$

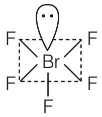
$$\therefore \quad p = p_r\, p_c = 1.11 \times 7 \text{ atm} = 7.77 \text{ atm}$$

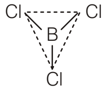
$$\approx 8 \text{ atm}.$$

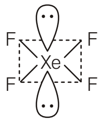
20. **(3)**

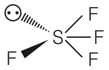
IF_7  : Octahedral

SeF_6  Octahedral

BrF_5  : Octahedral

BCl_3  : Trigonal planar

XeF_4  : Octahedral

SF_4  : Trigonal planar

Paper 2

1. **(c)** We have the rate equation,

Rate = $[NO]^a\ [Cl_2]^b$ ...(i)

where, a and b are the orders of reaction with respect to NO and Cl_2.

If $a = 0, b = 1$, then $r = k_1[Cl_2]$ ...(ii)

If $a = 1, b = 1$, then $r = k_2[NO][Cl_2]$ ...(iii)

Doubling the concentration of both the reactants will increase the rate by a factor of 4, which is not given.

If $a = 0, b = 2$, then $r = k_1[Cl_2]^2$

Doubling the concentration of Cl_2 will increase the rate by a factor of 4 which is not given.

If $a = 1, b = 1$, then $r = k_2[NO][Cl_2]^2$

Doubling the concentrations of both the reactants will increase the rate by a factor of 8 but doubling the concentration of Cl_2 alone will increase the rate by a factor of 4, which is again not given.

The other alternative for 3rd order reaction is

$a = 2, b = 1$, so that $r = k_3[NO]^2[Cl_2]$

We see that this rate equation satisfies both the given conditions. Hence, overall order of reaction = 2 + 1 = 3.

2. **(c)** Xenon hexafluoride (XeF_6) when treated with water, xenon trioxide is obtained with a byproduct HF.

$$XeF_6 + 3H_2O \longrightarrow \underset{P}{XeO_3} + 6HF$$

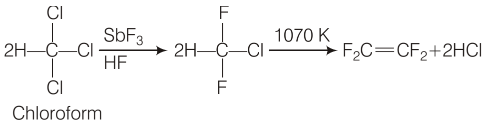
XeO_3 is a powerful oxidising agent so, it oxidises Pu^{2+} to Pu^{4+} in presence of acid.

$$3Pu^{2+} + XeO_3 + 6H^+ \longrightarrow 3Pu^{4+} + Xe + 3H_2O$$

Also, it reacts with aqueous alkali to give xenate and perxenate ions.

$$XeO_3 + \bar{O}H \longrightarrow HXeO_4^-$$
$$2HXe\bar{O}_4 + 2\bar{O}H \longrightarrow XeO_6^{4-} + Xe + 2H_2O + O_2$$

3. ***(a)***



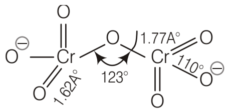
$$2H{-}CCl_2{-}Cl \xrightarrow[HF]{SbF_3} 2H{-}CF_2{-}Cl \xrightarrow{1070\ K} F_2C{=}CF_2 + 2HCl$$

4. ***(c)*** The given reaction is

$$2Na_2\overset{+6}{Cr}O_4 + H_2SO_4 \longrightarrow \underset{P}{Na_2\overset{+6}{Cr_2}O_7} + Na_2SO_4 + H_2O$$

It is not a redox reaction because there is no change in oxidation state of Cr-metal.

P i.e. $Na_2Cr_2O_7$ is a dimeric bridged tetrahedral ion having orange colour.



5. ***(b)*** Given, $T_1 = 40°C, T_2 = 60°C$

$$k_1 = 0.86, k_2 = 0.35$$

We have the equation to check the spontaneity of the reaction is

$$\Delta G° = \Delta H° - T\Delta S° \text{ [Gibb's Helmholtz reaction]} \quad \ldots(i)$$

where, $\Delta G°$ = Standard Gibb's free energy
$\Delta H°$ = Standard enthalpy of the reaction
$\Delta S°$ = Standard entropy of the reaction
T = Temperature at which reaction occurs

So, from Eq. (i),

$$\Delta G° = \Delta H° - T\Delta S° = -RT\ln k$$

$$\Rightarrow \quad \ln k = \frac{\Delta S°}{R} - \frac{\Delta H°}{RT} \quad \ldots(ii)$$

Now solving Eq. (ii) for T = 40°C and 60°C

$$\ln 0.86 = \frac{\Delta S°}{R} - \frac{\Delta H°}{313\,R} \quad \ldots(iii)$$

$$\text{and} \quad \ln 0.35 = \frac{\Delta S°}{R} - \frac{\Delta H°}{333\,R} \quad \ldots(iv)$$

On solving both equations (iii) and (iv), we get

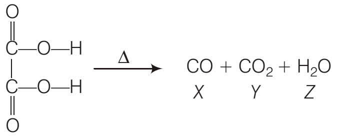
$$\Delta S° = -125.7\ JK^{-1}$$

$$\Delta H° = -38.95\ kJ$$

$$\Rightarrow \text{at } 27°C,\ \Delta G° = \Delta H° - T\Delta S°$$
$$= -38.95\ kJ - 300K \times (-125.7\ JK^{-1})$$
$$= -1.24\ kJ$$

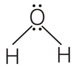
Since, $\Delta G°$ has negative value hence, this reaction is spontaneous at 27°C. It is not necessary that at the temperature lower than 27°C, reaction is non-spontaneous. Spontaneity of a reaction only depends upon negative value of ΔG.

6. ***(c)***



Non-polar, X ; CO ; —C≡O; *sp*-hybridised C-atom.

Polar, neutral, Y ; CO_2 ; O═ C ═ O ; *sp*-hybridised C-atom.

Polar neutral Z ; H_2O ;  ; sp^3-hybridised O-atom

7. ***(b)*** (a) Sodium peroxide liberates O_2 with hot water.

$$2Na_2O_2 + 2H_2O(\text{warm}) \longrightarrow 4NaOH + O_2$$

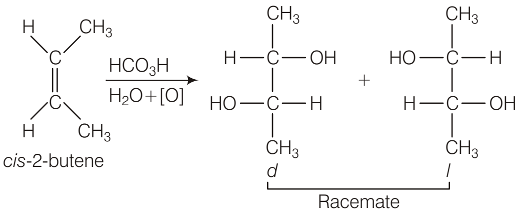
(b) Sodium peroxide is a yellow coloured substance but turns white on exposure to moist air due to the formation of NaOH and Na_2CO_3.

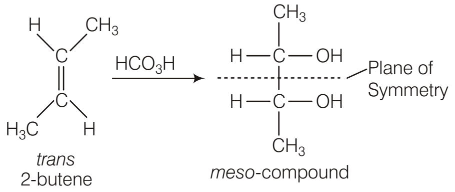
$$Na_2O_2 + 2H_2O \longrightarrow 2NaOH + H_2O_2$$
$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

(c) Sodium peroxide is a powerful oxidising agent and it oxidises chromic compounds (Cr^{3+}) to chromate (Cr^{6+}).

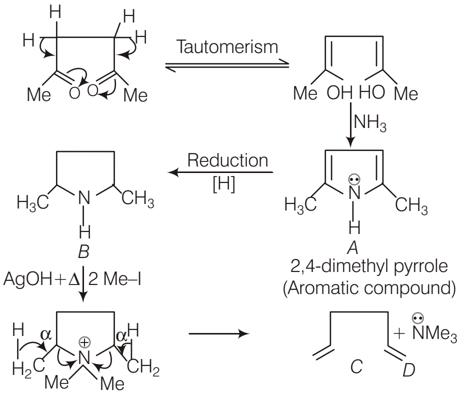
$$5Na_2O_2 + \overset{+3}{Cr_2}(SO_4)_3 \longrightarrow 3Na_2SO_4 + 2Na_2\overset{+6}{Cr}O_4 + O_2$$

8. ***(d)*** 2-butene can be written as,





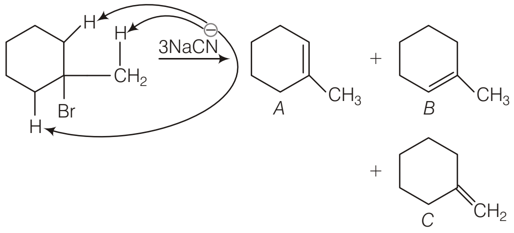
9. ***(a)***



10. ***(a)*** Since, the reactant is a 3°-alkylhalide, so in the presence of NaCN, it will show E_2 rather than S_N2.

So, path II is not facile.

The possible product by path II is,



11. **(a)** Number of *A* atoms per unit cell

$$= 8 \times \frac{1}{8} = 1$$

Number of *B* atoms per unit cell

$$= 2 \times \frac{1}{2} + 12 \times \frac{1}{4} = 4$$

Number of *C* atoms per unit cell

$$= 4 \times \frac{1}{2} + 1 \times 4 = 6$$

Hence, the formula of compound is AB_4C_6.

But in the given question two cases arise.

***Case* I** If the tetrad axis passes through the face-centres where, *B* lies, then,

Number of *B*-atoms $= 4 - \left(\frac{1}{2} \times 2\right) = 3$

The formula of the compound left is AB_3C_6.

***Case* II** If the tetrad axis passes through the face-centres where '*C*' lies, then

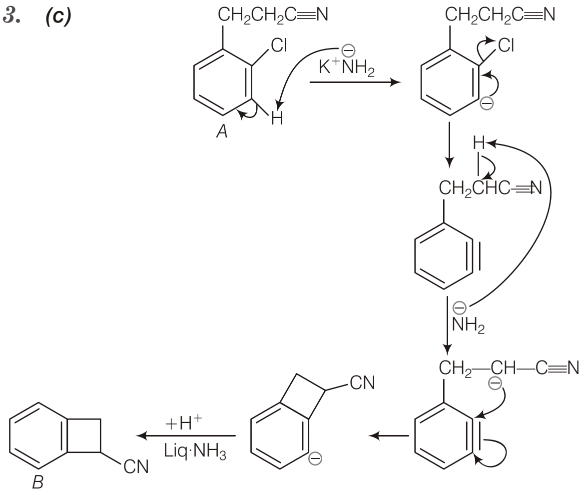
number of *C*-atoms $= 6 - \left(\frac{1}{2} \times 2\right) = 5$

$\therefore$ Formula of the compound is AB_4C_5.

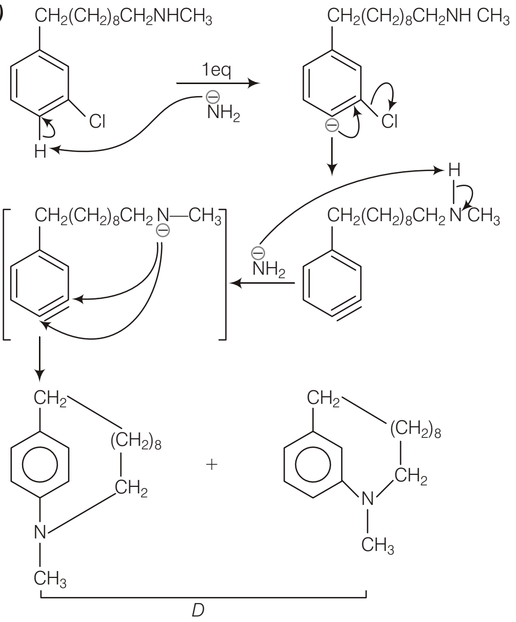
12. **(a)** There are 8-effective tetrahedral voids out of which four are occupied (one at each body diagonal) and 4-effective octahedral voids such that one is not filled (body-centred). So, out of 12 (8 tetrahedral voids + 4 octahedral voids), only 7 are filled (4 tetrahedral voids + 3 octahedral voids)

$\therefore$ Fraction of void occupied $= \frac{7}{12} = 0.58$

13. **(c)**



14. **(c)**

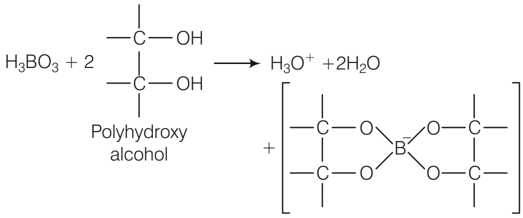


15. **(d)** Boric acid when dissolved in water only one H^+ ion is removed to form $[B(OH)_4]^-$.

$$H_3BO_3 + H_2O \rightleftharpoons [B(OH)_4^-] + H^+$$

There is no replacement of H-atom, occurs in the above reaction.

16. **(d)** In the presence of anhyd. H_2SO_4, glycerol or mannitol, boric acid furnishes H^+ ions, so it acts as a strong acid.



$$H_3BO_3 + \underset{\text{(Anhydrous)}}{6H_2SO_4} \longrightarrow 3H_3O^+ + 2HSO_4^- + [B(HSO_4)_4]^-$$

17. **(b)** A - r, B - p, C - q, D - s

A. $K_n[Fe(CN)_6]$. Diamagnetic; $n = 4$

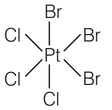
$\because K_4[Fe(CN)_6]$ contains Fe in +2 oxidation state having $3d^6$ configuration showing low-spin in the presence of strong ligand, e.g. CN^-. Hence, it is diamagnetic in nature.

B. $[Ag(CN)_n]^-$: $n = 2$

$\because [Ag(CN)_2]^-$ contains Ag in +1 oxidation state.

$\therefore +1 - n = -1$ or $n = 2$

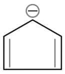
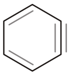
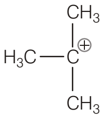
C. Facial $-[PtCl_3Br_n]^{2-}$; $n = 3$



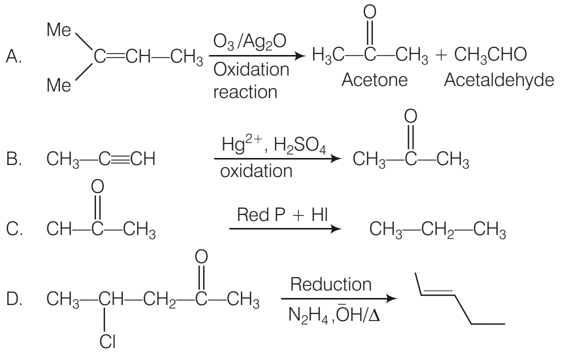
Facial isomer

D. $[Pt(NH_3)_n]Cl_4$ octahedral $n = 6$
$\therefore$ $[Pt(NH_3)_6]Cl_4$ is an octahedral compound having Pt^{4+} ion.

18. ***(b)*** A - q, r, s; B - q, r, s ; C - q, r, s; D - p, s

A.		All C-atoms are sp^2 - hybridised Aromatic in nature because it follows Huckel rule. Diamagnetic compound as both π-electrons have opposite spins.
B.		All C-atoms are sp^2- hybridised. Aromatic compound Diamagnetic.
C.		All C-atoms are sp^2-hybridised Aromatic compound Diamagnetic
D.		It exhibits hyperconjugation as it has nine hyperconjugative structures. Diamagnetic.

19. ***(a)*** P - q,r ; Q - q,r ; R - p ; S - p,s



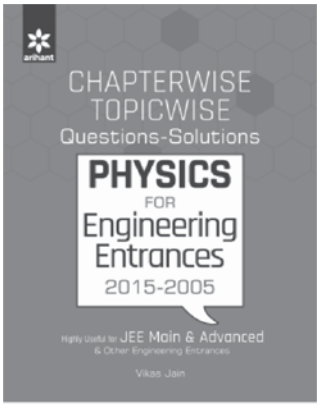
20. ***(b)*** A - q, B - r, C - s, D -p

A. H_2O has largest H—O —H bond angle.

B. H_2S has lowest boiling point.

C. H_2Se has two lone pairs.

D. H_2Te has largest Te—H bond.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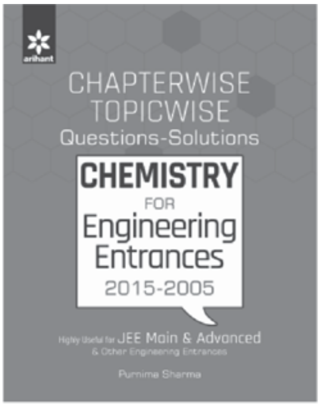
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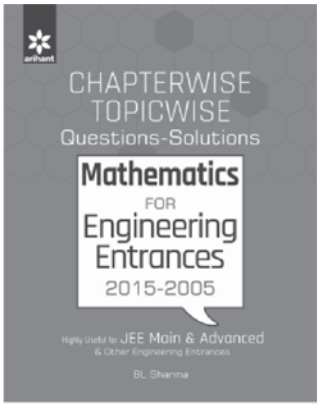
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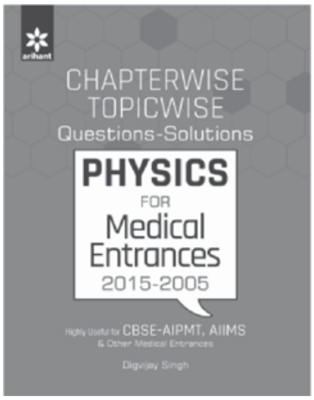
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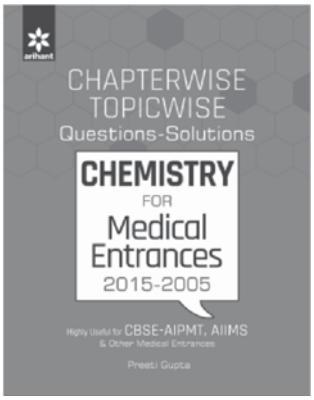
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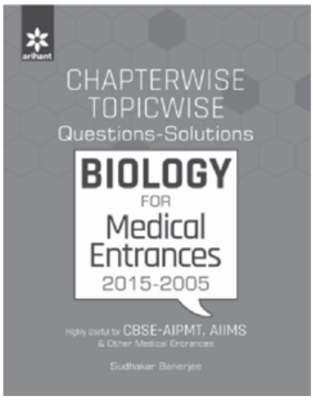
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CHEMISTRY SPECTRUM for You

In this section, we invite our readers to send their problems and we will try to provide the best possible solutions given by our expert panel.

01

Sir, I was reading molecular orbital theory yesterday. I want to know that how do we measure the energies of molecular orbitals? **[Arjun Singh, Meerut]**

➥ You have asked a very interesting question, Arjun. The energies of molecular orbitals are measured by the use of photoelectron spectroscopy (PES) technique. As name suggest, this technique is based on photoelectric effect.

A sample is bombarded with photons of known energy ($h\nu$) and kinetic energy of ejected electrons (E_{KE}) is measured. As electrons are ejected from the sample, it results rearrangement of remaining electrons in the ion formed. Assuming that there is no loss of energy due to rearrangement of electrons in the ion formed, this leads to equation,

$$h\nu = I + E_{KE}$$

In the above equation, I is the ionisation energy, the energy required to remove a single electron from a particular molecular orbital, so it provides a measure of the orbital energy. Since, ν is known and E_{KE} is measured, therefore I can be calculated from the above equation.

Ultraviolet radiation is used to measure the orbital energy of the valence electrons (UV-PES), and the higher energy X-ray radiation is used for the core electrons (X-PES).

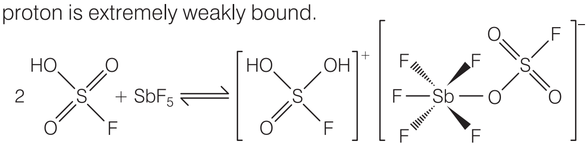
02

Sir, what are superacids and how are these formed? Please explain. **[Neha Chaudhary, Muzaffarnagar]**

➥ Superacids are the acids which are stronger than 100% sulphuric acid. Now, you can imagine how much strong they are.

A superacid is formed by dissolving a powerful Lewis acid (SbF_5) in a Bronsted-Lowry acid (HF or HSO_3F). The combination of SbF_5 and HSO_3F, is known as magic acid because it can dissolve candle wax. Magic acid is 10^{18} times stronger than 100% sulphuric acid.

Superacids are so strong because the Bronsted-Lowry acid donates a lone pair of electrons to the Lewis acid. The H—X bond is broken, and the proton becomes attached to the another molecule of the Bronsted-Lowry acid. This leads to high concentrations of cations such as H_2F^+ and $H_2SO_3F^+$ in which proton is extremely weakly bound.



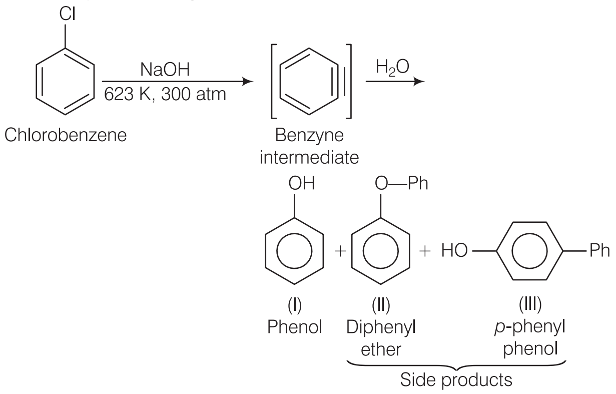
Magic acid

These acids are so strong that they can even protonate hydrocarbons. Protonation is the first step to dissolve candle wax which is made from long chain hydrocarbons such as $C_{30}H_{62}$.

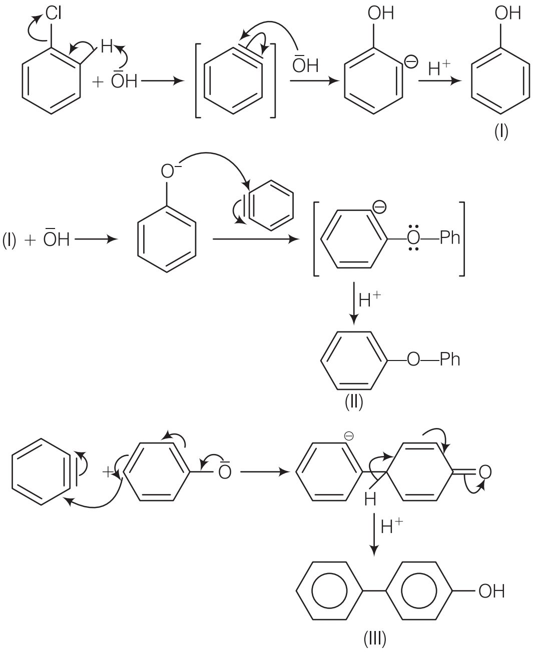
03

Sir, how three products are obtained from Dow's process? Please explain me with mechanism. **[Pooja Chauhan, Kanpur]**

➥ Dow's process involved reaction of chlorobenzene with a concentrated sodium hydroxide solution at high temperature (above 350°C) and high pressure (300 atm). This reaction takes place *via* benzyne intermediate. The reaction and mechanism of Dow's process is given below:



Mechanism



04

Sir, how can I relate ionisation energy to the other properties like metallic character, basic character etc? Please explain.

[Manish Kumar, Lucknow]

➥ You can solve many problems in board or entrance exams in less than few minutes, if you know how to correlate ionisation energy (IE) with various properties. Some important points I am mentioning below:

As the ionisation energy increases, basic character of hydroxides increases. Thus, ionisation energy gives a rough idea about basic character of hydroxides.

The ionisation energy of the metalloids generally fall between those of metals and non-metals. The difference in ionisation energy suggest why metals (show low ionisation energy) always form cations and non-metals (show high ionisation energy) form anions.

Metallic or electropositive character of elements increases as the value of ionisation energy decreases. So, in a group on moving from top to bottom, metallic or electropositive character increases as ionisation energy value decreases. In a period, moving from left to right, ionisation energy value increases, hence, metallic character decreases and non-metallic character increases.

The relative reactivity of the metals increases with the decrease in ionisation value. The ionisation value of inert gases are very high. So, they are almost inactive. In a group, on moving from top to bottom, the reactivity of metal atoms increases because their ionisation value decreases.

The reducing power of elements increases as values of ionisation energy decreases because tendency to lose the electron increases. The reducing power increases on going down a group because the ionisation energy value decreases.

$$\text{Li} > \text{Cs} > \text{Rb} > \text{K} > \text{Na}$$

Li is strongest reductant among all alkali metals because Li is much smaller than the other alkali metal cations. Its hydration energy is highest as compare to the other alkali metal ions. This high hydration energy of Li^+ compensates for its higher ionisation energy.

CHEMISTRY IN action

A Love Hate Relationship with Chlorine

Chlorine is the anti-hero of disinfected drinking water. A pathogen-killer with that fresh swimming pool scent, the green gas has kicked cholera and *E.coli* to the curb in most developed nations. In recent years however, chlorine's "dark side" _ a tendency to increase the rate of bladder cancer and miscarriages _ has prompted water treatment facilities to shun the chemical and turn to alternative disinfectants.

The results of this switch have proved toxic in some cities, such as in Washington D.C., where the use of chloramine, the ammonia diluted version of chlorine, allowed lead to leach from city pipes into the drinking water. Chlorine, with its oxidizing powers that could coat lead pipes with a less soluble compound, would never have let that happen to our nation's capital.

TARGET PMT 2016

TEST Tuner

Comprehensive Simulator Test Series for AIPMT & AIIMS

AIIMS PREP UP

Mock Questions with Complete Solutions

Instructions

- This test consists of 60 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 de-Broglie wavelength associated with a ball of mass 1kg having kinetic energy 0.5 J is

(a) 6.626×10^{-34} m (b) 13.20×10^{-34} m

(c) 10.38×10^{-21} m (d) 6.626×10^{-34} Å

2. The value of $\log_{10} K$ at 298 K for a reaction $A \rightleftharpoons B$ is

[Given, $\Delta_r H° = -54.07$ kJ mol^{-1}

$\Delta_r S° = 10$ J K^{-1}

and $R = 8.314$ JK^{-1}mol^{-1} $2.303 \times 8.314 \times 298 = 5705.84$]

(a) 5 (b) 10

(c) 95 (d) 100

3. Which one of the following statements is correct?

(a) Zeolites are hydrated aluminosilicates which can be used as shape-selective catalysts

(b) Enzymes show maximum activity when pH is either very low or very high

(c) Chemically, all enzymes are globular proteins

(d) All of the above

4. The correct decreasing order of reactivity for the following coupling compounds with PhN_2Cl is

I. Toluene II. Ethyl benzene

III. Cumene IV. *t*-butyl benzene

V. Anisole

(a) IV > I > III > II > VI (b) V > I > II > III > IV

(c) II > I > IV > V > III (d) III > I > II > VI > IV

5. In the decomposition of acetaldehyde in gaseous phase, various values of $\log_{10} K$ were plotted against $\frac{1}{T}$ and a straight line with a slope of – 7525 K was obtained. Similarly, a slope of – 6045 K was obtained in case of decomposition of acetone dicarboxylic acid. The energies of activation (cal mol^{-1}) in these cases were (where, $R = 3$ cal/mol K)

(a) 61990 and 51764 (b) 41764 and 51940

(c) 51990 and 41765 (d) 71990 and 41764

6. Which two elements in the periodic table would you expect to combine in the most violent fashion?

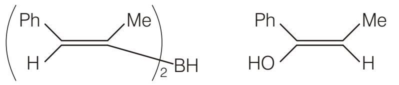
(a) H and O (b) Cl and F (c) Cs and F (d) Mg and N

7. $Ph—C{\equiv}C—Me \xrightarrow{B_2H_6,\ THF} A \xrightarrow{CH_3COOH} B$

A and *B* are

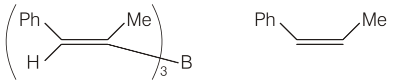
A B

(a)

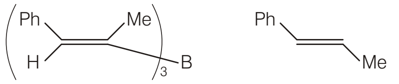


(b)

(c)



(d)



8. Which one of the following statements is correct?

(a) Persons working in cement plants and limestone quarries are more prone to disease like silicosis

(b) Lead in water can cause eye disease

(c) Ferrocene is responsible for depletion of the ozone layer in the upper stratosphere of the atmosphere

(d) Fishes can grow both in warm and in cold water

9. Which of the following statements is incorrect?

(a) The freezing point of water is depressed by addition of glucose

(b) The degree of dissociation of a weak electrolyte decreases as its concentration decreases

(c) Energy is released when a substance dissolves in water provided that the hydration energy of the substance is more than its lattice energy

(d) All of the above

10. In the brown ring test for NO_3^- ion, complex $[Fe(H_2O)_5NO]^{2+}$ is formed. In this complex

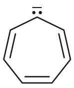
(a) NO transfers its electron to Fe^{2+} such that iron is Fe^+ and NO is NO^+

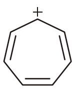
(b) Three unpaired electrons are present so that its magnetic moment is 3.87 BM

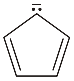
(c) The colour is due to charge transfer

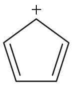
(d) All of the above statements are correct

11. Which of the following species could be expected to exhibit aromatic character?


I


II


III


IV

Select the correct answer from the following.

(a) I and II

(b) II and III

(c) III and IV

(d) I and IV

12. 1 dm^3 solution containing 10^{-5} moles each of Cl^- and CrO_4^{2-} ions, is treated with 10^{-4} moles of silver nitrate. Which one of the following observations is found to be correct?

$[K_{sp}\ (Ag_2CrO_4) = 4 \times 10^{-12},\ K_{sp}\ (AgCl) = 1 \times 10^{-10}]$

(a) Silver chromate gets precipitated first

(b) Precipitation does not occur

(c) Silver chloride gets precipitated first

(d) Both silver chromate and silver chloride start precipitating simultaneously

13. The complex $K_4[Fe(CN)_5O_2]$ has $t_{2g}^6 e_g^{\circ}$ electronic configuration then which of the following statements is correct?

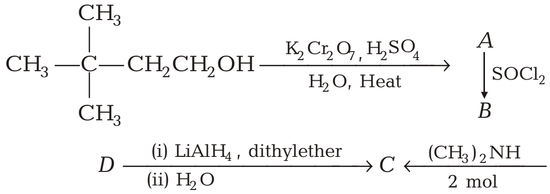
(a) It is d^2sp^3 hybridised and paramagnetic

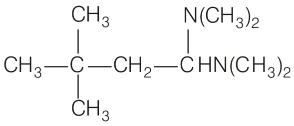
(b) It is d^2sp^3 hybridised and diamagnetic

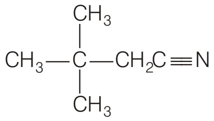
(c) It is sp^3d^2 hybridised and paramagnetic

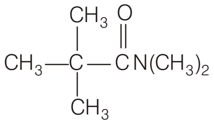
(d) It is sp^3d^2 hybridised and diamagnetic

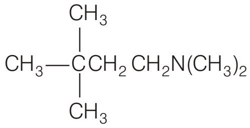
14. Identify product *D* in the following reaction sequence



(a) 
$CH_3-\overset{\overset{\large CH_3}{|}}{\underset{\underset{\large CH_3}{|}}{C}}-CH_2-\overset{\overset{\large N(CH_3)_2}{|}}{C}HN(CH_3)_2$

(b) 
$CH_3-\overset{\overset{\large CH_3}{|}}{\underset{\underset{\large CH_3}{|}}{C}}-CH_2C\equiv N$

(c) 
$CH_3-\overset{\overset{\large CH_3}{|}}{\underset{\underset{\large CH_3}{|}}{C}}-\overset{\overset{\large O}{||}}{C}N(CH_3)_2$

(d) 
$CH_3-\overset{\overset{\large CH_3}{|}}{\underset{\underset{\large CH_3}{|}}{C}}CH_2CH_2N(CH_3)_2$

15. A white crystalline salt *A* reacts with dil. HCl to liberate a suffocating gas *B* and it also forms a yellow precipitate. The gas *B* turns potassium dichromate acidified with dil. H_2SO_4, to a green coloured solution *C*. *A*, *B* and *C* respectively, are

(a) Na_2SO_4, SO_2, $Cr_2(SO_4)_3$

(b) Na_2S, SO_2, $Cr_2(SO_4)_3$

(c) $Na_2S_2O_3$, SO_2, $Cr_2(SO_4)_3$

(d) Na_2SO_3, SO_2, $Cr_2(SO_4)_3$

16. The colour is not due to *d-d* transition in which of the following?

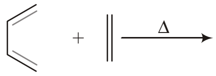
(a) $[CoF_6]^{3-}$

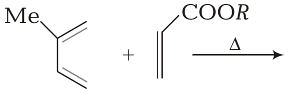
(b) CrO_4^{2-}

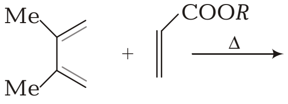
(c) $[Ti(H_2O)_6]^{3+}$

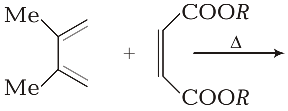
(d) $[Cu(NH_3)_4]^{2+}$

17. Give the decreasing order of reactivity of Diels-Alder reaction for the following

I. 

II. 

III. 

IV. 

(a) II > I > III > IV

(b) IV > III > I > II

(c) IV > III > II > I

(d) I > II > III > IV

18. Which of the following statements is incorrect?

(a) $CaCl_2$ has electrovalent linkage

(b) NO_3^- and CO_3^{2-} are not isoelectronic and isostructural

(c) H_2O is liquid while H_2S is a gas due to H-bonding

(d) Peroxide ion is diamagnetic and has bond order 1

19. The K_{sp} for AgCl is 1.0×10^{-10}. If $E^{\circ}_{Ag^+/Ag} = 0.799$ V then E_{cell} for Ag^+/Ag electrode immersed in 1M KCl at 25°C is

(a) 0.148 V

(b) 0.312 V

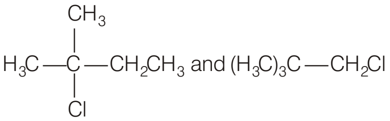
(c) 0.208 V

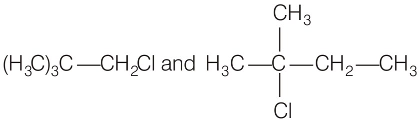
(d) 0.481 V

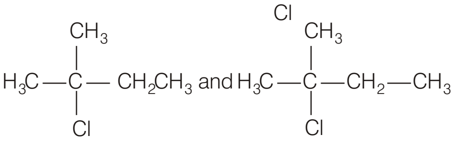
20. Identify the product *P* and *Q*, respectively are

$$P \xleftarrow{HCl + ZnCl_2} (H_3C)_3C—CH_2OH \xrightarrow{SOCl_2/PCl_5} Q$$

(a) $(H_3C)_3C—CH_2Cl$ and $(H_3C)_3C—CH_2Cl$

(b)

$H_3C—C(CH_3)(Cl)—CH_2CH_3$ and $(H_3C)_3C—CH_2Cl$

(c)

$(H_3C)_3C—CH_2Cl$ and $H_3C—C(CH_3)(Cl)—CH_2—CH_3$

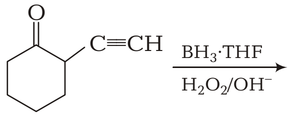
(d)

$H_3C—C(CH_3)(Cl)—CH_2CH_3$ and $H_3C—C(CH_3)(Cl)—CH_2—CH_3$

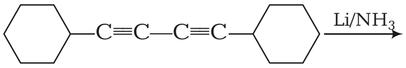
21. The number of lone pair on iodine and number of *d*-orbitals used in hybridisation by iodine are same in

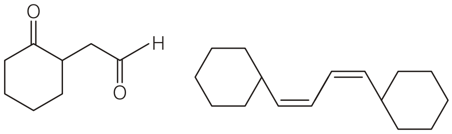
(a) ICl_2^- (b) ICl_2^+

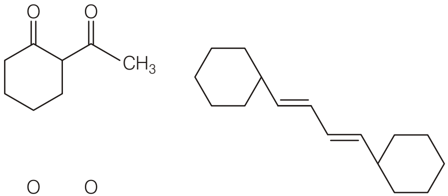
(c) IF_7 (d) ICl_4^-

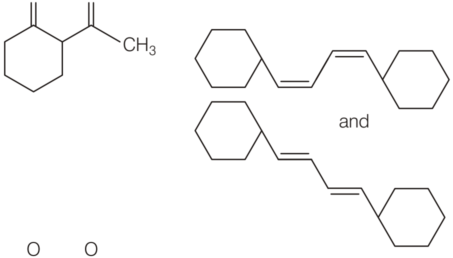
22. Identify the product formed in the given reaction

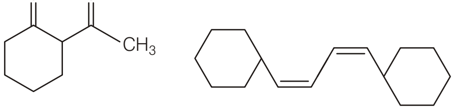
I


II


(a)


(b)


(c)


(d)


23. The average speed is greatest in which of the following gas samples?

(a) 2.0 mole of He at 140 K

(b) 0.20 mole of CO_2 at 440 K

(c) 0.50 mole of Ne at 500 K

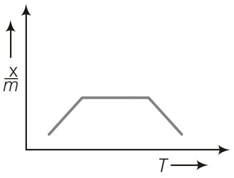
(d) 1.0 mole N_2 at 560 K

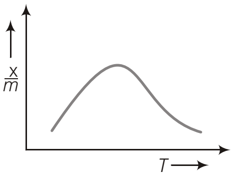
24. One mole of SO_3 was placed in a 1 L flask at a given temperature, when the equilibrium was established in the reaction, $2SO_3 \rightleftharpoons 2SO_2 + O_2$ the vessel was found to contain 0.6 mole of SO_2. The value of the equilibrium constant $(mol L^{-1})$ is

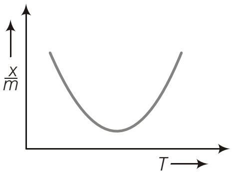
(a) 0.36 (b) 0.675

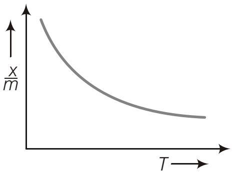
(c) 0.45 (d) 0.54

25. Which of the following is the adsorption isobar for chemisorption?

(a)


(b)


(c)


(d)


26. Hydrogen peroxide when added to a solution of potassium permanganate acidified with sulphuric acid

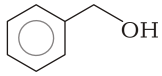
(a) reduces sulphuric acid

(b) acts as a reducing agent

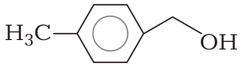
(c) acts as an oxidising agent

(d) forms water only

27. The correct decreasing order of reactivity of the following compound with HBr is

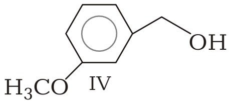


I



II

III



IV

(a) III > II > IV > I (b) III > II > I > IV

(c) II > III > IV > I (d) III > IV > II > I

28. Which of the following statements is correct?

(a) H_3PO_3 is dibasic and reducing in nature

(b) The number of S—S bonds in sulphur trioxide trimer (S_3O_9) is three

(c) O_2 diffuses faster than N_2 through an orifice

(d) NO_2 gas is evolved when PbO_2 is treated with conc. HNO_3

29. If same quantity of electricity is passed through three electrolytic cells containing $FeSO_4$, $Fe_2(SO_4)_3$ and $Fe(NO_3)_3$, then choose the incorrect statement.

(a) The amount of iron deposited in cells containing $FeSO_4$ and $Fe_2(SO_4)_3$ are equal
(b) The amount of iron deposited in cells containing $FeSO_4$ is 1.5 times of the amount of iron deposited in $Fe(NO_3)_3$
(c) The amount of iron deposited in cells containing $Fe_2(SO_4)_3$ and $Fe(NO_3)_3$ are equal
(d) The same amount of gas is evolved in all three cases at the anode

30. Consider the first order reaction,

$$C_2H_4O(g) \longrightarrow CH_4(g) + CO(g)$$

If the initial pressure of $C_2H_4(g)$ is 80 mm and the total pressure at the end of 20 min is 120 mm, then the half-life is

(a) 120 min
(b) 20 min
(c) 60 min
(d) 45 min

31. The hormone that controls the process like burning of fats, proteins and carbohydrates to liberate energy in the body is

(a) cortisone
(b) thyroxine
(c) adrenalin
(d) insulin

32. A mineral consists of an equimolar mixture of the carbonates of two bivalent metals. One metal is present to the extent of 15.0% by weight, 3.0 g of mineral on heating lost 1.10 g of CO_2. The per cent by weight of other metal is

(a) 35%
(b) 75%
(c) 25%
(d) 65%

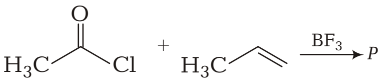
33. The basicities of hypophosphorus acid, phosphorous acid, hypophosphoric acid and pyrophosphoric acid respectively, are

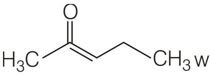
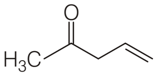
(a) 1, 2, 4 and 4
(b) 1, 3, 4 and 2
(c) 2, 2, 3 and 4
(d) 1, 1, 2 and 3

34. The number of atoms in 100 g of a fcc crystal with density and cell edge of 10 g cm^{-3} and 200 pm, respectively is

(a) 5×10^{20} atoms
(b) 5×10^{24} atoms
(c) 3×10^{20} atoms
(d) 3×10^{24} atoms

35. Which of the following statements are correct about the given reaction?



(a) The product P is  which is proceeds *via* the formation of acylium ion
(b) The product P is 
(c) The formation of P proceeds *via* the formation of carbonation
(d) All of the above

36. Cuprous ion is colourless while cupric ion is coloured because

(a) cupric ion has an incomplete *d*-orbital and cuprous ion has a complete *d*-orbital
(b) both cuprous ion and cupric ion have half-filled *p*-and *d*-orbitals
(c) both cuprous and cupric ions have more than one unpaired electrons in *d*-orbitals
(d) cupric ion has a complete *d*-orbital and cuprous ion has an incomplete *d*-orbital

37. If AgI crystallises in zinc blende structure with I^- ions at lattice points. What fractions of tetrahedral voids is occupied by Ag^+ ions?

(a) 75%
(b) 50%
(c) 100%
(d) 25%

38. Consider the following sequence of reactions,

$$(CH_3)_2CHOH \xrightarrow[\text{Oxidation [O]}]{\text{Mild}} A \xrightarrow[\text{(ii) Hydrolysis}]{\text{(i) } CH_3MgI} B$$

The product B is

(a) *n*-butyl alcohol
(b) isobutyl alcohol
(c) isobutylene
(d) tertiary butyl alcohol

39. Which of the following statements is incorrect about formic acid?

(a) It reduces Tollen's reagent
(b) It is a stronger acid than benzoic acid
(c) It forms formyl chloride with PCl_5
(d) It gives CO and H_2O on heating with conc. H_2SO_4

40. Select the correct statement(s).

(a) Cyanamide ion (CN_2^{2-}) is isoelectronic with CO_2 and has the same linear structure
(b) Mg_2C_3 reacts with water to form propyne
(c) CaC_2 has NaCl type lattice
(d) All of the above

Directions (Q. Nos. 41 to 60) *In the following questions a statement of Assertion followed by a statement of reason, is given. Choose the correct answer out of the following choices.*

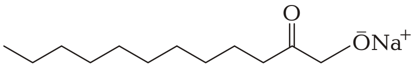
(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion
(b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion
(c) Assertion is true but Reason is false
(d) Both Assertion and Reason are false

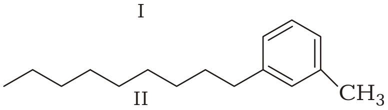
41. Assertion (A) The intermolecular forces of polymer Nylon-6 6, buna-S, polythene increase in order.
I II III

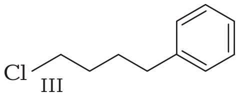
II < III < I.

Reason (R) Nylon-6 6 is a fiber and buna-S is an elastomer.

42. **Assertion** (A) Among I, II and III, the molecules of II are most suitable to disperse benzene in water.


I





Reason (R) II is non-polar covalent organic compound.

43. **Assertion** (A) A mixture of *o*- and *p*-aminosulphonic acid is formed on heating aniline hydrogen sulphate.
Reason (R) Sulphonic acid shows electron withdrawing nature.

44. **Assertion** (A) The O—O bond length in H_2O_2 is shorter than that of O_2F_2.
Reason (R) H_2O_2 is an ionic compound.

45. **Assertion** (A) *tert*-butyl methyl ether on treatment with HI at 373 K gives a mixture of methyl iodide and *tert*-alcohol.
Reason (R) The reaction takes place by S_N2 mechanism.

46. **Assertion** (A) When rain is accompanied by a thunderstorm, the collecter rain water will have a pH value slightly lower than that of rain water without thunderstorm.
Reason (R) There is formation of SO_2 which ultimately changes to H_2SO_4.

47. **Assertion** (A) *p*-methyl benzyl carbocation(I) is more stable than benzyl carbocation (II).
Reason (R) I is more stable than II due to hyperconjugation.

48. **Assertion** (A) NF_3 is a weaker ligand than $N(CH_3)_3$.
Reason (R) NF_3 ionises to give F^- ion in aqueous solution.

49. **Assertion** (A) The electrolysis of NaCl solution gives $H_2(g)$ at cathode and $Cl_2(g)$ at anode.
Reason (R) H_2O has lower oxidation potential than Cl_2.

50. **Assertion** (A) The order of bond angle decreases as follows $NH_3 > NH_4^+ > NH_2^-$
Reason (R) The repulsive force increases in the order

$$NH_3 > NH_4^+ > NH_2^-$$

51. **Assertion** (A) On compressing a gas to half the volume, the number of molecules is halved.
Reason (R) The number of moles of gas present decreases with decrease in volume.

52. **Assertion** (A) Greater the value of K, more is the fraction of initial concentration of reactants converted to products at equilibrium.
Reason (R) The value of K depends on the initial concentration of reactants.

53. **Assertion** (A) Softening of hard water is done using sodium aluminium silicate (zeolite).
Reason (R) Al^{3+} ions replaces Ca^{2+} and Mg^{2+} ions from hard water.

54. **Assertion** (A) The structure of glycogen is similar to that of amylopectin.
Reason (R) Glycogen is hydrolysed by enzyme β-amylase.

55. **Assertion** (A) Among Li, Na, K, Rb and Cs, lithium salts exhibit the least electrical conductance and Cs salts exhibits more electrical conductance in aqueous solutions.
Reason (R) Smaller the radius of the hydrated cation, lower is the electrical conductance in aqueous solution.

56. **Assertion** (A) Towards nucleophilic attack, benzaldehyde is less reactive than ethanol.
Reason (R) All the carbon atoms of benzaldehyde are sp^2-hybridised.

57. **Assertion** (A) Zn, Cd and Hg are placed in *d*-block elements but not regarded as transition elements.
Reason (R) Zn, Cd and Hg have fully filled *d*-orbitals in their most common oxidation states.

58. **Assertion** (A) When a solution becomes hot on mixing two liquids it indicates that it shows negative deviation from Raoult's law.
Reason (R) Solutions which show negative deviation from Raoult's law are accompanied by the decrease in volume.

59. **Assertion** (A) Sulphide ores generally roasted to oxide for the extraction of metals instead of being directly reduced.
Reason (R) For the reduction of ores if sulphide ores are used, these will form carbon disulphide.

60. **Assertion** (A) $C_p - C_V = R$ for an ideal gas.
Reason (R) $\left[\frac{\partial E}{\partial V}\right]_T = 0$ for an ideal gas.

Answers *with* Explanation

1. **(a)** de-Broglie wavelength is given as

$$\lambda = \frac{h}{\sqrt{2m(\text{KE})}} = \frac{6.6 \times 10^{-34}\ \text{Js}}{\sqrt{2 \times 1\,\text{kg} \times (0.5\ \text{J})}}$$

$$= 6.626 \times 10^{-34}\ \text{m}$$

2. **(b)** $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

$$= -54.07 \times 10^3\ \text{J} - 298 \times 10\ \text{J}$$

$$= -57.05 \times 10^3\ \text{J}$$

$$\Delta G^\circ = -2.303RT \log K$$

$$\log K = \frac{-\Delta G^\circ}{2.303RT} = \frac{57.05 \times 10^3}{5705.84} \simeq 10$$

3. **(c)** Zeolites are not used as such but are first heated in vacuum so that the water on hydration is lost.

Enzymes have maximum activity at pH of 7.4.

4. **(b)** Electron donating power of $-\ddot{\underset{\cdot\cdot}{\text{O}}}\text{Me} > -\text{Me}$

(3 hyperconjugated (HC) structures and + *I*-effect)

$> -\text{CH}_2\text{CH}_3$ (2 HC structures and + *I*-effect)

$> \text{Me}_2\text{CH}-$(isopropyl) (1 HC structure and + *I*-effect)

$> \text{Me}_3\text{C}-$(*t*-butyl) (no HC only + *I*-effect)

5. **(c)** From Arrhenius equation, we know that slope

$$= -\frac{E_a}{2.303 \times R}$$

$$= -\frac{E_a}{2.303 \times 3}$$

For the decomposition of acetaldehyde

$$-7525 = -\frac{E_a}{6.909}$$

$\therefore E_a = 51{,}990$ cal/mol

Similarly, for the decomposition of acetone dicarboxylic acid

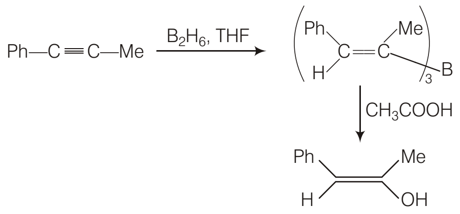
$$-6045 = -\frac{E_a}{6.909}$$

$\therefore E_a = 41{,}765$ cal/mol

6. **(c)** Cs and F

There is a large electronegativity difference between the two elements Cs and F, thus forces of attraction will be strongest between them. Hence, they react violently.

7. **(c)** Hydroboration reaction first gives R_3B and then with CH_3COOH, it gives *cis*-alkene



8. **(a)**
- Lead in water can cause kidney damage.
- Freon is responsible for depletion of the ozone layer in the upper stratosphere of the atmosphere.
- Fishes do not grow in warm as well as in cold water.

9. **(c)** There will be a depression in the freezing point by the addition of glucose in water.

The degree of dissociation (α) increases as concentration decreases.

$$\Delta_{\text{sol}} H = \underset{(-\text{ve})}{\Delta_{\text{lattice}} H} + \underset{(-\text{ve})}{\Delta_{\text{hyd}} H}$$

10. **(d)**

$$\text{NO} \longrightarrow \text{NO}^+ + e^-$$

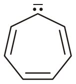
$$\underset{\substack{3d^6 \\ \text{4 unpaired} \\ \text{electrons}}}{\text{Fe}^{2+}} + e^- \longrightarrow \underset{\substack{3d^7 \\ \text{3 unpaired} \\ \text{electrons}}}{\text{Fe}^+}$$

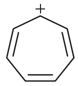
Magnetic moment, μ for $\text{Fe}^+ = \sqrt{n(n+2)}$ BM

$$= \sqrt{3 \times 5}\ \text{BM}$$

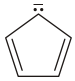
$$= 3.87\ \text{BM}$$

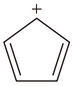
11. **(b)** For an organic compound to be aromatic, it should be planar and contains $(4n + 2)$ π-electrons (Huckel's rule).

I.  ; 8π-electrons; Antiaromatic

II.  ;

Tropylium cation is planar and has 6π -electrons according to Huckel's rule, hence, it is an aromatic compound.

III.  ; 6π-electrons; Planar; Aromatic

IV.  ; 4 π-electrons, Antiaromatic

12. **(c)** For precipitation,

Ionic product > solubility product (K_{sp})

For Ag_2CrO_4,

Ionic product (IP) $= [\text{Ag}^+]^2[\text{CrO}_4^-] = (10^{-4})^2(10^{-5}) = 10^{-13}$

K_{sp} for $\text{Ag}_2\text{CrO}_4 = 4 \times 10^{-12}$

$$K_{\text{sp}} > \text{IP}$$

Thus, precipitation does not occur.

For AgCl, Ionic product $= [\text{Ag}^+][\text{Cl}^-] = [10^{-4}][10^{-5}] = 10^{-9}$

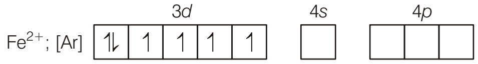
$$K_{\text{sp}}[\text{AgCl}] = 1 \times 10^{10}$$

$$\text{IP} > K_{\text{sp}}$$

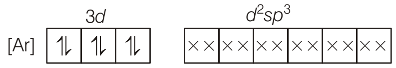
So, percipition occurs

Thus, silver chloride gets precipitated first.

13. **(a)**

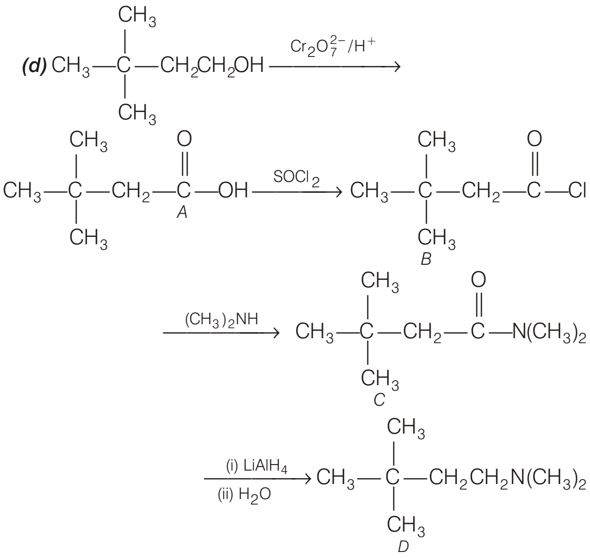


Fe^{2+} in $\text{K}_4[\text{Fe(CN)}_5\text{O}_2]$;



Complex is paramagnetic due to the presence of unpaired electron of O_2^-, i.e. superoxide ion acting as *a* ligand.

14. **(d)**



15. **(c)** Gas *B* turns the colour of acidified $K_2Cr_2O_7$ green thus it is SO_2. SO_2 is obtained alongwith yellow precipitate when thiosulphate is treated with dilute acid. Thus, *A*, *B* and *C* are $Na_2S_2O_3$, SO_2 and $Cr_2(S_2O_4)_3$ respectively.

Reactions involved

$$Na_2S_2O_3 + HCl \longrightarrow \underset{\substack{\text{Suffocating}\\ \text{gas }(B)}}{SO_2} + NaCl + H_2O + \underset{\text{Yellow}}{S}$$

$$K_2Cr_2O_7 + SO_2 + H_2SO_4 \longrightarrow K_2SO_4 + \underset{\text{Green}}{Cr_2(SO_4)_3}$$

16. **(b)** In CrO_4^{2-}, Cr is in + 6 oxidation state and has d^0 configuration. The colour is due to charge transfer and not due to *d*-*d* transition.

17. **(c)** The rate of Diels-Alder reaction increases, when dienophiles have electron-withdrawing groups and dienes have electron -donating group.

Thus, the correct order is IV > III > II > I.

18. **(b)** Isoelectronic means same number of electrons and isostructural means same structure.

$NO_3^- = 7 + 8 \times 3 + 1 = 32$, $CO_3^- = 6 + 8 \times 3 + 2 = 32$

(a) In $CaCl_2$, Ca—Cl bonds are electrovalent bonds

(c) Correct

(d) Peroxide ion is O_2^{2-}

$$O_2^{2-} = \sigma 1s^2, \overset{*}{\sigma} 1s^2, \sigma 2s^2, \overset{*}{\sigma} 2s^2, \sigma 2p_z^2, \pi 2p_x^2 \approx \pi 2p_y^2, \overset{*}{\pi} 2p_x^2 \approx \overset{*}{\pi} 2p_y^2$$

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

19. **(c)** Ag(I) ion collects as solid AgCl on the electrode itself. However, there is some Ag^+ in equilibrium with AgCl(*s*) in solution.

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$$

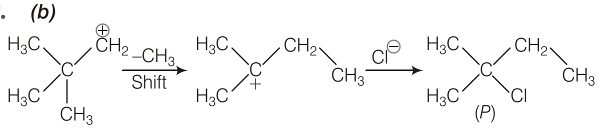
$$\therefore \quad K_{sp} = [Ag^+][Cl^-]$$

$$[Ag^+] = \frac{K_{sp}}{[Cl^-]} = \frac{1 \times 10^{-10}}{1} = 10^{-10}\ M$$

$$Ag^+ + e^- \longrightarrow Ag$$

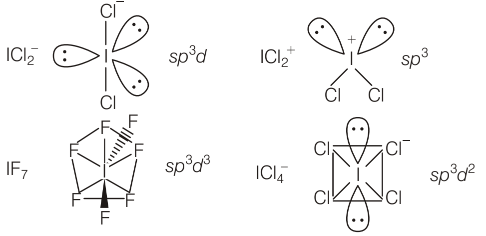
$$E = E^\circ - \frac{0.0591}{n} \log \frac{1}{10^{-10}} = 0.799 - 0.591 = 0.208\ V$$

20. **(b)**

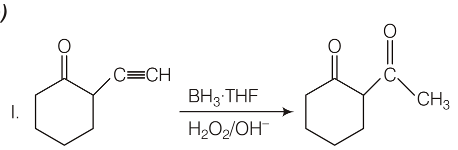


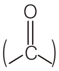
The formation of *Q* does not involve carbocation formation and rearrangement. So the product *Q* is $(H_3C)_3CCH_2Cl$.

21. **(d)**



22. **(b)**





$(\overset{O}{\overset{\|}{-C-}})$ is an electron withdrawing group, thus electron migration is takes place.

$—C{\equiv}CH$, hydroboration-oxidation addition of H_2O is against normal addition.

II. By Li/NH_3, *trans*-addition is occurred.

23. **(a)** $\bar{u} = \sqrt{\frac{8RT}{\pi M}}$, $\bar{u} \propto \sqrt{\frac{T}{M}}$

(a) $\bar{u} \propto \sqrt{\frac{140}{4}} = \sqrt{35}$ (b) $\bar{u} \propto \sqrt{\frac{440}{44}} = \sqrt{10}$

(c) $\bar{u} \propto \sqrt{\frac{500}{20}} = \sqrt{25}$ (d) $\bar{u} \propto \sqrt{\frac{560}{28}} = \sqrt{20}$

24. **(b)**

	$2SO_3 \rightleftharpoons$	$2SO_2$	$+ O_2$
Initially	1	0	0
At equilibrium	$1 - 2x$	$2x$	x

$\therefore$ $2x = 0.6$ $\therefore x = 0.3$

$[SO_3] = 1 - 2x = 1 - 0.6 = 0.4$

$[SO_2] = 2x = 0.6$

$[O_2] = x = 0.3$

$$K = \frac{x \times (2x)^2}{(1 - 2x)^2} = \frac{0.3 \times 0.6 \times 0.6}{0.4 \times 0.4} = 0.675\ \text{mol L}^{-1}$$

25. **(b)** In chemisorption, adsorption first increases and then decreases.

26. **(b)** $$2K\overset{+7}{Mn}O_4 + 3H_2SO_4 + 5H_2O_2 \longrightarrow K_2SO_4 + 2\overset{2+}{Mn}SO_4 + 8H_2O + SO_2$$

$\therefore$ H_2O_2 acts as a reducing agent. It reduces $K\overset{+7}{Mn}O_4$ to Mn^{2+} ion.

27. **(b)** Electron donating group (EDG) favours S_N1 reactivity with HBr.

Electron withdrawing group (EWG) retards S_N1 reactivity with HBr.

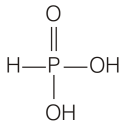
ED effect of ($—OCH_3$) group ($+R, -I$) is greater than ($—CH_3$) group ($+I$ and hyperconjugation). So, reactivity of III > II.

In IV, ($—OCH_3$) group is at *m*-position and exerts only $-I$-effect, hence, reactivity of (IV) is less than (I).

∴ The correct decreasing order is, III > II > I > IV.

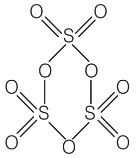
28. **(a)** H_3PO_3 is a dibasic reducing acid.

Its structure is given as,



$$H—\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle OH}{|}}{P}}—OH$$

(b) The structure of S_3O_9 is



No, S—S linkage is present in S_3O_9.

(c) Rate of diffusion, $r = \frac{V}{t} \propto \frac{1}{\sqrt{M}}$

(d) $PbO_2 + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O + O_2$

29. **(a)** $FeSO_4 : Fe^{2+} + 2e^- \longrightarrow Fe;\ 1\ F = \frac{1}{2}$ mol of Fe

$Fe(NO_3)_3 :\ Fe^{3+} + 3e^- \longrightarrow Fe;\ 1\ F = \frac{1}{3}$ mol of Fe

$Fe_2(SO_3)_3 : Fe^{3+} + 3e^- \longrightarrow Fe;\ 1\ F = \frac{1}{3}$ mol of Fe

Amount of Fe deposited in cell containing $Fe(NO_3)_3$ = Amount of Fe deposited in cell containing $Fe_2(SO_4)_3$

Amount of Fe deposited in cell containing $Fe_2(SO_4)_3$

$$= \frac{1}{2} : \frac{1}{3} = 1.5 : 1$$

At anode : $\quad 4\overset{-}{O}H \longrightarrow O_2 + 2H_2O + 4e^-$

In all cases same amount of gas is evolved at the anode.

30. **(b)**

$$\begin{array}{llll} & C_2H_4O(g) & \longrightarrow CH_4(g) & + CO(g) \\ \text{At } t = 0 & p_0 & 0 & 0 \\ \text{At } t = t & p_0 - x & x & x \end{array}$$

Total pressure at time *t*

$$(p_t) = p_0 - x + x + x = p_0 + x$$

$$p_0 = 80\text{ mm},\ p_0 + x = 120\text{ mm}$$

$$\therefore \quad x = 120 - 80 = 40\text{ mm}$$

$$k = \frac{2.303}{20}\log\frac{p_0}{p_0 - x}$$

$$= \frac{2.303}{20}\log\frac{80}{80 - 40}$$

$$= \frac{2.3 \times 0.3}{20}$$

$$t_{1/2} = \frac{0.69}{k} = \frac{0.69 \times 20}{0.69}$$

$$= 20\text{ min}$$

31. **(d)** Insulin maintains the blood level in glucose. It controls the processes of burning of fats, proteins and carbohydrates.

32. **(a)** $\quad MCO_3 \longrightarrow MO + CO_2\uparrow$

$$M'CO_3 \longrightarrow M'O + CO_2\uparrow$$

Equivalent of CO_2 = Equivalent of carbonates of metals

$$1\text{ mol of }CO_2 = 1\text{ mol of }CO_3^{2-}$$

$$44\text{ g of }CO_2 = 60\text{ g of }CO_3^{2-}$$

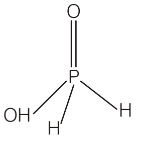
$$1.1\text{ g of }CO_2 = \frac{60}{44} \times 1.1 = 1.5\text{ g of }CO_3^{2-}$$

$$\%\text{ of }CO_3^{2-} = \frac{1.5 \times 100}{3} = 50\%$$

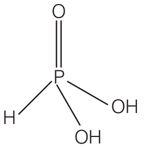
% of one metal = 15%

% of another metal = 100 − (50 + 15) = 35%

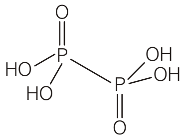
33. **(a)**



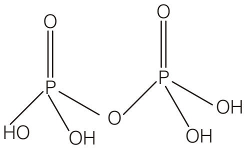
Hypophosphorous acid
(H_3PO_2)
Basicity=1



Phosphorus acid
(H_3PO_3)
Basicity=2



Hypophosphoric acid
($H_4P_2O_6$)
Basicity=4



Pyrophosphoric acid
($H_4P_2O_7$)
Basicity=4

34. **(b)** Density, $d = \frac{Z \times M_w}{a^3 \times 10^{-3} \times N_A}$

$$M_w = \frac{d \times a^3 \times 10^{-30} \times N_A}{Z}\ [\text{For fcc, } Z = 4/\text{unit cell}]$$

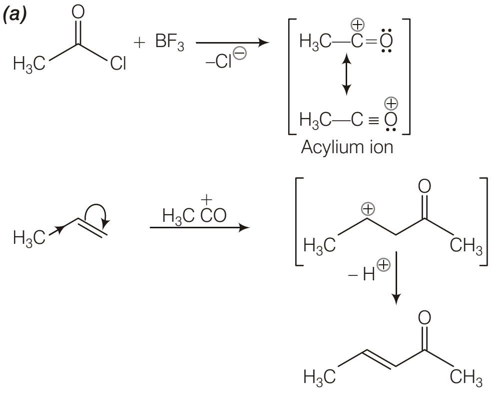
$$= \frac{10\text{ g cm}^{-3} \times (200)^3 \times 10^{-30}\text{ cm}^3 \times 6 \times 10^{23}\text{ atoms}}{4}$$

$$= 12\text{ g mol}^{-1}$$

Thus, 12 g mol^{-1} contains, N_A atoms = 6×10^{23} atoms

∴ 100 g will contain = $\frac{6 \times 10^{23}}{12} \times 100 = 5 \times 10^{24}$ atoms

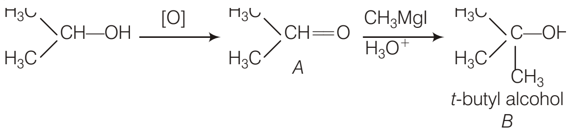
35. **(a)**

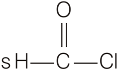


36. **(a)** Option (a) is correct .

37. ***(b)*** In AgI crystal, number of Ag^+ ions is equal to I^- ions. However, the number of tetrahedral voids are twice than the number of atoms forming the cubic lattice. Therefore, number of tetrahedral voids occupied by Ag^+ ion = 50%.

38. ***(d)***



39. ***(c)*** Statements (a), (b) and (d) are correct, but statement (c) is incorrect, although $HCOOH + PCl_5$ gives  $H—\overset{\overset{\displaystyle O}{\|}}{C}—Cl$ (formyl chloride) but it is unstable and does not exist.

40. ***(d)*** $:\overset{\ominus}{N}═C═\overset{\ominus}{N}:$, $O═C═O$

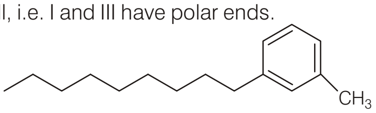
Thus, CN_2^{2-} and CO_2 both are isoelectronic and isostructural.

$$Mg_2C_3 + 3H_2O \longrightarrow \underset{\text{Propyne}}{CH_3—C \equiv CH} + Mg(OH)_2$$

$Ca^{2+}C_2^{2-}$ has NaCl type lattice.

41. ***(b)*** **Correct explanation** Nylon-6,6 is a fiber and has hydrogen bonding as intermolecular force. Buna-S is an elastomer and has weak van der Waals' force. Polythene is thermoplastic and has intermediate forces (i.e. stronger than elastomer but weaker than fiber). Thus, the given order of intermolecular force is correct.

42. ***(d)*** Benzene is non-polar, covalent organic compound. As we know that like dissolves like, i.e. polar compound is soluble in polar medium and non-polar is soluble in non-polar medium. Among the given compounds *meta*-methylnonyl benzene is the only non-polar compound, hence it is soluble in benzene. Rest all, i.e. I and III have polar ends.



43. ***(b)*** **Correct explanation** Aniline hydrogen sulphate on heating decomposes to aniline and H_2SO_4. Sulphonation of aniline with H_2SO_4 takes place (SE reaction) at *o*-and *p*-positions, since $—NH_2$ group is *o*-and *p*-directing.

44. ***(d)*** Both Assertion and reason are false.
The O—O bond length is shorter in O_2F_2 than in H_2O_2 due to higher electronegativity of F-atom. H_2O_2 is a covalent compound.

45. ***(d)*** **Correct Assertion** *tert*-butyl methyl ether on treatment with HI at 373 K gives *tert*-butyl iodide and methyl alcohol.
Correct Reason The reaction occurs *via* S_N1 mechanism.

46. ***(c)*** Assertion is true but Reason is false.
Correct Reason During thunderstorm, there is the formation of NO which changes to NO_2 and ultimately to HNO_3 (acid-rain).

$$N_2 + O_2 \longrightarrow NO \xrightarrow{O_2} NO_2 \longrightarrow N_2O_5 \xrightarrow{H_2O} \underset{(pH<7)}{HNO_3}$$

47. ***(a)*** (I) is more stable than (II) as (I) shows more hyperconjugative structures than (II).

48. ***(c)*** The correct reason is that the lone pair of electron on the N-atom is strongly attracted by the three strongly electronegative F-atoms. As a result, not available for donation and hence NF_3 is a weak ligand.

49. ***(c)*** **Correct Reason** Cl_2 has higher reduction potential than H_2O, but has lower discharge potential on account of over potential of O_2. As a reference,

(i) $Cl^-(aq) \longrightarrow \frac{1}{2} Cl_2(g) + e^-; E^-_{red} = 1.36$ V

or $E^-_{oxide} = -1.36$ V

(ii) $2H_2O(l) \longrightarrow 4H^{\oplus}(aq) + 4e^- + O_2(g)$

$E^-_{red} = 1.23$ V or $E^-_{oxi} = -1.23$ V

50. ***(d)*** The correct order of decreasing bond angle is

$$NH_4^+ > NH_3 > NH_2^-$$

This is because all of them involves sp^3 hybridisation. The number of lone pair of electron present on N-atoms of NH_4^+, NH_3 and NH_2^- are 0, 1 and 2 respectively. Greater the number of lone pairs, greater will be the repulsion on the bond pairs and hence, smaller is the bond angle.

51. ***(d)*** Number of molecules is independent of pressure, and mole number is independent of volume.

52. ***(c)*** *K* depends only upon temperature.

53. ***(c)*** Hardness of water is due to carbonate or sulphate of Ca^{2+} and Mg^{2+} ions. When sodium aluminium silicate is added to the hard water. Na^+ replaces Ca^{2+} and Mg^{2+} by adsorption and hence, water becomes soft.

54. ***(b)*** Like starch, glycogen is also a condensation polymer of α-D-glucose. It is hydrolysed by the enzyme β-amylase to form maltose. Glycogen is also called animal starch because its structure is similar to that of amylopectin. One main difference between glycogen and amylopectin is that amylopectein chains consist of about 20-25 glucose units but glycogen chains are much shorted i.e. they consist of about 10-14 glucose units.

55. ***(c)*** Electrical conductance $\propto \frac{1}{\text{size of hydrated cation}}$

Hydration energy $\propto \frac{1}{\text{size}}$

As we move from Li to Cs, size of alkali metals increases and thus, hydration energy increases. Thus, lithium ion being smallest in size among alkali metals, is most extensively hydrated and becomes largest in size. Thus, it has least electrical conductivity among alkali metals.

56. ***(b)*** Due to electron withdrawing effect of carbonyl group of aldehyde, electron density of benzene ring decreases and electron density on carbonyl group increases. Hence, carbonyl carbon of benzaldehyde is less reactive towards nucleophilic attack.

57. ***(a)*** Zn, Cd and Hg are *d*-block elements but not regarded as transition elements because these element do not have partially filled *d*-orbitals in their most common oxidation states.

58. ***(b)*** In case of solutions showing negative deviation, the forces of interaction between the components are stronger than those in the pure components.

59. ***(a)*** Carbon is usually used for the reduction of ores and if sulphide ores are used, it will form carbon disulphide which is difficult to get rid off. Therefore, sulphide ores are first roasted to get metal oxides which are then reduced by carbon to give metal and CO_2 escapes easily into the air.

60. ***(b)*** Both expression are true for an ideal gas.

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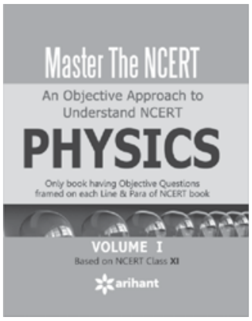

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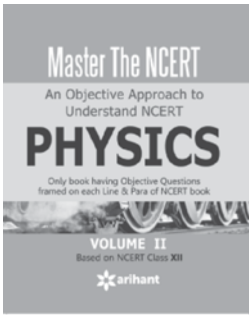

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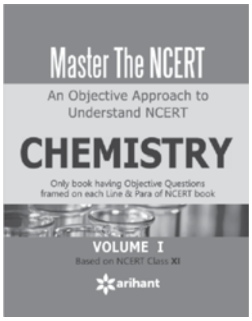

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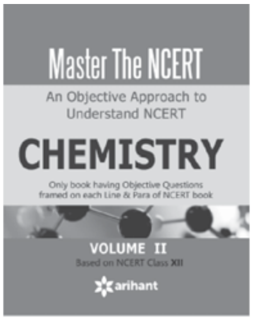

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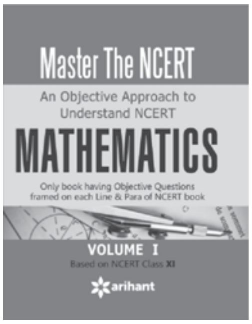

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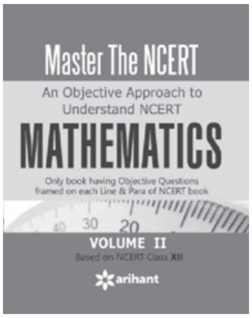

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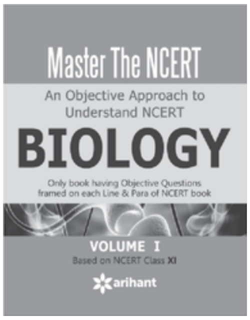

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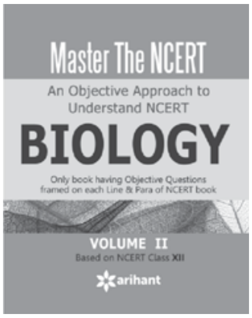

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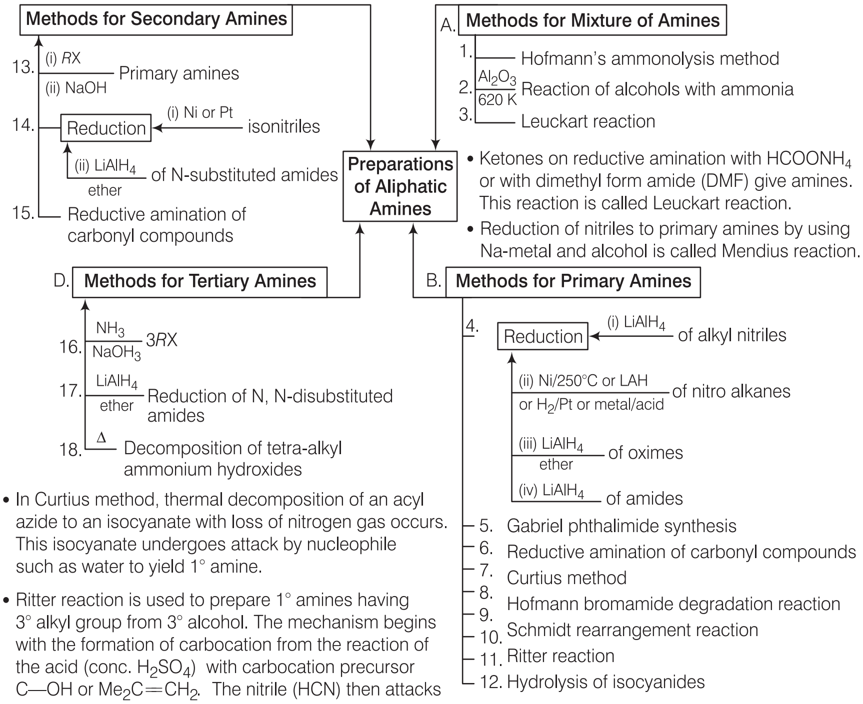
Revisi
CONCE
AMI

- Amines are the compounds that contain a basic nitrogen atom with a lone pair of electrons. These are derivatives of ammonia in which one or more hydrogen atoms have been replaced by a substituent such as an alkyl or an aryl group.
- Aliphatic and aromatic amines are alkyl and aryl derivatives of ammonia, respectively in which one or more hydrogen atoms of ammonia have been replaced by alkyl and aryl groups, respectively.

ALIPHATIC AMINES



Preparations of Aliphatic Amines

A. Methods for Mixture of Amines

1. Hofmann's ammonolysis method
2. $\xrightarrow[620\text{ K}]{Al_2O_3}$ Reaction of alcohols with ammonia
3. Leuckart reaction

- Ketones on reductive amination with $HCOONH_4$ or with dimethyl form amide (DMF) give amines. This reaction is called Leuckart reaction.
- Reduction of nitriles to primary amines by using Na-metal and alcohol is called Mendius reaction.

B. Methods for Primary Amines

4. Reduction
   - $\xleftarrow{\text{(i) } LiAlH_4}$ of alkyl nitriles
   - $\xrightarrow[\text{or } H_2/Pt \text{ or metal/acid}]{\text{(ii) Ni/250°C or LAH}}$ of nitro alkanes
   - $\xrightarrow[\text{ether}]{\text{(iii) } LiAlH_4}$ of oximes
   - $\xrightarrow{\text{(iv) } LiAlH_4}$ of amides
5. Gabriel phthalimide synthesis
6. Reductive amination of carbonyl compounds
7. Curtius method
8. Hofmann bromamide degradation reaction
9. Schmidt rearrangement reaction
10. Ritter reaction
11. Hydrolysis of isocyanides
12.

Methods for Secondary Amines

13. $\xrightarrow[\text{(ii) NaOH}]{\text{(i) } RX}$ Primary amines
14. Reduction $\xleftarrow{\text{(i) Ni or Pt}}$ isonitriles; $\xrightarrow[\text{ether}]{\text{(ii) } LiAlH_4}$ of N-substituted amides
15. Reductive amination of carbonyl compounds

D. Methods for Tertiary Amines

16. $\xrightarrow[NaOH_3]{NH_3}$ $3RX$
17. $\xrightarrow[\text{ether}]{LiAlH_4}$ Reduction of N, N-disubstituted amides
18. $\xrightarrow{\Delta}$ Decomposition of tetra-alkyl ammonium hydroxides

- In Curtius method, thermal decomposition of an acyl azide to an isocyanate with loss of nitrogen gas occurs. This isocyanate undergoes attack by nucleophile such as water to yield 1° amine.
- Ritter reaction is used to prepare 1° amines having 3° alkyl group from 3° alcohol. The mechanism begins with the formation of carbocation from the reaction of the acid (conc. H_2SO_4) with carbocation precursor C—OH or $Me_2C{=}CH_2$. The nitrile (HCN) then attacks the carbocation to form a nitrilium ion. On hydrolysis and a series of proton transfer steps, amide product is obtained.

REACTION 1

In this method alkyl halide is heated with alcoholic solution of ammonia in a sealed tube at about 393 K and a mixture of amines is obtained. If excess of ammonia is used, primary amine is obtained as the main product.

REACTION 5

This reaction begins with the deprotonation of the phthalimide which attacks at alkyl halide in an S_N2 fashion followed by either alkaline hydrolysis or hydrazinolysis with hydrazine, produces the corresponding 1° amine.

REACTION 8

In this reaction, amides on reaction with Br_2 in an aqueous or ethanolic solution of NaOH give 1° amine having one carbon atom less than the corresponding amide.

REACTION 9

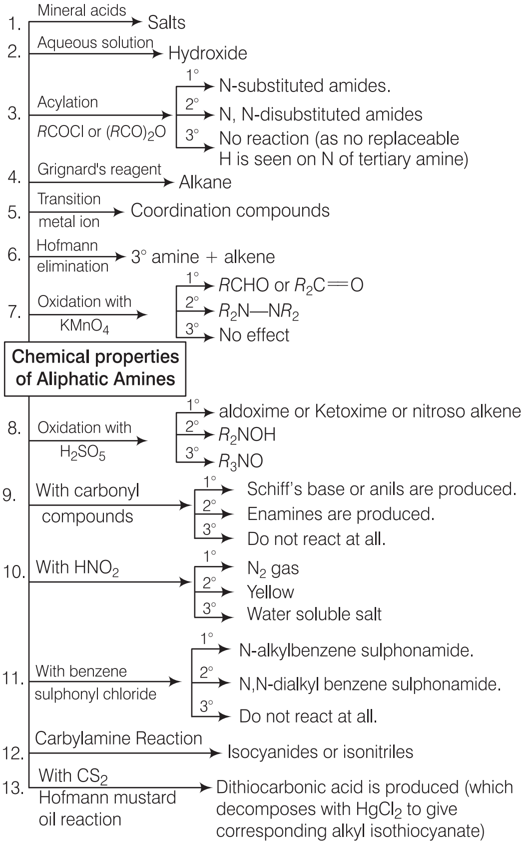
Carboxylic acid when warmed with hydrazoic acid (N_3H) in the presence of concentrated sulphuric acid, gives a high yield of 1° amines.

REACTION 10

Hydroxamic acid on reaction with a base followed by hydrolysis gives 1° amine.

REACTION 15

A mixture of carbonyl compound, hydrogen and 1° amine when passed over Ni catalyst at high temperature, 2°-amine is obtained.

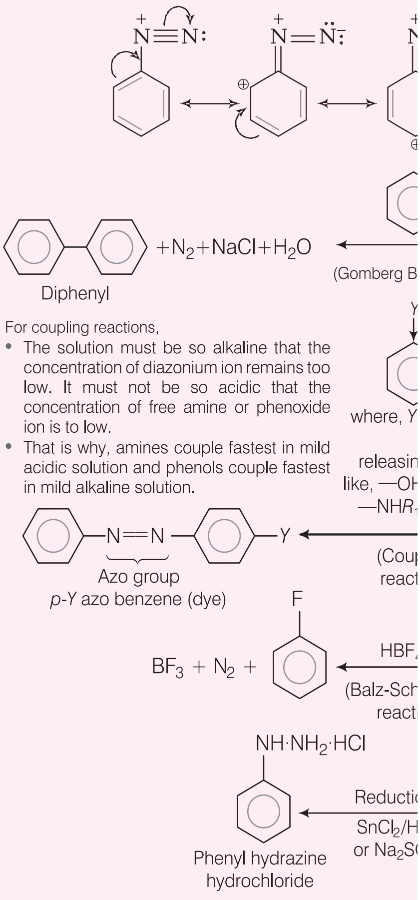


Chemical properties of Aliphatic Amines

1. $\xrightarrow{\text{Mineral acids}}$ Salts
2. $\xrightarrow{\text{Aqueous solution}}$ Hydroxide
3. $\xrightarrow[RCOCl \text{ or } (RCO)_2O]{\text{Acylation}}$
   - 1° N-substituted amides.
   - 2° N, N-disubstituted amides
   - 3° No reaction (as no replaceable H is seen on N of tertiary amine)
4. $\xrightarrow{\text{Grignard's reagent}}$ Alkane
5. $\xrightarrow[\text{metal ion}]{\text{Transition}}$ Coordination compounds
6. $\xrightarrow[\text{elimination}]{\text{Hofmann}}$ 3° amine + alkene
7. $\xrightarrow[KMnO_4]{\text{Oxidation with}}$
   - 1° $RCHO$ or $R_2C{=}O$
   - 2° $R_2N{-}NR_2$
   - 3° No effect
8. $\xrightarrow[H_2SO_5]{\text{Oxidation with}}$
   - 1° aldoxime or Ketoxime or nitroso alkene
   - 2° R_2NOH
   - 3° R_3NO
9. $\xrightarrow{\text{With carbonyl compounds}}$
   - 1° Schiff's base or anils are produced.
   - 2° Enamines are produced.
   - 3° Do not react at all.
10. $\xrightarrow{\text{With } HNO_2}$
    - 1° N_2 gas
    - 2° Yellow
    - 3° Water soluble salt
11. $\xrightarrow{\text{With benzene sulphonyl chloride}}$
    - 1° N-alkylbenzene sulphonamide.
    - 2° N,N-dialkyl benzene sulphonamide.
    - 3° Do not react at all.
12. $\xrightarrow{\text{Carbylamine Reaction}}$ Isocyanides or isonitriles
13. $\xrightarrow{\text{With } CS_2}$ Dithiocarbonic acid is produced (which decomposes with $HgCl_2$ to give corresponding alkyl isothiocyanate)
    Hofmann mustard oil reaction

BENZENE DIAZONIUM SALT Ar— $N{\equiv}\overset{\oplus}{N}\,\overset{-}{X}$

All benzene diazonium salts contain benzene diazoni



For coupling reactions,

- The solution must be so alkaline that the concentration of diazonium ion remains too low. It must not be so acidic that the concentration of free amine or phenoxide ion is to low.
- That is why, amines couple fastest in mild acidic solution and phenols couple fastest in mild alkaline solution.

In Balz-Schiemann reaction, a fluorine atom is introduced into aromatic rings through the thermal decomposition of diazonium tetrafluoroboarate by diazotisation of the corresponding aromatic amine.

PHYSICAL PROPERTIES OF ALIPHATIC AMINES

- Aliphatic amines with one or two carbon-atoms are gases with fishy odour.
- 1° amines with three or more carbon atoms are liquid and soluble in water due to the presence of intermolecular hydrogen bonding.
- They possess different orders of basic strength in gaseous and aqueous phase due to steric hindrance and solvation effect.

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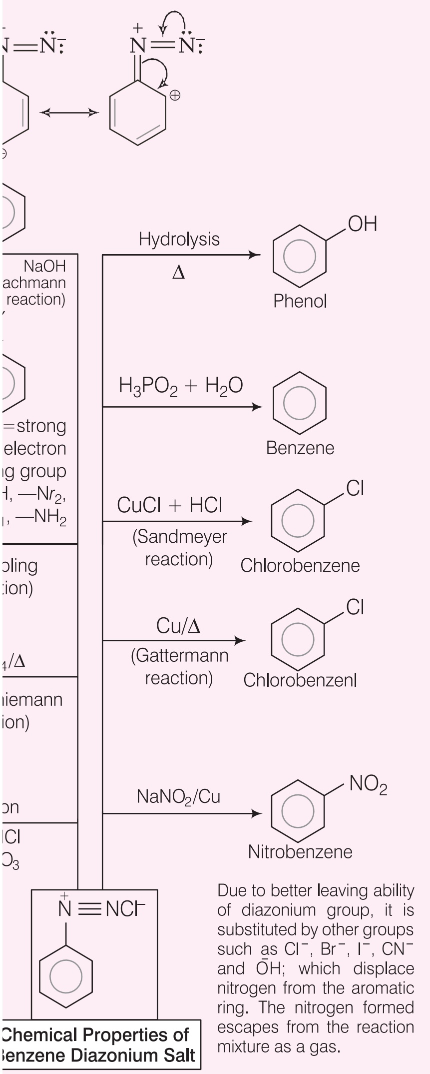
NES

ium ion, which is stabilised by resonance as

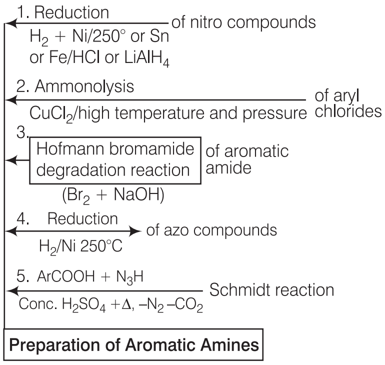


Due to better leaving ability of diazonium group, it is substituted by other groups such as Cl⁻, Br⁻, I⁻, CN⁻ and OH; which displace nitrogen from the aromatic ring. The nitrogen formed escapes from the reaction mixture as a gas.

PHYSICAL PROPERTIES OF AROMATIC AMINES

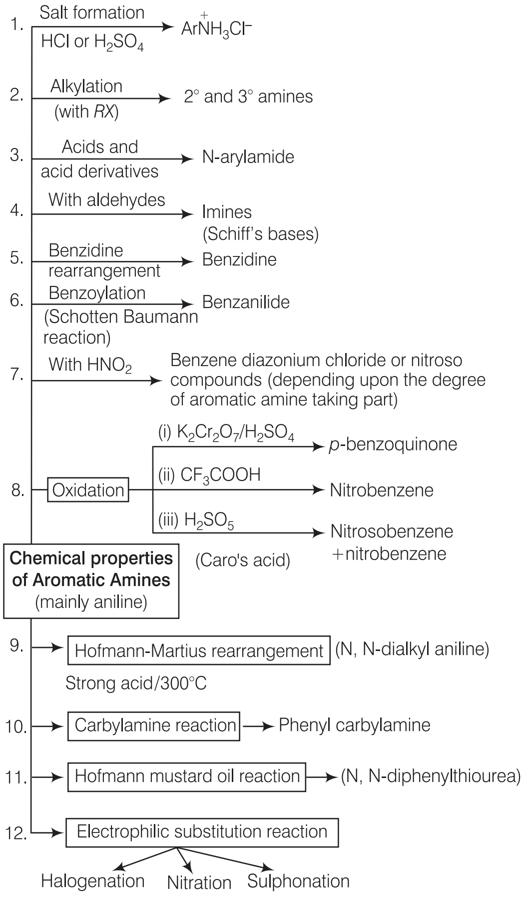
- These are colourless liquids or solids having characteristic odour. They turn brown in air due to oxidation
- They are soluble in water due to intermolecular hydrogen bonding. They are less basic than the corresponding aliphatic amines due to electron withdrawing nature of benzene ring and the basicity decreases as the number of benzene ring directly attached to N-atom increases.

AROMATIC AMIN



REACTION 6

This reaction is used to convert an acyl halide or anhydride to an amide by reacting with an amine and base.



REACTION 9

In this reaction, N-alkylated aniline rearranges into the corresponding *ortho* and/or *para* aryl alkylated aniline. This reaction requires heat and the catalyst (hydrochloric acid).

REACTION 11

1° aromatic amines, like aniline when heated with ethanolic solution of CS_2 and solid KOH, give N, N′-diphenylthiourea which reacts with conc.HCl to give phenylthiocyanate (having a smell of mustard oil).

REACTION 12

NH_2 is an *ortho/para* directing group and activates the ring strongly so that the substitution takes place readily even under mild conditions.

- On halogenation, in aqueous medium, aniline gives 2, 4, 6-tribromoaniline (light yellow ppt.).
- However, in order to prepare monohalo aniline derivative, the $-NH_2$ group of aniline is first protected by reacting it with acetyl chloride or acetic anhydride and after that it is subjected to halogenation.
- On nitration, aniline gets converted into black tarry mass and a nitro product is obtained in very poor yield. However, in the presence of strongly acidic medium, aniline gets converted into anilinium ion which being electron deficient, deactivates the *o*/*p*-position and thus, a *meta*-nitro derivative is obtained.
- To obtain *o*/*p* products, first aniline is deactivated by treating it with acetic anhydride (or acetyl chloride) and then subjected to nitration.
- Aniline when subjected to sulphonation form anilinium hydrogen sulphate, a salt, which on heating at 453-473 K gives *p*-aminobenzene sulphonic acid.

METHOD OF PREPARATION

When 1° aromatic amine reacts with sodium nitrite and mineral acid (HCl) at lower temperature ($0-5°C$); forms diazonium salts. This reaction is called diazotisation.

Note Alcohol is formed when temperature of diazotisation process becomes high.

PHYSICAL PROPERTIES

- These are colourless crystalline solids but get colour when exposed to air
- They are water soluble due to their ionic nature.
- In aqueous solution, these are good conductor of electricity.

USES OF AMINES

- These are the important constituents of proteins, enzymes and many harmones.
- Lower member of the aliphatic amines suchas ethylamine, diethylamine etc., are used as reagents in the synthesis of organic compounds and also as solvents in labouratory and industry.
- Quaternary ammonium salts derived from long chain tertiary amines are used as detergents.
- Aniline and other aromatic amines are used in the manufacture of dyes and drugs.
- Aniline is used to synthesise diazonium salts which have synthetic importance.

BASIC CHARACTER OF AMINES

- Due to +*I*-effect of alkyl groups lone pair of nitrogen, will become more available for protonation and results in increased basicity.
- Greater the number of methyl groups, more will be the steric effect, lesser will be basic strength.
- Greater the solvation of cation, more will be the tendency of amine to change into cation by releasing the electron pair on nitrogen-atom. Thus, more will be the basic strength of amine.
- In case of aniline, the lone pair of electrons of nitrogen, is delocalised into benzene ring by resonance. As a result of resonance the lone pair is less available for protonation. Therefore, aniline and other aromatic amines are less basic than aliphatic and aryl alkyl amine.
- The basicity of *o*-substituted anilines, is generally lower as compare to aniline. This is due to *ortho*-effect in which the substituent at the *ortho*-position hinders the attack of the acid on the amino group.
- More tha *s*-character of the hybrid orbital containing lone pair of electrons, lesser is the basic character.

JEE MAIN SOLVED PAPER 2016

EXAM CRUX

In chemistry, there are total 30 Questions asked in JEE Main (online) 2016 paper. Out of which 8 are numericals, while 22 questions are theory based. Overall paper was tricky and easy to solve.

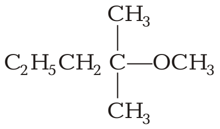
According to chapterwise distribution number of questions were asked as–

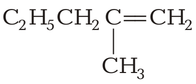
- **From Class XI** Some Basic Principles of Organic Chemistry3-Qs, Hydrocarbons-2Qs, *s*-block Elements-2Qs, Atomic Structure-2Qs, States of Matter-1Q, Thermodynamics, Equilibrium, Hydrogen and Chemical bonding-1Q from each.
- **From Class XII** Metallurgy-3Qs, Chemistry in Everyday life-2Qs, *p*-block Elements-2Qs, Solutions, Solid State, Chemical Kinetics, Surface Chemistry, Coordination Compounds, Alcohols, Phenols and Ethers, Amines-1Q from each.
- **Difficulty Level** Around 40% of questions can be considered as easy, 30% are relatively tough and 30% are considered to be tough by Arihant team. This year paper was little tough as compare to the previous year paper.

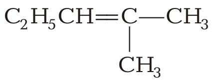
1. A stream of electrons from a heated filament was passed between two charged plates kept at a potential difference V esu. If e and m are charge and mass of an electron, respectively, then the value of h/λ (where, λ is wavelength associated with electron wave) is given by

(a) 2 meV *(b)* $\sqrt{\text{meV}}$ *(c)* $\sqrt{2\,\text{meV}}$ *(d)* meV

2. 2-chloro-2-methylpentane on reaction with sodium methoxide in methanol yields

I. 
$C_2H_5CH_2\overset{CH_3}{\underset{CH_3}{C}}-OCH_3$

II. 
$C_2H_5CH_2\underset{CH_3}{C}=CH_2$

III. 
$C_2H_5CH=\underset{CH_3}{C}-CH_3$

(a) Both I and III *(b)* Only III *(c)* Both I and II *(d)* All of these

3. Which of the following compounds is metallic and ferromagnetic?

(a) CrO_2 *(b)* VO_2 *(c)* MnO_2 *(d)* TiO_2

4. Which of the following statements about low density polythene is false?

(a) It is a poor conductor of electricity
(b) Its synthesis required dioxygen or a peroxide initiator as a catalyst
(c) It is used in the manufacture of buckets, dustbins etc
(d) Its synthesis requires high pressure

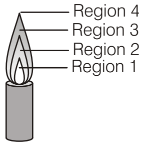
5. For a linear plot of $\log(x/m)$ *versus* $\log p$ in a Freundlich adsorption isotherm, which of the following statements is correct? (k and n are constants)

(a) $1/n$ appears as the intercept
(b) Only $1/n$ appears as the slope
(c) $\log\left(\frac{1}{n}\right)$ appears as the intercept
(d) Both k and $1/n$ appear in the slope term

6. The heats of combustion of carbon and carbon monoxide are -393.5 and -283.5 kJ mol^{-1}, respectively. The heat of formation (in kJ) of carbon monoxide per mole is

(a) 676.5 *(b)* –676.5 *(c)* –110.5 *(d)* 110.5

7. The hottest region of Bunsen flame shown in the figure given below is



(a) region 2
(b) region 3
(c) region 4
(d) region 1

8. Which of the following is an anionic detergent?

(a) Sodium lauryl sulphate
(b) Cetyltrimethyl ammonium bromide
(c) Glyceryl oleate
(d) Sodium stearate

9. 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g water. The vapour pressure of water (in torr) for this aqueous solution is

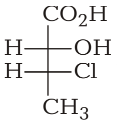
(a) 76.0 *(b)* 752.4 *(c)* 759.0 *(d)* 7.6

10. The distillation technique most suited for separating glycerol from spent lye in the soap industry is
(a) fractional distillation (b) steam distillation
(c) distillation under reduced pressure
(d) simple distillation

11. The species in which the N-atom is in a state of *sp* hybridisation is
(a) NO_2^- (b) NO_3^- (c) NO_2 (d) NO_2^+

12. Decomposition of H_2O_2 follows a first order reaction. In 50 min, the concentration of H_2O_2 decreases from 0.5 to 0.125 M in one such decomposition. When the concentration of H_2O_2 reaches 0.05 M, the rate of formation of O_2 will be
(a) 6.93×10^{-4} mol min^{-1} (b) 2.66 L min^{-1} at STP
(c) 1.34×10^{-2} mol min^{-1} (d) 6.93×10^{-2} mol min^{-1}

13. The pair having the same magnetic moment is [at. no. Cr = 24, Mn = 25, Fe = 26 and Co = 27]
(a) $[Cr(H_2O)_6]^{2+}$ and $[Fe(H_2O)_6]^{2+}$
(b) $[Mn(H_2O_6)]^{2+}$ and $[Cr(H_2O)_6]^{2+}$
(c) $[CoCl_4]^{2-}$ and $[Fe(H_2O)_6]^{2+}$
(d) $[Cr(H_2O)_6]^{2+}$ and $[CoCl_4]^{2-}$

14. The absolute configuration of  $\begin{array}{c} CO_2H \\ H-\!\!+\!\!-OH \\ H-\!\!+\!\!-Cl \\ CH_3 \end{array}$ is
(a) (2*S*, 3*R*) (b) (2*S*, 3*S*) (c) (2*R*, 3*R*) (d) (2*R*, 3*S*)

15. The equilibrium constant at 298 K for a reaction, $A + B \rightleftharpoons C + D$ is 100. If the initial concentrations of all the four species were 1 M each, then equilibrium concentration of D (in mol L^{-1}) will be
(a) 0.818 (b) 1.818 (c) 1.182 (d) 0.182

16. Which one of the following ores is best concentrated by froth floatation method?
(a) Siderite (b) Galena (c) Malachite (d) Magnetite

17. At 300 K and 1 atm, 15 mL of a gaseous hydrocarbon requires 375 mL air containing 20% O_2 by volume for complete combustion. After combustion, the gases occupy 330 mL. Assuming that the water formed is in liquid form and the volumes were measured at the same temperature and pressure, the formula of the hydrocarbon is
(a) C_3H_8 (b) C_4H_8 (c) C_4H_{10} (d) C_3H_6

18. The pair in which phosphorus atoms have a formal oxidation state of +3 is
(a) pyrophosphorous and hypophosphoric acids
(b) orthophosphorous and hypophosphoric acids
(c) pyrophosphorous and pyrophosphoric acids
(d) orthophosphorous and pyrophosphorous acids

19. Which one of the following complexes shows optical isomerism?
(a) *cis* $[Co(en)_2Cl_2]Cl$ (b) *trans* $[Co(en)_2Cl_2]Cl$
(c) $[Co(NH_3)_4Cl_2]Cl$ (d) $[Co(NH_3)_3Cl_3]$

20. The reaction of zinc with dilute and concentrated nitric acid, respectively, produces
(a) NO_2 and NO (b) NO and N_2O
(c) NO_2 and N_2O (d) N_2O and NO_2

21. Which one of the following statements about water is false?
(a) Water can act both as an acid and as a base
(b) There is extensive intramolecular hydrogen bonding in the condensed phase
(c) Ice formed by heavy water sinks in normal water
(d) Water is oxidised to oxygen during photosynthesis

22. The concentration of fluoride, lead, nitrate and iron in a water sample from an underground lake was found to be 1000 ppb, 40 ppb, 100 ppm and 0.2 ppm, respectively. This water is unsuitable for drinking due to high concentration of
(a) lead (b) nitrate (c) iron (d) fluoride

23. The main oxides formed on combustion of Li, Na and K in excess of air respectively are
(a) LiO_2, Na_2O_2 and K_2O (b) Li_2O_2, Na_2O_2 and KO_2
(c) Li_2O, Na_2O_2 and KO_2 (d) Li_2O , Na_2O and KO_2

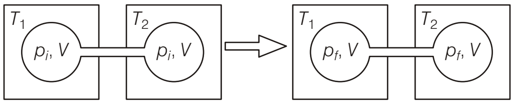
24. Thiol group is present in
(a) cystine (b) cysteine (c) methionine (d) cytosine

25. Galvanisation is applying a coating of
(a) Cr (b) Cu (c) Zn (d) Pb

26. Which of the following atoms has the highest first ionisation energy?
(a) Na (b) K (c) Sc (d) Rb

27. In the Hofmann-bromamide degradation reaction, the number of moles of NaOH and Br_2 used per mole of amine produced are
(a) four moles of NaOH and two moles of Br_2
(b) two moles of NaOH and two moles of Br_2
(c) four moles of NaOH and one mole of Br_2
(d) one mole of NaOH and one mole of Br_2

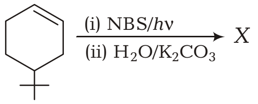
28. Two closed bulbs of equal volume (V) containing an ideal gas initially at pressure p_i and temperature T_1 are connected through a narrow tube of negligible volume as shown in the figure below. The temperature of one of the bulbs is then raised to T_2. The final pressure p_f is

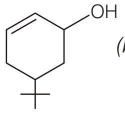


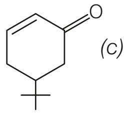
(a) $2p_i\left(\dfrac{T_1}{T_1 + T_2}\right)$ (b) $2p_i\left(\dfrac{T_2}{T_1+T_2}\right)$ (c) $2p_i\left(\dfrac{T_1T_2}{T_1+T_2}\right)$ (d) $p_i\left(\dfrac{T_1T_2}{T_1+T_2}\right)$

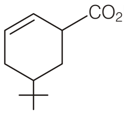
29. The reaction of propene with HOCl ($Cl_2 + H_2O$) proceeds through the intermediate
(a) $CH_3-\overset{+}{C}H-CH_2-Cl$ (b) $CH_3-CH(OH)-\overset{+}{C}H_2$
(c) $CH_3-CHCl-\overset{+}{C}H_2$ (d) $CH_3-\overset{+}{C}H-CH_2-OH$

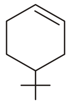
30. The product of the reaction given below is



(a) 

(b) 

(c) 

(b) 

Answers *with* Explanation

1. ***(c)* Plan** *As you can see in options, energy term is mentioned hence, we have to find out relation between* $\frac{h}{\lambda}$ *and energy. For this, we shall use de-Broglie wavelength and kinetic energy term in* eV.

de-Broglie wavelength for an electron $(\lambda) = \frac{h}{p}$

$$\Rightarrow \qquad p = \frac{h}{\lambda} \qquad \ldots\text{(i)}$$

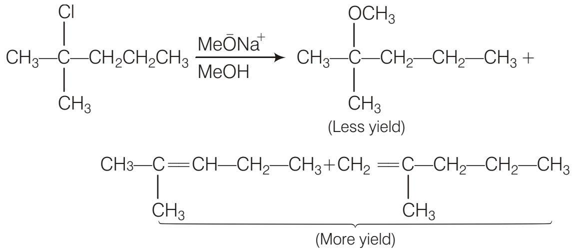
Kinetic energy of an electron = eV

As we know that, $\text{KE} = \frac{p^2}{2m}$

$$\therefore \qquad \text{eV} = \frac{p^2}{2m} \quad \text{or} \quad p = \sqrt{2m\text{eV}} \qquad \ldots\text{(ii)}$$

From equations (i) and (ii), we get $\frac{h}{\lambda} = \sqrt{2m\text{eV}}$

2. ***(d)* Key concept** **Strong nucleophile ($\bar{\text{O}}$Me) in polar solvent (MeOH) gives elimination products over substitution products but all products are possible in different yields.**



$$CH_3-\underset{CH_3}{\overset{Cl}{\underset{|}{\overset{|}{C}}}}-CH_2CH_2CH_3 \xrightarrow[\text{MeOH}]{\text{Me}\bar{\text{O}}\overset{+}{\text{Na}}} \underset{\text{(Less yield)}}{CH_3-\underset{CH_3}{\overset{OCH_3}{\underset{|}{\overset{|}{C}}}}-CH_2-CH_2-CH_3} +$$

$$\underbrace{CH_3-\underset{CH_3}{\underset{|}{C}}=CH-CH_2-CH_3+CH_2=\underset{CH_3}{\underset{|}{C}}-CH_2-CH_2-CH_3}_{\text{(More yield)}}$$

3. ***(a)*** Only three elements iron (Fe), cobalt (Co) and nickel (Ni) show ferromagnetism at room temperature. CrO_2 is also a metallic and ferromagnetic compound which is used to make magnetic tapes for cassette recorders.

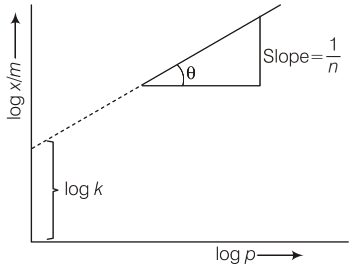
4. ***(c)*** High density polythene is used in the manufacture of buckets, dustbins etc.

5. ***(b)*** According to Freundlich adsorption isotherm, $\frac{x}{m} = kp^{1/n}$

On taking logarithm of both sides, we get

$$\log\frac{x}{m} = \log k + \log p^{1/n} \quad \text{or} \quad \log\frac{x}{m} = \log k + \frac{1}{n}\log p$$

$$y = c + mx$$



$y = \log\frac{x}{m}$, c = intercept = $\log k$, m = slope = $\frac{1}{n}$ and $x = \log p$

6. ***(c)*** $C(s) + O_2(g) \longrightarrow CO_2(g); \Delta H = -393.5 \text{ kJ mol}^{-1}$ ...(i)

$$CO + \frac{1}{2}O_2 \longrightarrow CO_2(g); \Delta H = -283.5 \text{ kJ mol}^{-1} \qquad \ldots\text{(ii)}$$

On subtracting Eq. (ii) from Eq. (i), we get

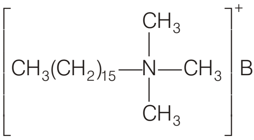
$$C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g);$$

$$\Delta H = (-393.5 + 283.5) \text{ kJ mol}^{-1} = -110 \text{ kJ mol}^{-1}$$

7. ***(a)*** Region 1 (Pre-heating zone)
Region 2 (Primary combustion zone, hottest zone)
Region 3 (Internal zone)
Region 4 (Secondary reaction zone)

8. ***(a)*** Sodium lauryl sulphate $[(CH_3(CH_2)_{10}CH_2OSO_3^-Na^+)]$ = Anionic detergent

Cetyltrimethyl ammonium bromide



$$\left[CH_3(CH_2)_{15}-\underset{CH_3}{\overset{CH_3}{\underset{|}{\overset{|}{N}}}}-CH_3\right]^+ Br^- = \text{Cationic detergent}$$

Glyceryl oleate $[(C_{17}H_{32}COO)_3C_3H_5]$ = Non-ionic detergent
Sodium stearate $[C_{17}H_{35}COO^-Na^+]$ = Anionic soap

9. ***(b)* Key concept** **Vapour pressure of water ($p°$) = 760 torr**

$$\text{Number of moles of glucose} = \frac{\text{Mass (g)}}{\text{Molecular mass (g mol}^{-1})}$$

$$= \frac{18 \text{ g}}{180 \text{ gmol}^{-1}} = 0.1 \text{ mol}$$

Number of moles of water = (1 − 0.1) mol = 9.9 moles
Total number of moles = (0.1 + 9.9) moles = 10 moles
Now, mole fraction of glucose in solution = Change in pressure with respect to initial pressure

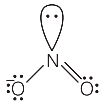
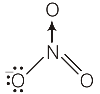
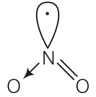
$$\text{i.e.} \qquad \frac{\Delta p}{p°} = \frac{0.1}{10}$$

$$\text{or} \qquad \Delta p = 0.01p° = 0.01 \times 760 = 7.6 \text{ torr}$$

$\therefore$ Vapour pressure of solution = (760 − 7.6) torr = 752.4 torr

10. ***(c)*** Glycerol with high boiling point (290°C) can be separated from spent lye by distillation under reduced pressure. This process is used to purify liquids having very high boiling points. By this process, liquid is made to boil at lower temperature than its boiling point by lowering the pressure on its surface.

11. ***(d)***

Species	**Hybridisation**
	sp^2
	sp^2
	sp^2
$O=\overset{+}{N}=O$	sp

12. **(a)** For first order reaction, $k = \frac{2.303}{t}\log\frac{a}{a-x}$

Given, $t = 50$ min, $a = 0.5$ M, $a - x = 0.125$ M

$$\therefore \quad k = \frac{2.303}{50}\log\frac{0.5}{0.125} = 0.0277\ \text{min}^{-1}$$

Now, as per reaction

$$2H_2O_2 \longrightarrow 2H_2O + O_2$$

$$-\frac{1}{2}\frac{d[H_2O_2]}{dt} = \frac{1}{2}\frac{d[H_2O]}{dt} = \frac{d[O_2]}{dt}$$

Rate of reaction, $-\frac{d\,[H_2O_2]}{dt} = k[H_2O_2]$

$$\therefore \quad \frac{d\,[O_2]}{dt} = -\frac{1}{2}\frac{d\,[H_2O_2]}{dt} = \frac{1}{2}k[H_2O_2] \quad \ldots(i)$$

When the concentration of H_2O_2 reaches 0.05 M,

$$\frac{d[O_2]}{dt} = \frac{1}{2}\times 0.0277\times 0.05 \quad \text{[from Eq. (i)]}$$

$$\text{or} \quad \frac{d[O_2]}{dt} = 6.93\times 10^{-4}\ \text{mol min}^{-1}$$

ALTERNATE

In fifty minutes, the concentration of H_2O_2 decreases from 0.5 to 0.125 M or in one half-life, concentration of H_2O_2 decreases from 0.5 to 0.25 M. In two half-lives, concentration of H_2O_2 decreases from 0.5 to 0.125 M or $2t_{1/2} = 50$ min

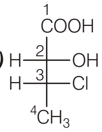
$$t_{1/2} = 25\ \text{min}$$

$$\therefore \quad k = \left(\frac{0.693}{25}\right)\text{min}^{-1}$$

$$\text{or} \quad \frac{d[O_2]}{dt} = -\frac{1}{2}\frac{d[H_2O_2]}{dt} = \frac{k[H_2O_2]}{2} = 6.93\times 10^{-4}\ \text{mol min}^{-1}$$

13. **(a)**

Complex ion	Electronic configuration of metal ion	Number of unpaired electrons (*n*)
$[Cr(H_2O)_6]^{2+}$	Cr^{2+}; [Ar] $3d^4$	[↿][↿][↿][↿][ ] ; 4
$[Fe(H_2O)_6]^{2+}$	Fe^{2+}; [Ar] $3d^6$	[⇂↿][↿][↿][↿][↿] ;
$[Mn(H_2O)_6]^{2+}$	Mn^{2+}; [Ar] $3d^5$	[↿][↿][↿][↿][↿] ;
$[CoCl_4]^{2-}$	Co^{2+}; [Ar] $3d^7$	[⇂↿][⇂↿][↿][↿][↿] ;

14. **(a)** 

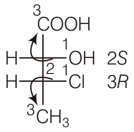
For C-2, order of priority of substituents is

$$OH > CH(Cl)(CH_3) > COOH$$

For C-3, order of priority of substituents is

$$Cl > CH(OH)COOH > CH_3$$

Hence, according to CIP rules,



15. **(b)**

	A	+ B	$\rightleftharpoons C$	+ D
Initially at $t = 0$	1	1	1	1
At equilibrium	$1-x$	$1-x$	$1+x$	$1+x$

$$K_{eq} = \frac{[C][D]}{[A][B]} = \frac{(1+x)(1+x)}{(1-x)(1-x)} = \frac{(1+x)^2}{(1-x)^2}$$

$$\text{or} \quad 100 = \left(\frac{1+x}{1-x}\right)^2$$

$$\text{or} \quad 10 = \frac{1+x}{1-x}$$

$$\text{or} \quad 10 - 10x = 1 + x$$

$$10 - 1 = x + 10x$$

$$9 = 11x$$

$$x = \frac{9}{11} = 0.818$$

$\therefore [D] = 1 + x = 1 + 0.818 = 1.818$

16. **(b)** Sulphide ores are concentrated by froth floatation method.

Galena (PbS)

17. **(None)** $C_xH_y(g) + \left(x + \frac{y}{4}\right)O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$

15 mL 75 mL 30 mL

O_2 used = 20% of 375 = 75 mL

Inert part of air = 80% of 375 = 300 mL

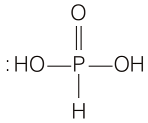
Total volume of gases

= CO_2 + Inert part of air = 30 + 300 = 330 mL

$$\frac{x}{1} = \frac{30}{15} \Rightarrow x = 2$$

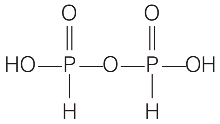
$$\frac{x + \frac{y}{4}}{1} = \frac{75}{15} \Rightarrow x + \frac{y}{4} = 5$$

$$\Rightarrow \quad x = 2,\ y = 12 \Rightarrow C_2H_{12}$$

18. **(d)** Orthophosphorous acid, H_3PO_3 : 

$$HO{-}\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle H}{|}}{P}}{-}OH$$

$$H_3\overset{x}{P}O_3 = 3 + x + 3(-2) = 0 \ \text{or}\ x = +3$$

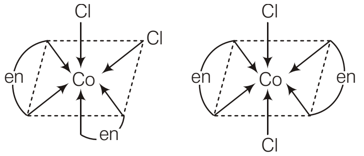
Pyrophosphorous acid, $H_4P_2O_5$: 

$$HO{-}\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle H}{|}}{P}}{-}O{-}\overset{\overset{\displaystyle O}{\|}}{\underset{\underset{\displaystyle H}{|}}{P}}{-}OH$$

$$H_4\overset{x}{P_2}O_5 = 4 + 2x + 5(-2) = 0$$

$$4 + 2x - 10 = 0$$

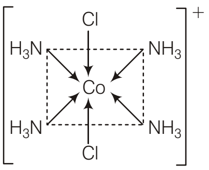
$$x = +3$$

19. **(a)** 

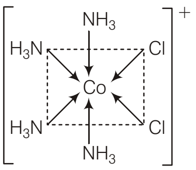
cis-$[Co(en)_2Cl_2]Cl$ (optically active)

trans-$[Co(en)_2Cl_2]Cl$ (optically inactive due to plane of symmetry)

$[Co(NH_3)_4Cl_2]Cl$ can exist in both *cis* and *trans* forms that are given below:

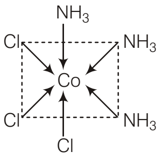


trans-$[Co(NH_3)_4Cl_2]Cl$
(optically inactive)

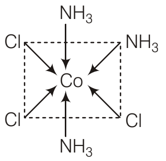


cis-$[Co(NH_3)_4Cl_2]Cl$
(optically inactive)

$[Co(NH_3)_3Cl_3]$ exists in *fac* and *mer*-isomeric forms and both are optically inactive.



fac-isomer
(optically inactive)



mer-isomer
(optically inactive)

20. ***(d)*** $\underset{\text{(Conc.)}}{Zn + 4HNO_3} \longrightarrow Zn(NO_3)_2 + 2H_2O + 2NO_2$

$\underset{\text{(Dil.)}}{4Zn + 10HNO_3} \longrightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$

21. ***(b)*** There is extensive intermolecular H-bonding in the condensed phase.

22. ***(b)*** This water is unsuitable for drinking due to high concentration of nitrate. In drinking water, maximum permissible concentration of

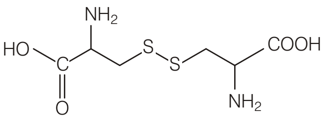
Lead $\simeq$ 50 ppb
Nitrate $\simeq$ 50 ppb
Iron $\simeq$ 0.2 ppm
Fluoride $\simeq$ 1 ppm

23. ***(c)*** $\underset{\text{(Excess)}}{2Li + \frac{1}{2}O_2(g)} \longrightarrow Li_2O$

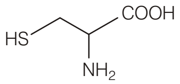
$\underset{\text{(Excess)}}{2Na + O_2(g)} \longrightarrow Na_2O_2$

$\underset{\text{(Excess)}}{K + O_2(g)} \longrightarrow KO_2$

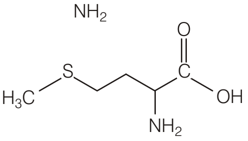
24. ***(b)*** Cystine :



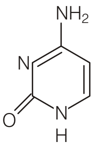
Cysteine :



Methionine :



Cytosine :



Thiol group (SH) is present in cysteine.

25. ***(c)*** Zinc metal is the most stable metal to cover iron surfaces. The process of coating the iron surface by zinc is called galvanisation.

26. ***(c)*** Order of first ionisation energy is Sc > Na > K > Rb

Due to poor shielding effect, removal of one electron from 4*s* orbital is difficult as compared to 3*s*-orbital.

27. ***(c)*** Hofmann-bromamide degradation reaction is given as:

$$RCONH_2 + 4NaOH + Br_2 \longrightarrow \underset{(1^\circ \text{ amine})}{RNH_2} + Na_2CO_3 + 2NaBr + 2H_2O$$

Hence, four moles of NaOH and one mole of Br_2 are used.

28. ***(b)*** Initially,

Number of moles of gases in each container $= \dfrac{p_iV}{RT_1}$

Total number of moles of gases in both containers $= 2\dfrac{p_iV}{RT_1}$

After mixing, number of moles in left chamber $= \dfrac{p_fV}{RT_1}$

Number of moles in right chamber

$$= \frac{p_fV}{RT_2}$$

Total number of moles

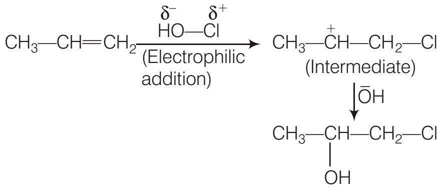
$$= \frac{p_fV}{RT_1} + \frac{p_fV}{RT_2} = \frac{p_fV}{R}\left(\frac{1}{T_1} + \frac{1}{T_2}\right)$$

As total number of moles remains constant.

Hence, $\dfrac{2p_iV}{RT_1} = \dfrac{p_fV}{RT_1} + \dfrac{p_fV}{RT_2}$

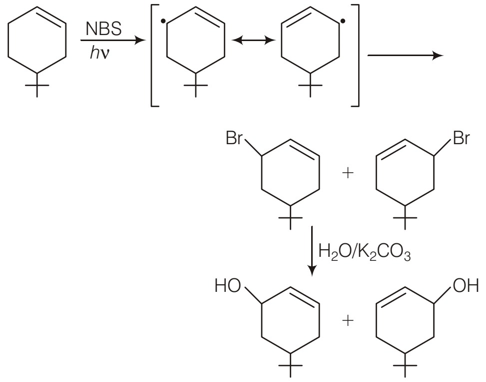
$\Rightarrow \quad p_f = 2p_i\left(\dfrac{T_2}{T_1 + T_2}\right)$

29. ***(a)***



$$CH_3{-}CH{=}CH_2 \xrightarrow[\text{(Electrophilic addition)}]{\overset{\delta^-}{HO}{-}\overset{\delta^+}{Cl}} \underset{\text{(Intermediate)}}{CH_3{-}\overset{+}{C}H{-}CH_2{-}Cl} \xrightarrow{\bar{O}H} CH_3{-}\underset{OH}{\underset{|}{CH}}{-}CH_2{-}Cl$$

30. ***(a)***



TARGET PMT 2016

TEST Tuner

Comprehensive Simulator Test Series for AIPMT & AIIMS

AIIMS PREP UP

Mock Questions with Complete Solutions

Instructions

- This test consists of 60 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. Equal volumes of 0.1 M $AgNO_3$ and 0.2 M NaCl solutions are mixed. The concentration of NO_3^- ions in the mixed solution will be

(a) 0.1 M (b) 0.05 M
(c) 0.2 M (d) 0.15 M

2. Which among the following actinoids does not have stable electronic configuration?

(a) Protoactinium (b) Nobelium
(c) Americium (d) Lawrencium

3. Which one of the following enzymes is present in animals like cow, buffaloes etc., to digest compounds like paper, cloth etc?

(a) Ureaze (b) Cellulase
(c) Silicase (d) Sucrase

4. Which buffer solution has maximum pH?

(a) Mixture of 0.1 M CH_3COOH and 0.1 M $CH_3CO\bar{O}Na^+$ [pK_a $(CH_3COOH) = 4.74$]
(b) Mixture of 0.2 M CH_3COOH and 0.2 M $CH_3CO\bar{O}Na^+$
(c) Mixture of 0.1 M NH_4Cl and 0.1 M NH_4OH [$pK_a(NH_4^+) = 9.26$]
(d) All the solutions have equal pH which is equal to 4.74

5. The ion which is not tetrahedral in shape is

(a) BF_4^- (b) NH_4^+
(c) $[Cu(NH_3)_4]^{2+}$ (d) $[NiCl_4]^{2-}$

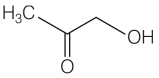
6. Which of the following electrodes is wrongly matched?

(a) Metal-metal ion electrode – Zn / Zn^{2+}; $Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$
(b) Gas electrode–Pt, $H_2(g)/H^+(aq)$; $2H^+(aq) + 2e^- \longrightarrow H_2(g)$
(c) Oxidation-reduction electrode– Pt, $Co^{3+}(aq) \mid Co^{2+}(aq)$; $Co^{3+}(aq) + e^- \longrightarrow Co^{2+}(aq)$
(d) Amalgam electrode– Pt, $Cl_2(g) \mid Cl^-(aq)$; $Cl_2(g) + 2e^- \longrightarrow 2Cl^-(aq)$

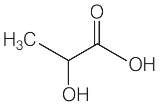
7. The correct order for the wavelengths of absorption in the visible region of the following complexes

(a) $[Ni(H_2O)_6]^{2+} < [Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+}$
(b) $[Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+} < [Ni(NO_2)_6]^{4-}$
(c) $[Ni(NO_2)_6]^{4-} < [Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+}$
(d) $[Ni(NH_3)_6]^{2+} < [Ni(H_2O)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

8. Fehling's solution can make distinction between

(a) CH_3CHO and 

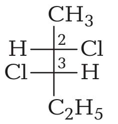
(b) CH_3CHO and HCHO

(c) 

and HCHO

(d) CH_3CHO and C_6H_5CHO

9. The absolute configuration of the following compound is



(a) 2*S*, 3*R* (b) 2*S*, 3*S* (c) 2*R*, 3*S* (d) 2*R*, 3*R*

10. 10 g of a sample of a mixture of $CaCl_2$ and NaCl is treated with sodium carbonate to precipitate all the calcium as $CaCO_3$. This $CaCO_3$ is heated to convert all the Ca to CaO and the final mass of CaO is found to be 1.62 g. The percent by mass of $CaCl_2$ in the original mixture is

(a) 11.0% (b) 21.8%
(c) 16.2% (d) 32.2%

11. An unsaturated hydrocarbon *X* gives white precipitate with Tollen's reagent. If *X* is gaseous in nature, what is the molecular formula of it?

(a) C_3H_6 (b) C_2H_4 (c) C_2H_2 (d) C_4H_8

12. Threshold Limit Value (TLV) of CO and CO_2 in the atmosphere should be

(a) 40 ppm, 5000 ppm (b) 43 ppm, 56 ppm
(c) 56 ppm, 43 ppm (d) 5000 ppm, 40 ppm

13. At two stages of disintegration, disintegration constants are respectively $1 \times 10^{-2}\,s^{-1}$ and $1 \times 10^{-5}\,s^{-1}$. At first stage 2000 atoms are disintegrating. At second stage number of atoms disintegrating would be

(a) 2 (b) 2×10^6
(c) 2×10^{-6} (d) 2×10^9

14. The only cations present in a slightly acidic medium are Fe^{3+}, Zn^{2+} and Cu^{2+}. The reagent added in excess to this solution would identify and separate Fe^{3+} in one step is

(a) 2M HCl (b) 6 M NH_3
(c) 6M NaOH (d) H_2S gas

15. Which of the following is arranged in the increasing order of bond dissociation energy?

(a) $F_2 < Cl_2 < N_2 < O_2$ (b) $F_2 < Cl_2 < O_2 < N_2$
(c) $F_2 < O_2 < Cl_2 < N_2$ (d) $N_2 < Cl_2 < O_2 < F_2$

16. Which one of the following statements is/are not correct for the fullerenes?

(a) They are large cage like spheroidal molecules with general formula C_{2n}
(b) Six membered rings are fused with both six membered as well as five membered rings
(c) This ball shaped molecule is a non-conducting substance and has 600 vertices
(d) All of the above are incorrect

17. On addition of 1 mL solution of 10% NaCl to 10 mL gold sol in the presence of 0.0250 g of starch, the coagulation is just prevented. Starch has the following gold number

(a) 0.025 (b) 0.25 (c) 2.5 (d) 25

18. Which one of the following statements is/are in accordance with the Arrhenius equations?

(a) Rate of a reaction, increases with decrease in activation energy and increase in temperature
(b) Rate constant value, decreases exponentially with increase in temperature
(c) Rate of a reaction, decreases with decrease in activation energy
(d) All of the above

19. Conductivity of 0.01M NaCl solution is found to be $0.00147\,\Omega^{-1}cm^{-1}$. What happens to this conductivity if extra 100 mL of H_2O will be added to the above solution?

(a) Increases
(b) Decreases
(c) Remains unchanged
(d) First increases then decreases

20. If the positions of Na^+ and Cl^- are interchanged in NaCl, having fcc arrangement of Cl^-ions then in the unit cell of NaCl.

(a) Na^+ ions will decrease by 1 while Cl^- ions will increase by 1
(b) Na^+ ions will increase by 1 while Cl^- ions will decrease by 1
(c) Number of Na^+ and Cl^- ions will remain same
(d) The crystal structure of NaCl will change

21. Which one of the following is the correct order of acidic strength of hypohalous acids?

(a) HOCl > HOI > HOBr
(b) HOI > HOBr > HOCl
(c) HOCl > HOBr > HOI
(d) HOI > HOCl > HOBr

22. In lanthanoids, the decrease in the atomic radius for 14 elements is only 11 pm. What is the reason?

(a) Lanthanoid contraction
(b) Stability of oxidation state +3
(c) Effective nuclear charge
(d) None of the above

23. Among the following complexes, which one has the largest magnetic moment?

(a) $[Mn(CN)_6]^{3-}$ (b) $[MnCl_6]^{3-}$ (c) $[Fe(CN)_6]^{3-}$ (d) $[FeF_6]^{3-}$

24. Which of the following is the correct order of decreasing reactivity towards nucleophilic substitution reaction?

(a) Allyl chloride > vinyl chloride > propyl chloride
(b) Vinyl chloride > allyl chloride > propyl chloride
(c) Allyl chloride > propyl chloride > vinyl chloride
(d) Propyl chloride > vinyl chloride > allyl chloride

25. In the commercial manufacture of ethyl alcohol from starchy substances by fermentation process, which enzyme order completes the fermentation reaction?

(a) Diastase, Maltase, Zymase
(b) Maltase, Zymase, Invertase
(c) Diastase, Zymase, Lactase
(d) Diastase, Invertase, Zymase

26. The end product in the following sequence of reaction, is $HC{\equiv}CH \xrightarrow[20\%\ H_2SO_4]{1\%\ HgSO_4} A \xrightarrow{CH_3MgX} B \xrightarrow{[O]} C.$

(a) Acetic acid (b) Isopropyl alcohol
(c) Acetone (d) Ethanol

27. Which test among the following is not used for the distinction among 1°, 2° and 3° aliphatic amine?

(a) Hinsberg's reagent test (b) Carbylamine reaction
(c) Azo dye test (d) Action with nitrous acid

28. An organic compound with molecular formula $C_6H_{12}O_6$ forms a yellow crystalline solid with phenyl-hydrazine and gives a mixture of sorbitol and mannitol when reduced with sodium. Which among the following could be the compound?

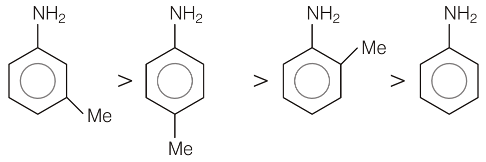
(a) Fructose *(b)* Glucose *(c)* Mannose *(d)* Sucrose

29. Which one of the following can possibly be used as analgesic without causing addiction and modification?

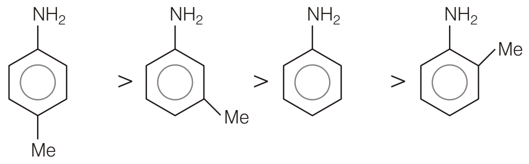
(a) Acetyl salicylic acid
(b) N-acetyl-*para*-amino phenol
(c) Phenyl salicylate
(d) Methyl salicylate

30. The increasing order of the basic character of the substituted aromatic amine is

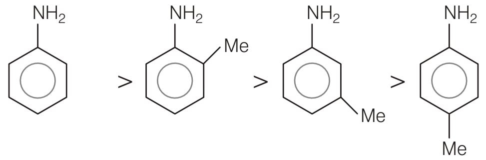
(a)



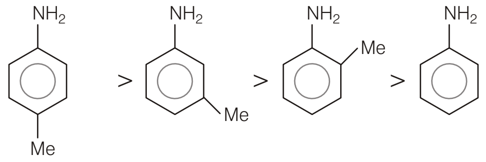
(b)



(c)



(d)



31. Triple ionised beryllium $[Be^{3+}]$ has the same orbit radius as that of the ground state of hydrogen atom. At which energy state, this situation arises?

(a) 2 *(b)* 4 *(c)* 3 *(d)* 1

32. The pair in which both species have iron is

(a) nitrogenase, cytochromes
(b) carboxypeptidase, haemoglobin
(c) haemocyanin, nitrogenase
(d) haemoglobin, cytochromes

33. A 5L vessel contains 1.4 g of nitrogen, when heated to 1800 K, 30% of molecules are dissociated into atoms. Calculate the pressure of the gas at 1800 K.

(a) 1.92 atm *(b)* 19.2 atm *(c)* 0.192 atm *(d)* 2.63 atm

34. Consider the following reaction at 298 K,

$$\frac{3}{2}O_2(g) \longrightarrow O_3(g)$$

The K_p for this conversion is 2.47×10^{-29}. The $\Delta_rG°$ for this conversion is

(a) 163 kJ mol^{-1}
(b) 206 kJ mol^{-1}
(c) 183 kJ mol^{-1}
(d) 136 kJ mol^{-1}

35. Extraction of gold from its ore is very beneficial process. The reactions involved are

$$\text{Roasted gold ore} + CN^- + H_2O \xrightarrow{O_2} X + OH^-$$
$$X + Zn \longrightarrow Y + Au$$

Identify the complexes X and Y,

(a) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$
(b) $X = [Au(CN)_4]^{2-}$, $Y = [Zn(CN)_4]^{2-}$
(c) $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_6]^{4-}$
(d) $X = [Au(CN)_4]^-$, $Y = [Zn(CN)_4]^{2-}$

36. An equilibrium mixture at 300K, contains N_2O_4 and NO_2 at 0.28 and 1.1 atm pressures, respectively. If the volume of the container is doubled, the new equilibrium pressure of these two gases respectively are

(a) 0.064 atm and 0.095 atm
(b) 0.640 atm and 0.095 atm
(c) 0.095 atm and 0.632 atm
(d) 0.095 atm and 0.64 atm

37. The concentration of H_2SO_4 required to precipitate $BaSO_4$ from a solution of 0.01 M Ba^{2+} ions (solubility product of $BaSO_4$ at 25°C is 1.0×10^{-9}) is

(a) 10^{-8} mol/L
(b) 10^{-2} mol/L
(c) 10^{-7} mol/L
(d) 10^{-6} mol/L

38. Which one of the following reactions does not show oxidising action of H_2O_2?

(a) $Na_3AsO_3 + H_2O_2 \longrightarrow Na_3AsO_4 + H_2O$
(b) $2Fe^{2+} + H_2O_2 \longrightarrow 2Fe^{3+} + 2OH^-$
(c) $PbS(s) + 4H_2O_2(aq) \longrightarrow PbSO_4(s) + 4H_2O(l)$
(d) $2K_3[Fe(CN)_6] + 2KOH + H_2O_2 \longrightarrow 2K_4[Fe(CN)_6] + 2H_2O + O_2$

39. Which of the following statements is/are correct?

(a) Washing soda is prepared by Solvay process and also called as soda ash
(b) Solvay process is economical discontinuous
(c) Washing soda when mixed with K_2CO_3, called as nitrating mixture
(d) All of the above

40. An alkane has a molecular mass of 72. The possible chain isomers for this molecule are

(a) 4 *(b)* 3
(c) 5 *(d)* 2

Directions (Q. Nos. 41 to 60) *In the following questions a statement of Assertion followed by a statement of Reason is given. Choose the correct answer out of the following choices.*

(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion
(b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion
(c) Assertion is true but Reason is false
(d) Both Assertion and Reason are false

41. **Assertion** (A) Water has a very high heat capacity.
Reason (R) $\Delta H = C_p \cdot \Delta T$ is high and there is extensive hydrogen bonding present among water molecules.

42. **Assertion** (A) Anhydrous salts with smaller cations can be prepared by heating the hydrated salts.

Reason (R) Smaller cations are inactive.

43. **Assertion** (A) Rise of sea levels is recorded by atleast 25 meters (82 feet) by the year 2100.

Reason (R) The warming effect of earth due to certain atmospheric gases such as CO_2 and water vapour.

44. **Assertion** (A) Al is obtained by high temperature reduction of alumina with carbon.

Reason (R) Alumina reacts with carbon to form aluminium carbide which decomposes at high temperature to form Al while carbon is oxidised to CO.

45. **Assertion** (A) Lead (IV) iodide is an unstable compound.

Reason (R) Iodine stabilises lower oxidation state.

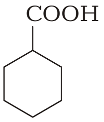
46. **Assertion** (A) pH of 10^{-8} M HCl is not equal to 8.

Reason (R) HCl does not dissociate properly in very dilute solution.

47. **Assertion** (A) H_2O is dipolar, whereas BeF_2 is not.

Reason (R) The value of dipole moment is not zero in case of H_2O while it comes out to be zero in case of BeF_2.

48. **Assertion** (A) PhCOOH (I) is more acidic than



II

Reason (R) The negative charge of the conjugate base of (I) is delocalised through the benzene ring.

49. **Assertion** (A) Aqueous gold colloidal solution is red in colour.
Reason (R) The colour arises due to scattering of light by colloidal gold particles.

50. **Assertion** (A) In an atom, the velocity of an electron in the higher orbits keeps on increasing.

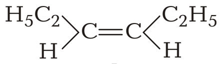
Reason (R) Velocity of electron is directly proportional to the radius of the orbit.

51. **Assertion** (R) If helium is allowed to expand in vacuum, it liberates heat.
Reason (R) The inversion temperature of helium is very low.

52. **Assertion** (A) Time taken for completion of 75% of first order reaction is double of its $t_{1/2}$.

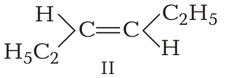
Reason (R) Time taken for completion of any fraction of first order reaction is proportional to the extent of completion of reaction.

53. **Assertion** (A) Boiling point of



I

is higher than



II

Reason (R) Dipole moment of I is higher than II.

54. **Assertion** (A) Among $[PbCl_4]^{2-}$, $[Ni(CN)_4]^{2-}$ and $[NiCl_4]^{2-}$, only $[NiCl_4]^{2-}$ shows tetrahedral geometry.

Reason (R) Cl^- is a weak field ligand.

55. **Assertion** (A) The monomer of natural rubber is isoprene.

Reason (R) Natural rubber is formed through cationic addition polymerisation.

56. **Assertion** (A) The ionic size of $S^{2-} > Cl^-$.

Reason (R) In the isoelectronic species, greater the nuclear charge, less is the size.

57. **Assertion** (A) Ce^{4+} is stable.

Reason (R) This is because of the half-filled *d*-orbitals.

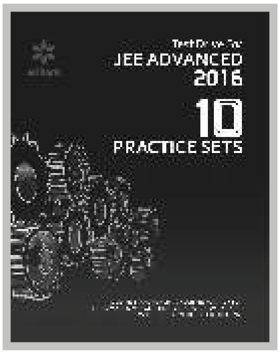
58. **Assertion** (A) The boiling points of the chlorinated derivatives of methane increase with number of chlorine atoms.

Reason (R) An increase in the induced dipole-dipole attractive forces.

59. **Assertion** (A) Corrosion is an electrochemical phenomenon.

Reason (R) A metal is oxidised by the loss of electrons to oxygen and forms metal oxide.

60. **Assertion** (A) The loss of a proton from an amine gives an imide ion, while the loss of a proton from alcohol gives an alkoxide ion.
Reason (R) RO^- is more stable than $R\bar{N}H$.



Answers *with* Explanation

1. ***(b)*** When 1L of 0.1 M $AgNO_3$ is mixed with 1 L of 0.2 M NaCl solution. Then, 0.1 mole of $AgNO_3$ will react with 0.1 mole of NaCl to form 0.1 mole of $NaNO_3$ in the solution. This solution will ionise to produce 0.1 mole NO_3^- ions, but new volume after mixing becomes 2 L. Hence, concentration of NO_3^- ions in the mixed solution $= \frac{0.1}{2} = 0.05$ M.

2. ***(a)*** Protoactinium [Pa] is the element that does not have stable electronic configuration

Protoactinium [Pa] = [Rn] $5f^2 6d^1 7s^2$ (Atomic number = 91)

Nobelium (No) = [Rn] $5f^{14} 6d^0 7s^2$ (Atomic number = 102)

Lawrencium [Lr] = [Rn] $5f^{14} 6d^1 7s^2$ (Atomic number = 103)

Americium [Am] = [Rn] $5f^7 6d^0 7s^2$ (Atomic number = 95)

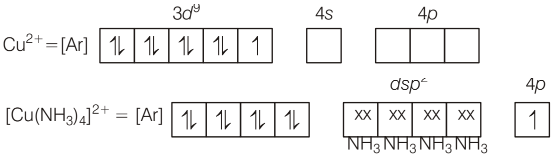
3. ***(b)***

4. ***(d)*** $pK_a = pH$

(a) pH = 4.74 (b) pH = 4.74

(c) $pOH = 14 - pH \Rightarrow pH = 14 - pK_a = 14 - 9.26$ or pH = 4.74.

5. ***(c)*** $[Cu(NH_3)_4]^{2+}$ is square planar in shape



6. ***(d)*** Generally amalgam electrode used for active metals like Na, K etc.

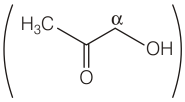
e.g. $Zn(Hg) \mid Zn^{2+}, Zn^{2+}(aq) + 2e^- \longrightarrow Zn(Hg)$

7. ***(c)*** As metal ion is fixed, the increasing field strengths (CFSE values) of the ligands from the spectrochemical series are in the order : $H_2O < NH_3 < NO_2^-$.

Thus, the energies absorbed for excitation will be in the order $[Ni(H_2O)_6]^{2+} < [Ni(NH_3)_6]^{2+} < [Ni(NO_2)_6]^{4-}$

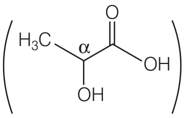
As $E = \frac{hc}{\lambda}$, the wavelengths absorbed will be in the opposite order.

8. ***(d)*** (a) Fehling's solution reacts with both CH_3CHO and α-hydroxy ketones



(b) Fehling's solution reacts with both aliphatic aldehydes, CH_3CHO and HCHO, respectively.

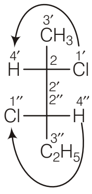
(c) Fehling's solution reacts with both HCHO and α-hydroxy ketone



(d) Fehling's solution reacts only with aliphatic aldehyde, not with aromatic aldehyde.

9. ***(b)*** If lowest priority substituent on asymmetric carbon occupies vertically upward or downward position in Fischer projection, the configuration obtained is equal to the actual configuration of the molecule.

If lowest priority substituent on asymmetric carbon occupies either of horizontal position, change the configuration from *R* to *S* and *vice-versa*.



(2*S*, 3*S*)

10. ***(d)*** The reaction involved in this process are

$$CaCl_2 + NaCl + Na_2CO_3 \longrightarrow CaCO_3 + 3NaCl$$
$$CaCO_3 \longrightarrow CaO + CO_2$$

According to above reactions, 1 mole of $CaCl_2$ gives 1 mole of $CaCO_3$ which further give 1 mole of CaO after heating.

$\because$ Mole of CaO formed $= \frac{1.62}{56} = 0.0289$ mol

$\therefore$ Mole of $CaCl_2$ formed = 0.0289 mol

or mass of $CaCl_2$ formed $= 0.0289 \times 111 = 3.208$ g

[$\because$ Molar mass = 111 g mol^{-1}]

Percentage of $CaCl_2$ in the original mixture

$$= \frac{3.208}{10} \times 100 = 32.08\%$$

11. ***(c)*** With Tollen's reagent (ammoniacal $AgNO_3$), a white precipitate of silver salt is obtained.

$$H{-}C{\equiv}C{-}H + 2AgNO_3 + 2NH_4OH \longrightarrow \underset{\substack{\text{Silver acetylide} \\ \text{(white ppt.)}}}{Ag{-}C{\equiv}C{-}Ag} + 2NH_4NO_3 + 2H_2O$$

12. ***(a)*** The permissible limit of a pollutant in the atmosphere to which a person is exposed for 8 h work day or 40 h work week or throughout his life, there is no adverse effect on him, is called threshold limit value (TLV). TLV of CO is 40 ppm while that of CO_2 is 5000 ppm. As the TLV decreases, poisonous effect increases.

13. ***(b)*** $N_1\lambda_1 = N_2\lambda_2$

$$N_2 = N_1 \frac{\lambda_1}{\lambda_2} = 2000 \times \frac{1 \times 10^{-2}}{1 \times 10^{-5}} = 2 \times 10^6 \text{ atoms}$$

14. ***(b)*** Fe^{3+}, Zn^{2+} and Cu^{2+} ions are present in slightly acidic solution. On adding 6 M NH_3 solution, i.e. 6 M NH_4OH we get the following reactions.

$$Fe^{3+} + 3OH^- \longrightarrow \underset{\text{Dark brown ppt.}}{Fe(OH)_3}$$
$$Zn^{2+} + 4\,NH_3 \longrightarrow \underset{\text{Colourless solution}}{[Zn\,(NH_3)_4]^{2+}}$$
$$Cu^{2+} + 4\,NH_3 \longrightarrow \underset{\text{Deep blue solution}}{[Cu\,(NH_3)]_4^{2+}}$$

In this way, dark brown precipitate of $Fe(OH)_3$ can be separated from Cu^{2+} and Zn^{2+} amine complex solutions in a single step by adding 6 M NH_3.

15. ***(b)*** $F_2 < Cl_2 < O_2 < N_2$

155 242 494 941 (kJ/mol)

In general, as the size of atom or multiplicity of bond increases, bond dissociation energy increases. But bond dissociation energy of F_2 is less than that of Cl_2 because of the small size of F. Thus, the correct order is $F_2 < Cl_2 < O_2 < N_2$.

16. *(b)* This ball shaped molecule has 60 vertices and each one is occupied by one carbon atom.
The alkali compounds of C_{60} are used as superconducting substance at the temperature range of 10-40 K.

17. *(d)* Amount of starch in milligram that prevents coagulation by 1 mL of 10% NaCl solution = $0.025 \times 1000 = 25$

Hence, gold number = 25

18. *(a)* Rate constant value increases exponentially with increase in temperature.
Rate of a reaction increases with decrease in activation energy.

19. *(b)* On dilution, number of ions/cm^3 decreases. Hence, conductivity decreases.

20. *(b)* In NaCl with fcc arrangement of Cl^- ions, number of Cl^- ion = 14, Na^+ ions = 13. On interchanging their positions, Cl^- ions will be 13 and Na^+ ions will be 14.

21. *(c)* $HO\overset{+}{Cl} > HO\overset{+1}{Br} > H\overset{+1}{OI}$

Acidic strength of oxoacids of different halogens having same oxidation state, decreases with the increase in atomic number.

Oxygen is more electronegative than the halogen (Cl, Br or I). Therefore, it attracts the electrons of the oxygen-halogen bond towards itself. Now, as the electronegativity of the halogen decreases from Cl to I, the shared pair of electrons of the oxygen-halogen bond moves closer towards the oxygen atom. As a result, electron-density of the oxygen atom increases from Cl to I. Consequently, O in H—O—Cl attracts the electrons of O—H bond towards itself most strongly followed by H—O—Br and least strongly by H—O—I. O—H bond breaks most readily in H—OCl and least easily in H—O—I.

22. *(a)* Lanthanoid contraction is the reason. As we move along the lanthanoid series, the nuclear charge increases by one unit at each successive element. The new electron is added into the same subshell. As as result, the attraction on the electrons by the nucleus increases and this tends to decrease in the size. Further, as the new electron is added into the *f*-subshell, there is imperfect shielding of one electron by another in this subshell due to the shapes of these *f*-orbitals. This imperfect shielding is unable to counter balance the effect of the increased nuclear charge. Hence, the net result is a contraction in the size though the decrease is very small.

23. *(d)* Magnetic moment of a complex is related to the presence of number of unpaired electrons.

$[Mn(CN)_6]^{3-}$ = two unpaired electrons
$[MnCl_6]^{3-}$ = four unpaired electrons
$[Fe(CN)_6]^{3-}$ = one unpaired electron
$[FeF_6]^{3-}$ = five unpaired electrons

24. *(c)* Vinyl chloride is least reactive towards nucleophilic substitution due to
(i) resonance stabilisation
(ii) more *s*-character of carbon, attached to halogen.
Allyl chloride is more reactive, since, allyl carbocation formed is resonance stabilised.

$$CH_2{=}CH{-}\overset{+}{C}H_2 \longleftrightarrow \overset{+}{C}H_2{-}CH{=}CH_2$$

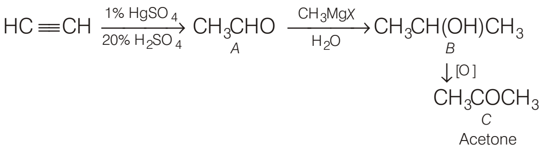
25. *(a)* Diastase, Maltase, Zymase

$$(C_6H_{10}O_5)_n + \frac{n}{2}H_2O \xrightarrow{\text{Diastase}} nC_{12}H_{22}O_{11}$$

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{Maltase}} 2C_6H_{12}O_6$$

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

26. *(c)*

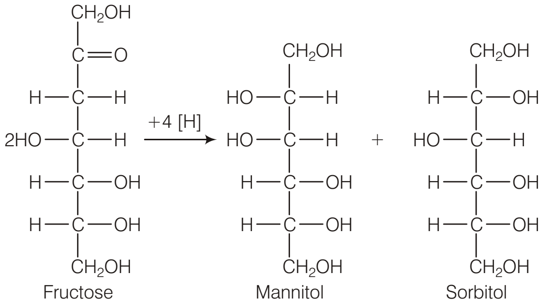


$$HC{\equiv}CH \xrightarrow[\text{20\% }H_2SO_4]{\text{1\% }HgSO_4} \underset{A}{CH_3CHO} \xrightarrow[H_2O]{CH_3MgX} \underset{B}{CH_3CH(OH)CH_3} \xrightarrow{[O]} \underset{\substack{C\\ \text{Acetone}}}{CH_3COCH_3}$$

27. *(c)* Azo dye test is not used for the distinction in 1°, 2° and 3° aliphatic amines. While other three tests can be easily used to distinguish between 1°, 2° and 3° amines.

	Test	Primary amine	Secondary amine	Tertiary amine
1.	Hinsberg's reagent test	Forms a sulphonamide, soluble in alkali.	Forms a sulphonamide insoluble in alkali.	No reaction
2.	Carbylamine reaction	Forms a carbylamine with unpleasant smell.	No action	No reaction
3.	Action with nitrous acid	Forms primary alcohol and evolves nitrogen with effervescence.	Forms nitrosamine which gives Libermann's nitrosa urine reaction.	Forms an amine salt

28. *(a)* As $C_6H_{12}O_6$ forms a crystalline osazone with phenyl hydrazine, it must be an aldohexose or ketohexose. As the compound on reduction with Na gives sorbitol and mannitol, therefore the given compound is fructose.



29. *(b)* N-acetyl-*para*-amino phenol can possibly be used as analgesic without causing addiction and modification.

30. *(b)* In case of aniline, the lone pair of electron of nitrogen is delocalised into benzene ring by resonance. As a result of resonance the lone pair is less available for protonation.

The basicity of *o*-substituted anilines is generally lower as compare to aniline and *m*-or *p*-substituted aniline. This is due to *ortho*-effect in which the substituent at *ortho*-position hinders the attack of the acid on the amino acid.

In a case of *p*-methylaniline, + *I* and hyperconjugation effect of methyl group increases the electron density on nitrogen atom while in case of *m*-methylaniline only + *I*-effect works. Therefore, *p*-methylaniline is more basic than *m*-methylaniline.

31. **(a)** For hydrogen like species (Be^{3+}) radius is given as,

$$r_n = \frac{n^2h^2}{4\pi^2 mKZe^2} \qquad \ldots(i)$$

where, $K = \frac{1}{4\pi \epsilon_0}, Z = 4$

For hydrogen atom radius is given as,

$$r_n = \frac{h^2}{4\pi^2 mKZe^2} \qquad \ldots(ii) \quad (n = 1, Z = 1)$$

Dividing Eq. (i) by Eq. (ii)

$$\frac{r_n}{r_1} = \frac{n^2}{Z} = \frac{n^2}{4}$$

when $r_n = r_1$

$\Rightarrow$ $n^2 = 4 \Rightarrow$ or $n = 2$

Thus, the second orbit of Be^{3+} has the same radius as the Bohr's radius of hydrogen atom.

32. **(d)** Nitrogenase contains nitrogen
Cytochromes contains iron
Carboxypeptidase contains carbon and nitrogen
Haemoglobin contains iron
Haemocyanin contains copper

33. **(a)**

	N_2 $\rightleftharpoons$	$2N$
Initial moles	$\frac{1.4}{28} = 0.05$	0
After dissociation	$0.05 - \left(\frac{30}{100} \times 0.05\right)$	2×0.015

$\therefore$ Total number of moles after dissociation

$$= 0.035 + 0.030 = 0.065,$$

i.e $n = 0.065$ mol, $V = 5$ L, $T = 1800$ K, p=?

From $pV = nRT$, we get $p = \frac{nRT}{V}$

$$= \frac{0.065 \text{ mol} \times 0.0821 \text{ L atm K}^{-1}\text{mol}^{-1} \times 1800 \text{ K}}{5 \text{ L}}$$

$$= 1.92 \text{ atm}$$

34. **(a)** $\Delta_r G° = -2.303\ RT \log K_p$

$$\Delta_r G° = -2.303(8.314 \text{ JK}^{-1} \text{ mol}^{-1}) \times (298 \text{ K})(\log 2.47 \times 10^{-29})$$

$$= 163229 \text{ J mol}^{-1} \approx 163 \text{ kJ mol}^{-1}$$

35. **(a)** $X = [Au(CN)_2]^-$, $Y = [Zn(CN)_4]^{2-}$

Extraction of gold involves, leaching of the metals present in the ore with CN^- ions. This is also an oxidation reaction because during the leaching process, Au oxidises to Au^+ which then combines with CN^- to form its respective soluble complexes.

$$\underset{\text{Gold}}{4Au(s)} + 8\ CN^-(aq) + 2H_2O(l) + O_2(g)$$
$$\longrightarrow \underset{\text{Soluble complex}}{4\ [Au(CN)_2]^-(aq)} + 4OH^-(aq)$$

The metals are extracted from these complexes by reduction or displacement method by using a more electropositive zinc metal.

$$2[Au(CN)_2]^-(aq) + Zn(s) \longrightarrow 2Au(s) + [Zn(CN)_4]^{2-}(aq)$$

36. **(d)**

	$N_2O_4(g) \rightleftharpoons$	$2NO_2(g)$
Pressure at equilibrium	0.28	1.1

$$K_p = \frac{p^2_{NO_2}}{p_{N_2O_4}} = \frac{(1.1)^2}{0.28} = 4.32 \text{ atm}$$

If volume of the container is doubled the pressure will reduced to half

	N_2O_4 $\rightleftharpoons$	$2NO_2$
New pressure	$\left(\frac{0.28}{2} - p\right)$	$\left(\frac{1.1}{2} + 2p\right)$

$$K_p = \frac{\left(\frac{1.1}{2} + 2p\right)^2}{\left(\frac{0.28}{2} - p\right)} = 4.32$$

On solving, $p = 0.045$

$\therefore$ $p_{N_2O_4} = 0.14 - 0.045 = 0.095$ atm

$p_{NO_2} = 0.55 + (2 \times 0.045) = 0.64$ atm

37. **(c)** Precipitation will take place when ionic product is greater than solubility product.

$$BaSO_4 \rightleftharpoons \underset{0.01}{Ba^{2+}} + \underset{S}{SO_4^{2-}}$$

$\because$ $K_{sp} = [Ba^{2+}]\ [SO_4^{2-}]$

$$S = \frac{1.0 \times 10^{-9}}{0.01} = 10^{-7} \text{mol/L}$$

38. **(d)** $2K_3[Fe(CN)_6] + 2KOH + H_2O_2 \longrightarrow$

$$2K_4[Fe\ (CN)_6] + 2H_2O + O_2$$

Reduction of potassium ferricyanide to potassium ferrocyanide. H_2O_2 has reducing property because of its electron donating property.

$H_2O_2 + 2OH^- \longrightarrow 2H_2O + O_2 + 2e^-$ (in basic medium)

$H_2O_2 \longrightarrow O_2 + 2H^+ + 2e^-$ (in acidic medium)

39. **(a)** Solvay process is economical, continuous and self contained. The raw material used for the process are only NaCl and $CaCO_3$ that are quite cheap and the biproduct of the reaction is only calcium chloride, which has no large scale industrial applications but NH_3 has large scale applications, is synthesise by other organic compounds or reagents.

40. **(b)** General molecular formula of alkane is C_nH_{2n+2}

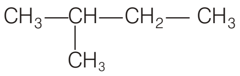
$\because$ Molecular mass = 72

$\therefore$ $12n + 2n + 2 = 72$

$n = 5$

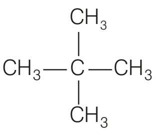
The alkane is C_5H_{12}. The possible chain isomers are :

(i) $CH_3—CH_2—CH_2—CH_2—CH_3$
Pentane

(ii) 

$CH_3—CH(CH_3)—CH_2—CH_3$

2-methylbutane

(iii) 

$CH_3—C(CH_3)_2—CH_3$

2, 2-dimethylpropane

41. **(a)** Due to extensive hydrogen bonding in water, it has a very high heat capacity. Because $\Delta H = C_p \cdot \Delta T$, $\Delta T = \frac{\Delta H}{C_p}$, which means that a large amount of heat is needed to raise the temperature of an aqueous solution by 1 K. This property is important in regulating the temperature of a cell from the heat generated by metabolic processes.

42. *(d)* Anhydrous salts with smaller cations cannot be prepared by heating the hydrated salts as the tendency for the smaller cations to get hydrated is so strong.

Thus, anhydrous $BaCl_2$ may be prepared by heating the hydrated salts beyond 127°C

$$BaCl_2 \cdot 2H_2O \xrightarrow{\text{Heat}} BaCl_2 + 2H_2O$$

However, analogous reaction cannot be carried out for magnesium chloride.

$$MgCl_2 \;.\; 6H_2O \xrightarrow{\text{Heat}} MgCl(OH) + HCl + 5H_2O$$

$$MgCl(OH) \longrightarrow MgO + HCl$$

43. *(a)* The increase of greenhouse gases concentrations (mainly carbon dioxide) led to a substantial warming of the earth and the sea, called global warming. In other words, the increase in the man-made emission of greenhouse gases is the cause for global warming. There are many major effects of global warming such as increase of temperature on the earth by about 3° to 5°C and rise of sea levels by atleast 25 metres by the year 2100.

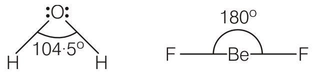
44. *(d)* Al is extracted by high temperature electrolytic reduction of Al_2O_3 to which fluorspar and cryolite have been added. Al_2O_3 reacts with carbon at high temperatures to form Al_4C_3 which does not decompose.

45. *(a)* Common oxidation state of IVA group elements are +2 and +4 but as we move down the group +2 oxidation state becomes more stable. Thus, Pb^{4+} is not possible, i.e. PbI_4 is highly unstable.

46. *(c)* **Correct Reason** In very dilute solutions both source of $H^{\oplus}$ ions from HCl and H_2O must be considered and also due to common ion (H^+) supression, ionisation occurs.

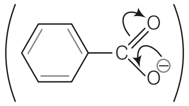
47. *(a)* The structure of H_2O is angular (V-shape) with sp^3-hybridisation and it shows bond angle equal to 104.5°. Its dipole moment (μ) value is positive or more than zero.

Hence, $\mu > 0$



But in BeF_2, structure is linear due to sp-hybridisation and its dipole moment (μ) value is zero. Thus, due to positive μ value H_2O is dipolar and due to zero μ value BeF_2 is non-polar.

48. *(c)* PhCOOH (I) is more acidic than (II) due to $-I$ and $+R$-effects of Ph group, while (II) is less acidic due to presence of only $+I$-effect, so Assertion is true. Reason is false



Since O^- of COO^- can delocalise to $>C{=}O$ group but not with the benzene ring because O^- is not conjugation with $-C{=}C-$ bond of benzene ring.

49. *(a)* The colour is due to scattering. It depends upon the size of gold sol particles. Finest gold sol has red colour. As the size of the particles increases, it becomes purple then blue and finally golden yellow.

50. *(d)* **Correct Assertion** In an atom, the velocity of electron in the higher orbits keep on decreasing.

Correct Reason Velocity of electron is inversely proportional to the radius of the orbit.

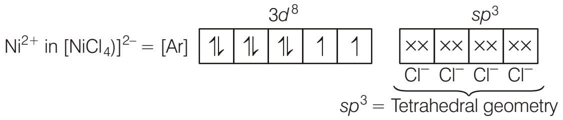
$$\text{Velocity} = 2.18 \times 10^6 \times \frac{Z}{r}.$$

51. *(a)* He shows heating effect at room temperature as it possesses very low values of inversion temperature.

52. *(c)* For a first order reaction $t_{1/2}$ does not depend upon the initial concentration of reaction. $t_{1/2}$ for first order reaction is given as $t_{1/2} = \frac{0.693}{k}$, k = rate constant.

53. *(a)* Boiling point of isomeric compounds depends on dipole-dipole interactions and *cis*-isomers have greater dipole moments (more polar) than *trans*-isomers (less polar).

54. *(b)* **Correct explanation** The complex, in which size of transition metal is small and ligand is weak field, has tetrahedral shape and sp^3 hybridisation Ni^{2+} = [Ar] $3d^8 4s^0$



55. *(c)* **Correct Reason** Natural rubber is formed through free radical addition polymerisation.

56. *(a)* Among isoelectronic species, ionic radii increase with increase in negative charge.

57. *(c)* **Correct Reason** The electronic configuration of, Ce is

$$Ce^{58} = [Xe]\, 4f^1 5d^2\, 6s^2 \text{ (predicted)}$$

$$= [Xe]\, 4f^2 5d^0\, 6s^2 \text{ (observed)}$$

$$Ce^{4+} = [Xe]\, 4f^0 5d^0\, 6s^0$$

Since, in +4 oxidation state, all, (i.e 4*f*, 5*d* and 6*s*) orbitals are empty therefore, Ce ion gains the stable configuration of nearest inert gas, hence Ce^{4+} is most stable.

58. *(a)* The boiling points of the chlorinated derivatives of methane increase with number of chlorine atoms because of an increase in the induced dipole attractive forces.

	CH_3Cl	CH_2Cl_2	$CHCl_3$	CCl_4
Boiling point	249 K	313 K	334 K	350 K

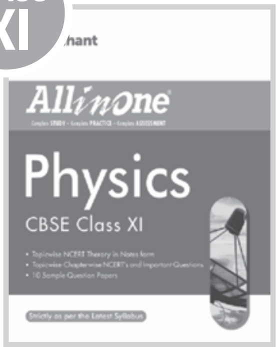
59. *(a)* Corrosion is the oxidative deterioration of a metal, such as conversion of iron to rust $[Fe_2O_3 \cdot xH_2O]$, the tarnishing of silver (due to formation of Ag_2O), development of a green coating on copper and bronze. Corrosion of iron (rusting) occurs in the presence of water and oxygen (air).

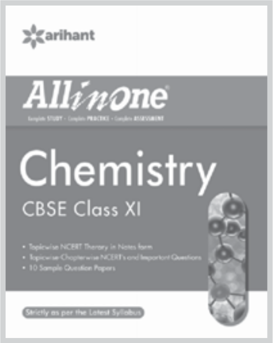
60. *(a)* The loss of a proton from an amine gives an imide ion while the loss of a proton from alcohol gives an alkoxide ion as shown

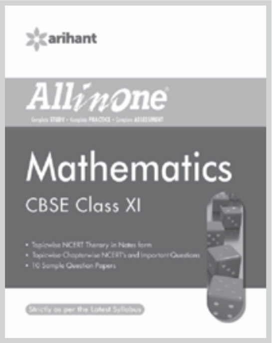
$$R{-}NH_2 \longrightarrow R{-}\bar{N}H + H^+$$

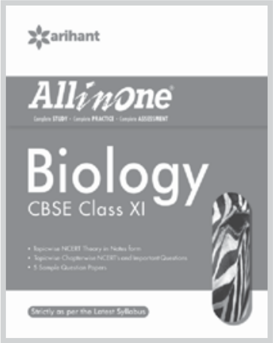
$$R{-}O{-}H \longrightarrow R{-}\bar{O} + H^+$$

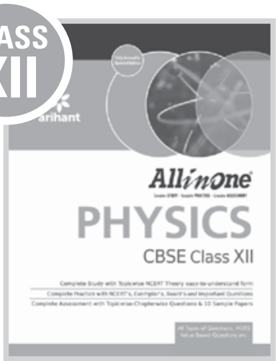
Since, oxygen is more electronegative than nitrogen, therefore, (RO^-) can accommodate the negative charge more easily than $R\bar{N}H$. In other words, RO^- is more stable than $R\bar{N}H$. Thus, alcohols are more acidic than amines. Conversely, amines are less acidic than alcohols.

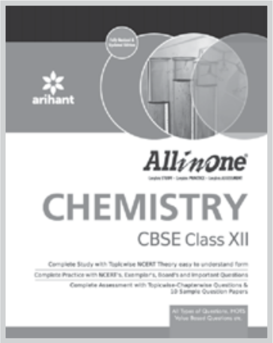


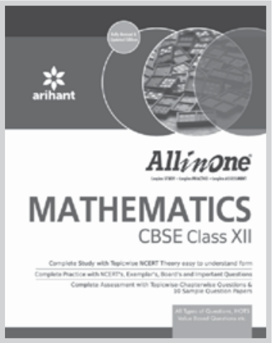


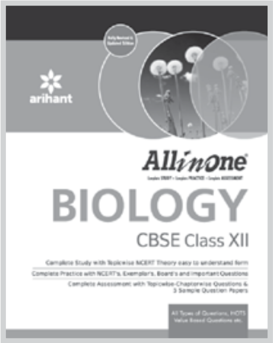












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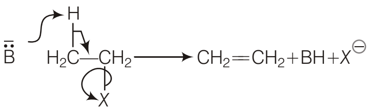
Mock Questions with Complete Solutions

Instructions

- This test consists of 60 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. β-elimination reaction is carried out with base $(\overset{..}{\bar{B}})$ as shown below:



The following bases are used for above reaction.

I. RO^- II. NO_3^-
III. $RCOO^-$ IV. $C\bar{N}$
V. $\bar{O}H$

The decreasing order of reactivity for the above elimination is

(a) I > V > IV > III > II (b) IV > V > II > I > III
(c) V > I > II > III > IV (d) III > I > IV > V > II

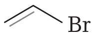
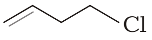
2. An ester used as medicine is.

(a) ethyl acetate (b) methyl acetate
(c) methyl salicylate (d) ethyl benzoate

3. Which of the following statements is correct?

(a) $La(OH)_3$ is the least basic hydroxide among hydroxides of lanthanides
(b) Ce^{4+} can act as an oxidising agent
(c) Ln (III) compounds are generally colourless
(d) None of the above

4. Which compound in each of the following pairs will react faster *via* S_N2 mechanism using $\bar{O}H$ nucleophile.

A. CH_3Br (I) and CH_3I (II)
B. $(CH_3)_3C—Cl$ (III) and CH_3Cl (IV)
C.  (V) and  (VI)

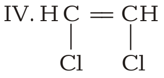
Codes

	A	B	C
(a)	I	III	V
(b)	II	III	VI
(c)	I	IV	V
(d)	II	IV	VI

5. 600 mL of ozonised oxygen at STP was found to weigh 1g. The volume of ozone in the ozonised oxygen is

(a) 150 mL (b) 50 mL
(c) 200 mL (d) 100 mL

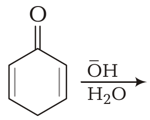
6. The decreasing order of reactivity towards electrophilic addition of the following is

I. $CH \equiv CH$ II. $CH_2 = CH_2$
III. $H_2C = CH—Cl$ IV.  $HC(Cl) = CH(Cl)$

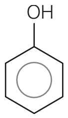
(a) II > I > III > IV
(b) I > II > III > IV
(c) IV > III > I > II
(d) IV > III > II > I

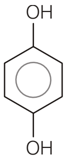
7. When 1g of an alloy of Al and Mg reacts with excess HCl it forms $AlCl_3$, $MgCl_2$ and H_2. The evolved H_2 collected over mercury at 0°C, occupied 1200 mL at 699 mm Hg. The composition of alloy with respect to Al and Mg is, respectively.

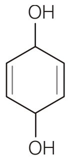
(a) 46.4% and 53.6%
(b) 58.2% and 41.8%
(c) 54.2% and 45.8%
(d) 41.8% and 58.2%

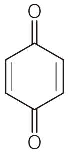
8. 

P. The product P is

(a) 

(b) 

(c) 

(d) 

9. A mixture of volatile components A and B, has total vapour pressure (in torr)

$$p = 254 - 119\chi_A$$

where, χ_A is the mole fraction of A in the mixture. Hence, p_A^0 and p_B^0 are (in torr)

(a) 119, 254 (b) 154, 119 (c) 254, 119 (d) 135, 254

10. Which one of the following statements is/are correct?

(a) AgCl with liquid ammonia forms a complex $[Ag(NH_3)_2]^+$

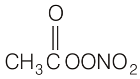
(b) Ammonium dichromate on heating, decomposes to give nitrogen and a green coloured compound

(c) CaNCN produces a white precipitate and a gas on hydrolysis. This gas turns, the moistened filter paper with copper sulphate solution, to deep blue

(d) All of the above

11. The brown haze of photochemical smog is largely attributed to

(a) NO (b) NO_2

(c) 
$CH_3\overset{\overset{\displaystyle O}{\|}}{C}OONO_2$

(d) $CH_2 = CHCHO$

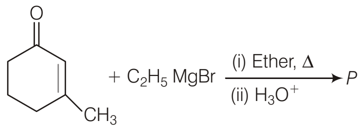
12. Consider the following sequence of reaction

$$\begin{tikzcd} Fe^{3+}(aq) \arrow[r, "\text{Excess of SCN}^-"] & \text{Blood red colour } A \arrow[dl, "\text{Excess of F}^-"'] \\ \text{Colourless } B & \end{tikzcd}$$

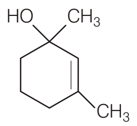
The spin only magnetic moment of (B) is

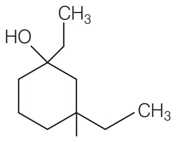
(a) $\sqrt{35}$ BM (b) $\sqrt{48}$ BM
(c) $\sqrt{15}$ BM (d) $\sqrt{24}$ BM

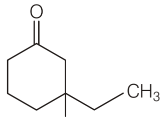
13. Consider the following reaction,



The product P is

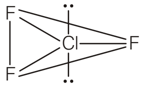
(a) 

(b) 

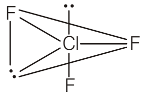
(c) 

(b) Both (a) and (b)

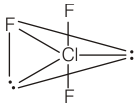
14. Central chlorine atom in ClF_3 is sp^3d-hybridised and theoretically three structures are possible



A



B



C

The most probable structure is

(a) Structure A

(b) Structure B

(c) Structure C

(d) All these three structures have same probability

15. Consider the reaction, $A(g) \rightleftharpoons B(g) + C(g)$

If K_p at 400°C is 1.5×10^{-4} and K_p at 600°C is 6×10^{-3}. Choose the incorrect statement.

(a) The reaction is exothermic

(b) Increase in pressure, increases the formation of A

(c) Increase in temperature, increases the formation of B

(d) Decrease in temperature and increase in pressure shift the equilibrium towards left

16. Consider the following statement(s).

I. Glucose exists in two different crystalline forms α-D-glucose and β-D-glucose

II. α-D-glucose and β-D-glucose are enantiomers

III. Starch is a mixture of amylose and amylopectin, both contain unbranched chain of α-D-glucose units

IV. α-D-glucose and β-D-glucose are anomers

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

17. Which of the following statements is correct?

(a) Blackened oil painting can be restored into original form by the action of MnO_2

(b) Pseudo-alum does not have Na^+ and K^+

(c) Zeolites have a more closed structure than feldspar

(d) $H_4As_2O_7$ is an *ortho* acid

18. The uncertainty in position of an electron is equal to its de-Broglie wavelength. The minimum percentage error in its measurement of velocity under this circumstance will be approximately.

(a) 18 (b) 22
(c) 8 (d) 4

19. The chemical reaction,

$$2AgCl(s) + H_2(g) \longrightarrow 2HCl(aq) + 2Ag(s)$$

taking place in a galvanic cell, is represented by the notation.

(a) $Pt(s) | H_2(g)$, 1 bar | 1M $KCl(aq) | AgCl(s) | Ag(s)$

(b) $Pt(s) | H_2(g)$, 1 bar | 1M $HCl(aq)$ | 1M $Ag^+(aq) | Ag(s)$

(c) $Pt(s) | H_2(g)$, 1 bar | 1M $HCl(aq) | AgCl(s) | Ag(s)$

(d) $Pt(s) | H_2(g)$, 1 bar | 1M $HCl(aq) | Ag(s) | AgCl(s)$

20. 0.3605 g of a metal is deposited on the electrode by passing 1.2 A current for 15 minutes through its salt. The valency of metal if its atomic weight is 96, will be

(a) 2 (b) 3
(c) 6 (d) 4

21. Which of the following is the best method for the synthesis of ester, $(H_3C)_3C—COOCH_3$?

(a) $(H_3C)_3C—COCl + CH_3OH \longrightarrow$

(b) $(H_3C)_3C—COOH + CH_2N_2 \longrightarrow$

(c) $(H_3C)_3C—COOH + CH_3OH \longrightarrow$

(d) $(H_3C)_3C—COCl + CH_3ONa \longrightarrow$

22. In the minerals, haematite and magnetite, the oxidation states of the metal respectively are

(a) + 2, + 3 in haematite and + 2 in magnetite

(b) + 3 in haematite and + 2, + 3 in magnetite

(c) + 2, + 3 in haematite and + 3 in magnetite.

(d) + 2 in haematite and + 2, + 3 in magnetite

23. A metal crystallises in a face centred cubic unit cell with edge length 0.560 nm. If it contains 0.1% Schottky defects then the density of metal is (Atomic mass of metal = 40g/ mol).

(a) 1.92 g cm^{-3} *(b)* 2.14 g cm^{-3}

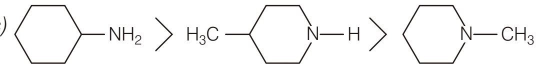
(c) 1.51 g cm^{-3} *(d)* 3.76 g cm^{-3}

24. Which of the following boiling point orders is incorrect for amines?

(a) For isomeric amines : 1° > 2° > 3°

(b) $C_4H_9NH_2 > (CH_3)_2N—C_2H_5 > (C_2H_5)_2NH$

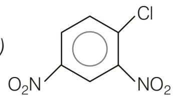
(c)



(d) None of the above

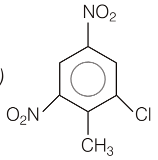
25. Which of the following compounds is correctly IUPAC named?

(a)



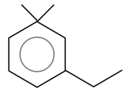
(4-chloro-1,3-dinitrobenzene)

(b)



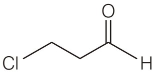
(4-methyl-5- chloronitrobenzene)

(c)



(3-ethyl-1,1-dimethylcyclohexane)

(d)



(1-chloropropanal)

26. In an adsorption experiment, a graph between log (*x* / *m*) and log *p* was linear with a slope of 45° and intercept of 0.310. Under a pressure of 0.5 atmosphere, the amount of gas adsorbed per gram of the adsorbent is

(a) 2 *(b)* 1

(c) 3 *(d)* 4

27. Which of the following complexes is correctly IUPAC named?

(a) $[CoCl(NH_3)_5]CO_3$
Chloropentaamminecobalt (III) carbonate

(b) $K_4[Ni(CN)_4]$
Potassium tetracyanonickel (0)

(c) $K_2[Zn(OH)_4]$
Potassium tetrahydroxozinc (III)

(d) $Fe_4[Fe(CN)_6]_3$
Iron (III) hexacyanoferrate (II)

28. 4% solution of sucrose $C_{12}H_{22}O_{11}$ is isotonic with 3% solution of an unknown organic substance. The molecular mass of the unknown substance is

(a) 282.2 *(b)* 261.8

(c) 256.5 *(d)* 232.7

29. The geometries of XeF_4, XeO_4 and XeO_2F_2 respectively, are

(a) tetrahedral, square pyramidal, square planar

(b) square pyramidal, square planar, tetrahedral

(c) square planar, tetrahedral, trigonal bipyramidal

(d) tetrahedral, square planar, square pyramidal

30. Consider the following reaction sequence.

$$CH_2{=}CH_2 \xrightarrow{HBr} A \xrightarrow{\text{Hydrolysis}} B \xrightarrow[I_2\text{ excess}]{Na_2CO_3} C$$

(a) C_2H_5OH *(b)* CH_3CHO

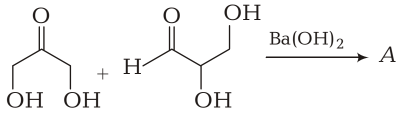
(c) CHI_3 *(d)* C_2H_5I

31. The solubility product of a salt having formula M_2X_3 is 2.2×10^{-20}. If the solubility of an another salt having formula M_2X is twice, molar solubility of M_2X is

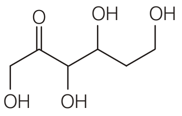
(a) 3×10^{-12} *(b)* 9.16×10^{-5}

(c) 4.58×10^{-5} *(d)* 2.76×10^{-18}

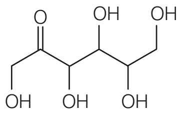
32. Consider the following reaction and give the structure of *A*.



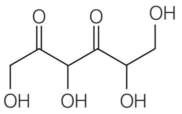
(a)



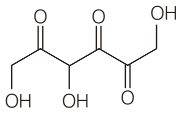
(b)



(c)



(d)



33. Which one of the following statements is correct?

(a) Among HF, CH_4, CH_3OH and N_2O_4 intermolecular hydrogen bonding is expected in all

(b) Among O_2^+, O_2, O_2^- and O_2^{2-}, O_2^{2-} has the strongest O—O bond

(c) Hydrogen bonding is the dominant intermolecular force or bond that must be overcome in converting liquid CH_3OH to a gas

(d) All of the above

34. At two stages of disintegration, constants are $2 \times 10^{-5} s^{-1}$ and $2 \times 10^{-8} s^{-1}$ respectively. At first stage 200 s atoms are disintegrating. At second stage number of atoms disintegrating will be

(a) 2 *(b)* 2000

(c) 2×10^6 *(d)* 2×10^{-6}

35. Analysis shows that nickel oxide consists of nickel ions with 96% ions having d^8 configuration and 4% having d^7 configuration. The formula of the oxide is best represented by

(a) $Ni_{0.96}O_{1.00}$ *(b)* $Ni_{0.98}O_{0.98}$
(c) $Ni_{1.00}O_{1.02}$ *(d)* $Ni_{1.02}O_{1.21}$

36. In an insulated container 1 mol of a liquid with molar volume 100 mL, is kept at 1 bar. When the volume of liquid decreases by 1mL, the liquid is steeply taken to 100 bar. The ΔH for the process is

(a) 8400 bar mL *(b)* 9900 bar mL
(c) 9240 bar mL *(d)* 7430 bar mL

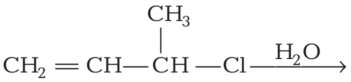
37. The nature of bonds in the dichromate dianion, are

(a) six equivalent Cr—O bonds and one Cr—Cr bond
(b) six equivalent Cr—O bonds and one Cr—O—Cr bond
(c) four equivalent Cr—O bonds
(d) six non - equivalent Cr—O bonds

38. Which one of the following is not the example of first order reaction?

(a) Acid-catalysed hydrolysis of ethyl acetate
(b) Inversion of sucrose in the presence of acid
(c) Oxidation of I^- ion by $S_2O_8^{2-}$ ion
(d) Hydrolysis of tertiary butyl halide using alkali

39. Consider the following reaction,



$$CH_2{=}CH{-}\underset{}{\overset{\displaystyle CH_3\atop|}{CH}}{-}Cl \xrightarrow{H_2O}$$

Which of the following statement is incorrect?

(a) The product is a mixture of $CH_2{=}CH{-}\overset{\displaystyle CH_3\atop|}{C}H{-}OH$ (I) and $HO{-}CH_2{-}CH{=}CH{-}CH_3$ (II) (major)
(b) The product is $CH_2{=}CH{-}\underset{\displaystyle |\atop CH_3}{C}H{-}OH$ (I) (major)
(c) Allyl chloride is reactive towards both S_N1 and S_N2 mechanisms but more reactive towards S_N1 mechanism
(d) Formation of (II) takes place by an allylic rearrangement

40. For the preparation of sodium thiosulphate by Spring's reaction, the reactants used are

(a) $Na_2S + Na_2SO_3 + Cl_2$
(b) $Na_2S + SO_2$
(c) $Na_2SO_3 + S$
(d) $Na_2S + Na_2SO_3 + I_2$

Directions (Q. Nos. 41-60) *In the following questions a statement of Assertion followed by a statement of Reason, is given. Choose the correct answer out of the following choice.*

(a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion
(b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion
(c) Assertion is true but Reason is false
(d) Both Assertion and Reason are false

41. **Assertion** (A) Buta-1, 3-diene is the monomer of Gutta Percha.

Reason (R) Gutta Percha is formed through anionic addition polymerisation.

42. **Assertion** (A) *t*-butyl bromide gives 2, 2, 3, 3-tetramethyl butane on reaction with sodium metal in dry ether.

Reason (R) *t*-alkyl halides readily undergo Wurtz reaction.

43. **Assertion** (A) The molecular masses of polymers cannot be calculated using the freezing point or boiling point method.

Reason (R) The boiling point method for determining the molecular masses is used for compounds stable at higher temperature.

44. **Assertion** (A) The dissociation of NH_3 on hot platinum surface may be of zero order or first order.

Reason (R) Pressure of the gas affects the order of reaction.

45. **Assertion** (A) The reaction between NH_3 and MnO_4^- occurs in an acidic medium

$$NH_3 + MnO_4^- \longrightarrow MnO_2 + NO_2$$

Reason (R) MnO_4^- is reduced to MnO_2 in acidic medium.

46. **Assertion** (A) Using Pt electrodes, at the end of electrolysis, an aqueous solution of $CuSO_4$ turns colourless.

Reason (R) $CuSO_4$ changes to $Cu(OH)_2$ during electrolysis.

47. **Assertion** (A) According to Werner's theory, ligands are connected to the metal ions by covalent bonds and secondary valencies have non directional properties.

Reason (R) Secondary valencies are ionisable.

48. **Assertion** (A) The actinoids exhibit more number of oxidation states in general than the lanthanoids.

Reason (R) The 5*f* orbitals extend farther from the nucleus than the 4*f* orbitals.

49. **Assertion** (A) RS^- is a stronger nucleophile and a better leaving group than RO^-.

Reason (R) RS^- is a weaker base than RO^-.

50. **Assertion** (A) The heat of neutralisation of a strong acid with a strong base is equal to heat of ionisation of water.

Reason (R) Water ionises to a very small extent while H^+ ions form an acid which combines very rapidly with $\bar{O}H$ from a base to form H_2O.

51. **Assertion** (A) HNO_3 renders iron passive.

Reason (R) Iron reacts with HNO_3 to form ferric nitrate.

52. **Assertion** (A) $\begin{matrix}H_3C\\H_3C\end{matrix}\!\!>\!\!{-}CHO$ undergoes Aldol condensation reaction.

Reason (R) Compounds containing α - H atom undergo Cannizzaro reaction.

53. **Assertion** (A) The boiling point of hexane (341K) is greater than CF_4 (144K).

Reason (R) Hexane and CF_4 have the same molecular mass and are non-polar in nature.

54. **Assertion** (A) Electronaffinity is positive, when O^- changes to O^{2-}.

Reason (R) O^- repels the incoming electron due to similar charge and needs energy to accept the electron.

55. **Assertion** (A) $PhNH_3Br$ is more acidic than NH_4Br.

Reason (R) $Ph\overset{+}{N}H_3$ (anilinium ion) is resonance stabilised.

56. **Assertion** (A) For a reaction,

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g);\ \Delta H > \Delta E$$

Reason (R) Enthalpy change is always greater than internal energy change.

57. **Assertion** (A) C—H bond in ethyne is shorter than C—H bond in ethene.

Reason (R) Carbon atom in ethene is *sp* hybridised while it is sp^2 hybridised in ethyne.

58. **Assertion** (A) Two different bond lengths are observed in PF_5 molecule but only one bond length is observed in SF_6.

Reason (R) PF_5 has trigonal bipyramidal structure and SF_6 has octahedral structure.

59. **Assertion** (A) Precisely 1 mole of helium and 1 mole of neon are placed in a container, then the molecules of helium strike the wall more frequently.

Reason (R) Molecules of helium have lesser average molecular speed.

60. **Assertion** (A) The decreasing order of the anti- knocking value of octane number is

$$C_4H_{10} > C_3H_8 > C_2H_6 > CH_4$$

Reason (R) As the number of carbon-atoms increases, knocking power decreases.

Answers *with* Explanation

1. ***(a)*** The reagent should be a strong Bronsted base.

Acidic order $HNO_3 > RCOOH > HCN > H_2O > ROH$

Basic order $NO_3^- < RCOO^- < CN^- < \bar{O}H < RO^-$

Hence, decreasing order of basicities for β-elimination is

$$I > V > IV > III > II.$$

2. ***(b)*** Methyl salicylate is used to relive muscular aches, pains and rheumatic conditions.

3. ***(b)*** $La(OH)_3$, is the most basic hydroxide among hydroxides of lanthanides. Ln(III) compounds are generally coloured due to the presence of unpaired *f*-electrons that undergo *f-f* transition.

4. ***(d)*** A. (II), I^- is a better leaving group than Br^-

   B. (IV), 1° alkyl halide undergoes faster S_N2 reaction than 3° alkyl halide

   C. (VI), Vinyl halide (V) does not undergo S_N1 or S_N2 reaction as nucleophile is repelled by the π-electron cloud of alkene. Since (VI) is 1° alkyl halide therefore it undergoes *via* S_N2 mechanism.

5. ***(c)*** Let, the volume of O_3 in ozonised oxygen = *x* mL

Volume of O_2 present in ozonised oxygen = (600 – *x*) mL

22400 mL of O_3 and O_2 at STP will weigh 48 g and 32 g, respectively.

The weight for *x* mL of $O_3 = \dfrac{x \times 48}{22400}$ g

The weight for (600 – *x*) mL of $O_2 = \dfrac{(600 - x)}{22400} \times 32$

Total weight of ozonised O_2 (600 mL) is

$$\frac{48x}{22400} + \frac{(600 - x) \times 32}{22400} = 1$$

$$48x + 19200 - 32x = 22400$$

$$16x = 3200$$

$$x = 200 \text{ mL}$$

6. ***(a)*** The order of electrophilic addition is alkene > alkyne. But if alkene has electron withdrawing group, reactivity of alkene becomes less than that of alkyne.

Due to EWG, electron density at (C=C) or nucleophilicity decreases, so addition of electrophile to C=C becomes slow.

So, the decreasing order of electrophilic addition is

alkene (II) > alkyne (I) > alkene with one EWG (III)
> alkene with two EWGs(IV).

7. ***(c)*** The reactions involved are as follow:

$$Al + 3HCl \longrightarrow AlCl_3 + \frac{3}{2}H_2$$

$$Mg + 2HCl \longrightarrow MgCl_2 + H_2$$

Let, the mass of Al = *x* g

∴ Mass of Mg = (1 – *x*) g

$$\text{Mole of } H_2(n) = \frac{PV}{RT} = \frac{\frac{699}{760} \times 1.2}{0.0821 \times 273} = 0.0492$$

$$\text{Mole of } H_2 = \frac{3}{2} \times \frac{x}{27} + 1 \times \frac{(1 - x)}{24} = 0.0492$$

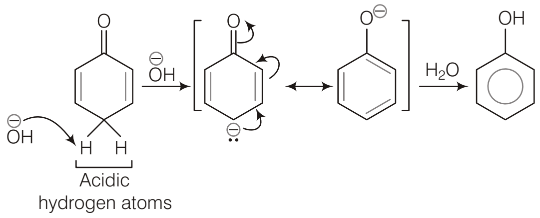
$$0.0555x + 0.042(1 - x) = 0.0492$$

$$\Rightarrow \quad 0.0135x = 7.24 \times 10^{-3}$$

$$x = 0.542 \text{ g}$$

$$\Rightarrow \quad \%\ Al = 54.2\%,\ \%\ Mg = (100 - 54.2)\ \% = 45.8\%.$$

8. ***(a)*** The reaction takes place as follows



Acidic
hydrogen atoms

9. **(d)** $p_{\text{Total}} = p_A^0\chi_A + p_B^0\chi_B$

$$= p_A^0\chi_A + p_B^0(1-\chi_A)$$

$$= p_B^0 - (p_B^0 - p_A^0)\chi_A \qquad \ldots \text{(i)}$$

$$p = 254 - 119\,\chi_A \qquad \text{[Given]}$$

On comparing with the equation (i), we get

$$\therefore \qquad p_B^0 = 254$$

$$p_B^0 - p_A^0 = 119$$

$$\Rightarrow \qquad p_A^0 = 254 - 119 = 135$$

10. **(d)** $AgCl + 2NH_3 \longrightarrow [Ag(NH_3)_2]^+ + Cl^-$

$$(NH_4)_2Cr_2O_7 \xrightarrow{\Delta} N_2 + Cr_2O_3 + 4H_2O$$

$$CaNCN + 3H_2O \longrightarrow \underset{\text{White ppt.}}{CaCO_3} + 2NH_3$$

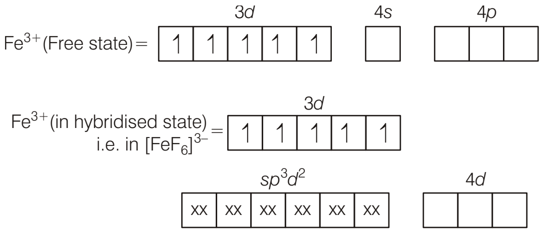
11. **(b)** Photochemical smog is mainly composed of ozone and nitrogen dioxide (NO_2). NO_2 is introduced in atmosphere *via* vehicular emissions and industrial processes. This NO_2 is photolysed by solar radiations to produce nitrogen oxide (NO) and an unpaired oxygen atom ($\dot{O}$). $\dot{O}$ combines with O_2 molecule to produce ozone (O_3).

However, when volatile organic compounds (VOCs) are present in the atmosphere, these oxidise NO to NO_2 without breaking down any ozone molecule in this process. These NO_2 molecules form brown haze of photochemical smog in atmosphere.

12. **(a)** The given reaction sequence is

$$Fe^{3+}(aq) + \underset{\text{Excess}}{SCN^-} \longrightarrow \underset{\substack{\text{Blood red}\\ \text{colour}\\ (A)}}{Fe(SCN)_3} \xrightarrow{\text{Excess of } F^-} \underset{\substack{\text{Colourless}\\ (B)}}{[FeF_6]^{3-}}$$

In $[FeF_6]^{3-}$, Fe^{3+} has electronic configuration $3d^5$, F^- being weak field ligand, cannot pair up the electrons of 3*d*-orbital. Hence, $[FeF_6]^{3-}$ shows sp^3d^2 hybridisation to possess octahedral shape with five unpaired 3*d* electrons.



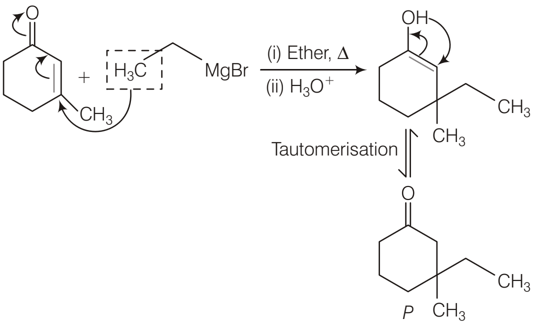
Thus, spin magnetic moment,

$$\mu = \sqrt{n(n+2)}\ \text{BM}$$

$$= \sqrt{5(5+2)}\ \text{BM}$$

$$= \sqrt{35}\ \text{BM}$$

13. **(c)** α, β-unsaturated ketone gives predominantly 1,4-addition product with Grignard's reagent.



14. **(c)** The most stable structure will be the one with lowest energy or with minimum steric repulsion. The order of repulsion between different kinds of electron pairs is

$$lp - lp > lp - bp > bp - bp.$$

Also, the less is separation, more is repulsion. Thus, repulsion between two electron pairs at 90° will be more than when they are at 120°.

(i) In structure *A*, there are 6 repulsions between *lp* – *bp* at 90°

(ii) In structure *B*, there is one 90°, *lp* – *lp* repulsion, and three 90°, *lp* – *bp* repulsion.

In structure (*C*), there are four 90° *lp-bp* repulsions and no 90° *lp-lp* repulsion. Therefore, structure (*C*) is most probable.

15. **(a)** For $A(g) \rightleftharpoons B(g) + C(g)$

(a) With increase of temperature, K_P increases, i.e. with increase of temperature, the reaction is favoured in forward direction and hence, reaction is endothermic

(b) $\Delta n_g = 1 + 1 - 1 = 1$

Δn_g = positive, i.e. with the increase of pressure, reaction is favoured in backward direction and hence, the formation of $A(g)$ increases

(c) Increase of temperature favours forward reaction and hence, the formation of *B* increases

(d) From the statements (a) and (b), the reaction is favoured in backward direction with decrease of temperature and increase of pressure

16. **(c)** II is incorrect because α-D-glucose and β-D-glucose are not enantiomers but are anomers.

III is incorrect because starch is a mixture of amylose and amylopectin. Amylose is a linear polymer of α-D-glucose but amylopectin is highly branched polymer of α-D-glucose.

17. **(b)** (a) Old oil paintings becomes black due to the formation of black PbS, H_2O_2 converts it into white $PbSO_4$.

$$\underset{\text{White}}{PbO} + H_2S \longrightarrow \underset{\text{Black}}{PbS} + H_2O$$

$$PbS + 4H_2O_2 \longrightarrow \underset{\text{White}}{PbSO_4} + 4H_2O$$

(b) Pseudo-alum constitutes a class in which monovalent atom of true alum is replaced by a divalent atom. Hence, Na^+ and K^+ are not present in pseudo-alums.

(c) Feldspar has more closed structure than zeolites

(d) $H_4As_2O_7$ is a pyro acid.

18. **(c)** We know de-Broglie wavelength $(\lambda) = \frac{h}{p}$

According to Heisenberg uncertainty principle,

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

On neglecting '>' sign

$$\frac{h}{p} \times \Delta p = \frac{h}{4\pi}$$

(As uncertainty in position $(\Delta x) = \frac{h}{p}$)

$$\frac{\Delta p}{p} = \frac{1}{4\pi}$$

$$\frac{m \times \Delta v}{m \times v} = \frac{1}{4\pi}$$

$$\frac{\Delta v}{v} = \frac{1}{4\pi}$$

$\therefore$ % (uncertainty in velocity) $= \frac{\Delta v}{v} \times 100 = \frac{1}{4\pi} \times 100 = 8\%$.

19. **(b)** The cell representation can be represented as

$$\underset{\text{Anode}}{\text{Pt}(s) \mid \text{H}_2(g)\,(1\text{ bar})} \mid 1\text{M HCl}(aq) \mid 1\text{ M } \underset{\text{Cathode}}{\text{Ag}^+(aq) \mid \text{Ag}(s)}$$

20. **(b)** Amount of electricity passed,

$$Q = it = 1.2 \times 15 \times 60 = 1080\text{ C}$$

Mass of metal deposited by passing

1080 C electricity = 0.3605

Mass of metal deposited by passing

$$96500\text{ C electricity} = \frac{0.3605}{1080} \times 96500 = 32.2\text{g}$$

$\therefore$ Equivalent mass of metal $= 32.2\text{g mol}^{-1}$

Atomic mass $= 96\text{ g mol}^{-1}$

$$\text{Valency} = \frac{\text{Atomic mass}}{\text{Equivalent mass}} = \frac{96}{32.2} = 3$$

21. **(b)** The esterification of an alcohol with $RCOCl$ or with $RCOOH$ is affected by steric hindrance. Bulky group on either alcohol or acid derivatives slow down the reaction.

So, the esterification with diazomethane (CH_2N_2) is the best method.

22. **(b)** In haematite, i.e. Fe_2O_3 oxidation state of Fe is

$$2x + 3 \times (-2) = 0$$

$$\therefore \quad x = 3$$

Magnetite, i.e. Fe_3O_4 is an equimolar mixture of FeO and Fe_2O_3

$\therefore$ Oxidation states of iron in FeO is +2 and in Fe_2O_3 is + 3.

23. **(c)** Due to Schottky defect, the vacant spaces will increase resulting decrease in number of atoms per unit cell. As 0.1% Schottky defects are present, Hence, decrease in number of atoms in fcc unit cell is,

$$Z = 4 - \frac{4 \times 0.1}{100} = 3.996$$

$$\text{Density, } \rho = \frac{Z \times M}{N_0 \times a^3}$$

$$= \frac{3.996 \times 40\text{ g mol}^{-1}}{(6.022 \times 10^{23}\text{ mol}^{-1})\,(0.560 \times 10^{-7}\text{ cm})^3}$$

$$= 1.51\text{g cm}^{-3}.$$

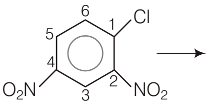
24. **(b)** The correct boiling point order for option (b) is

$$C_4H_9NH_2 > (C_2H_5)_2\,NH > (CH_3)_2\,N{-}C_2H_5$$

(As for amines boiling point follows the order 1° > 2° > 3°).

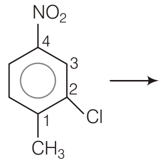
25. **(c)**

(a)



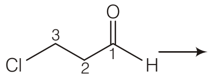
1-chloro-2,4-dinitrobenzene

(b)



2-chloro-1-methyl-4- nitorobenzene

(d)



3-chloropropanal

26. **(b)** According to Freundlich adsorption isotherm,

$$\frac{x}{m} = k\,p^{1/n}$$

Taking logarithm on both the sides

$$\log\,(x\,/\,m) = \log\,k + \frac{1}{n}\log\,p$$

Plot of $\log\,(x\,/\,m)$ vs $\log\,p$ is linear with slope $= 1\,/\,n$ and intercept $= \log\,k$

$$\text{Slope} = \frac{1}{n} = \tan 45° = 1$$

$\therefore n = 1$

Intercept, $\log\,k = 0.3010$

or $\quad k = 2$

$$\frac{x}{m} = kp^{1/n} = 2 \times (0.5)^1 = 1.0$$

27. **(d)** Correct names of (a), (b) and (c) respectively, are

(a) Pentaamminechlorocobalt (III) carbonate.

(b) Potassium tetracyanonickelate (0)

(c) Potassium tetrahydroxozincate (II)

28. **(c)** Since, the two solutions are isotonic, they must have same concentrations in moles/litre for sucrose solution,

Concentration of sucrose solution

$$= 40\text{g / L} = \frac{40}{342}\text{ mol L}^{-1}$$

For unknown substance, suppose m is the molecular mass, then

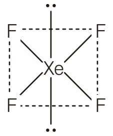
Concentration of unknown substance

$$= 30\text{g/L} = \frac{30}{M_w}\text{ mol L}^{-1}$$

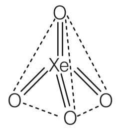
$$\therefore \quad \frac{30}{M_w} = \frac{40}{342}$$

$$M_w = \frac{30 \times 342}{40} = 256.5\text{ g mol}^{-1}$$

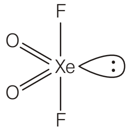
29. **(c)**



Hybridisation-sp^3d^2
Geometry-square planar

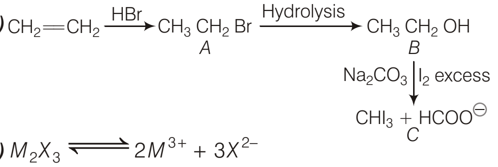


Hybridisation-sp^3
Geometry-Tetrahedral



Hybridisation-sp^3d
Geometry-Trigonal bipyramidal or *see-saw*

30. **(c)**



$$\underset{A}{CH_2{=}CH_2 \xrightarrow{HBr} CH_3CH_2Br} \xrightarrow{\text{Hydrolysis}} \underset{B}{CH_3CH_2OH} \xrightarrow[Na_2CO_3]{I_2\ \text{excess}} CHI_3 + \underset{C}{HCOO^{\ominus}}$$

31. **(a)** $M_2X_3 \rightleftharpoons 2M^{3+} + 3X^{2-}$

$2S \qquad 3S$

Solubility product $K_{sp} = (2S)^2\,(3S)^3$

$= 108S^5 \qquad (S = \text{Solubility})$

or $\quad 2 \cdot 2 \times 10^{-20} = 108S^5$

or $\quad S = 4.59 \times 10^{-5}$

Again for M_2X

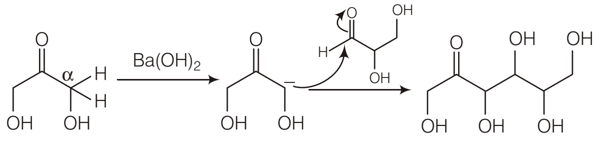
$$M_2X \rightleftharpoons \underset{2S'}{2M^+} + \underset{S'}{3X^{2-}}$$

$$K'_{sp} = (2S')^2 \cdot (S') = 4S'^3$$

or $\quad K'_{sp} = 4\,(2 \times 4.59 \times 10^{-5})^3 \qquad (\because S' = 4 \times S)$

$\therefore \quad K'_{sp} = 3 \times 10^{-12}$

32. **(b)** Aldehydes react faster than ketones as they are good electron acceptors. Therefore, carbanion formed by the removal of α – H-atom of ketone with base, adds to the C-atom of (CH ═ O) group to give β-hydroxy ketone.



Required product

33. **(c)** Intermolecular hydrogen bond is present in HF and CH_3OH

$O_2(8 + 8 = 16 \text{ electrons})$

$$= \sigma 1s^2, \sigma^* 1s^2, \sigma 2s^2, \sigma^* 2s^2, \pi 2p_z^2,$$

$$\pi 2p_x^2 \approx \pi 2p_y^2, \pi^* 2p_x^1 \approx \pi^* 2p_y^1$$

$$\text{Bond order} = \frac{10 - 6}{2} = 2$$

$$O_2^+ \text{ (electrons} = 8 + 8 - 1) = 15;\ BO = \frac{10 - 5}{2} = 2.5$$

$$O_2^- \text{ (electrons} = 8 + 8 + 1) = 17;\ BO = \frac{10 - 7}{2} = 1.5$$

$$O_2^{2-} \text{ (electrons} = 8 + 8 + 2) = 18;\ BO = \frac{10 - 8}{2} = 1$$

$$\text{Bond order} \propto \frac{1}{\text{Bond length}};\ \propto \text{Bond strength}$$

$\because O_2^+$ has the minimum bond length as its bond order is maximum

The O—O bond is strongest

The molecules of CH_3OH are associated by H-bonding.

34. **(c)** $N_1\lambda_1 = N_2\lambda_2$

$$N_2 = N_1 \frac{\lambda_1}{\lambda_2} = 2000 \times \frac{2 \times 10^{-5}}{2 \times 10^{-8}}$$

$= 2 \times 10^6$ atoms

35. **(c)** Ni (Atomic number = 28) = $3d^8 4s^2$

$\therefore \quad Ni^{2+} = 3d^8$ and $Ni^{3+} = 3d^7$

Hence, 96% ions of Ni^{2+} and 4% ions of Ni^{3+} are present.

Let, the number of O^{2-} ions present in the crystal = x

Applying electroneutrality rule,

Total positive charge = Total negative charge

0.96×2 (positive charge) + 0.04×3 (positive charge)

$= x \times 2$ (negative charge)

$\therefore (0.96 \times 2) + (0.04 \times 3) - 2x = 0$

$\therefore \quad x = 1.02$

Therefore, formula of crystal is

$Ni_{1.00}O_{1.02}$

36. **(b)** At pressure 1 bar

Volume of 1 mol of liquid = 100 mL

At pressure 100 bar

Volume of 100 mol liquid = 99 mL

Since, the process is steeply changed from 1 bar to 100 bar, it is irreversible process.

$\therefore \quad w = -\,p(V_2 - V_1) = -\,100 \times (99 - 100) = 100$ bar mL

$\Delta U = q + w$

$\Rightarrow \quad \Delta U = w$

$[\because q = 0$, adiabatic nature due to insulation]

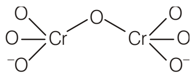
$\Delta U = 100$ bar mL

$\Delta H = \Delta U + p\Delta V = \Delta U + (p_2V_2 - p_1V_1)$

$= 100 + (100 \times 99 - 1 \times 100)$

$= 9900$ bar mL

37. **(b)** In $Cr_2O_7^{2-}$ ion, there are six equivalent Cr—O bonds and one Cr—O—Cr bond

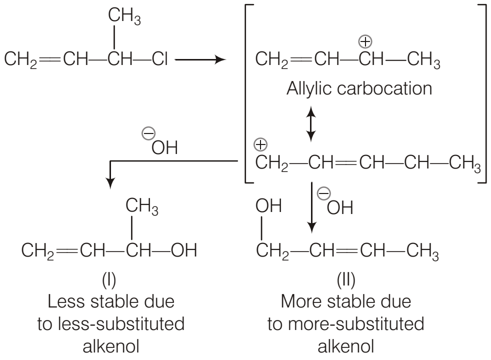


38. **(c)** It is a second order reaction, first order with respect to both $S_2O_8^{2-}$ and I^-

$\therefore r = k[S_2O_8^{2-}]\,[I^-]$

All other options except(c) are the examples of first order reaction.

39. **(b)** The reaction takes place as follows:



40. **(d)** Spring's method is used for the preparation of sodium thiosulphate (hypo).

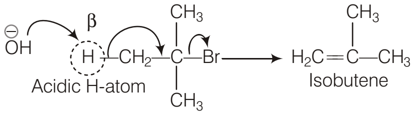
$$I_2 + \underset{\text{Sodium sulphide}}{Na_2S} + \underset{\text{Sodium sulphite}}{Na_2SO_3} \longrightarrow 2NaI + \underset{\text{Sodium thiosulphate}}{Na_2S_2O_3}$$

41. **(d)** Gutta Percha is synthetic rubber and its monomer is isoprene.

Since, isoprene contains electron donating group, therefore it is prepared by cationic addition polymerisation.

42. **(d)** *t*-BuBr gives isobutene on reaction with strong base.

t-alkyl halides undergo dehydrohalogenation in the presence of strong base such as alc. KOH rather than Wurtz reaction.



∴ 1° and 2° *RX* undergo Wurtz reaction, while 3° *RX* undergoes dehydro halogenation to give alkenes.

43. **(a)** The molecular masses of large molecules are determined using the osmotic pressure technique. The molecular masses of smaller molecules are determined using the freezing point lowering method.

44. **(a)** At low pressure, it is first order reaction while at high pressure, it is a zero order reaction.

The expression for the rate of decomposition of NH_3 on Pt surface is

Rate $= \dfrac{k_1 p_{NH_3}}{1 + k_2 p_{NH_3}}$, where k_1 and k_2 are rate constants for different steps involved during reaction.

When pressure of ammonia is very small then

$$k_2 p_{NH_3} << 1$$

Rate $= k_1 \; p_{NH_3}$, i.e. first order

When pressure of ammonia is high then $k_2 p_{NH_3} >> 1$

$$\text{Rate} = \frac{k_1 p_{NH_3}}{k_2 \; p_{NH_3}} = \frac{k_1}{k_2} = k$$

i.e. zero order.

45. **(d)** MnO_4^- is reduced to MnO_2 in a mild basic medium or neutral medium whereas in an acidic medium, MnO_4^- is reduced to Mn^{2+} and in a strong basic medium, it is reduced to MnO_4^{2-}.

46. **(c)** Assertion is correct. Since, Cu^{2+} ions are reduced to Cu and deposited at cathode. H_2O is oxidised at anode (SO_4^{2-} is not oxidised)

$$H_2O \longrightarrow 2H^+ + 2e^- + \frac{1}{2}O_2 ; 2H^+ + SO_4^{2-} \longrightarrow H_2SO_4$$

The solution becomes colourless due to the formation of H_2SO_4 in solution.

47. **(d)** Ligands are attached to the metal ion by coordinate bonds, which are directional and are called secondary valencies in case of complex ion. Secondary valencies are non-ionisable.

48. **(a)** As 5*f* orbitals extend farther from the nucleus than 4*f* orbitals, the attraction on the 5*f* electrons in actinoid series decreases. Hence, they can easily participate in bonding and, therefore exhibit more number of oxidation states.

49. **(a)** *R*SH has more acidity as compare to *R*OH and RS^- has less basicity than RO^-.

When nucleophilic centres are different and belong to the same group, nucleophilicity is antiparallel to basicity.

Nucleophilicity $R\bar{S} > RO^-$

Weaker the base, better is the leaving group.

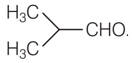
So, the leaving group ability of RS^- is greater than RO^-.

50. **(b)** Dissociation of water is

$$H_2O \rightleftharpoons H^+ + \bar{O}H$$

Which is reverse of the heat of neutralisation and the value of heat is equal but sign is reverse.

51. **(c)** Correct reason is HNO_3 reacts with Fe to form a thin impervious layer of ferrosoferric oxide ($FeO \cdot Fe_2O_3 \equiv Fe_3O_4$) on the surface of iron which protects it from further reaction.

52. **(d)** Compounds containing α-H-atom undergo aldol condensation but the α H-atom of compound  does not undergo aldol condensation. It undergoes Cannizzaro reaction because the mobility of α-H-atom is arrested by two sterically hindered methyl groups.

53. **(b)** Hexane is a straight-chain alkane (or unbranched), so it is less compact or has more surface area and hence has higher boiling point than CF_4. Whereas, CF_4 is spherical and has less approachable area for intermolecular attractive force and hence, has lower boiling point.

54. **(a)** When O^- changes into O^{2-}, change is endothermic. The reason is that O^- repels the incoming electron due to similar charge, hence it needs energy to accept the electron. Hence, electronaffinity is positive.

55. **(c)** NH_3 is a stronger base than aniline; therefore, the conjugate acid of aniline, i.e. $Ph\overset{+}{N}H_3$ is more acidic than the conjugate acid of NH_3, i.e. $\overset{+}{N}H_4$ ion.

56. **(c)** $\Delta n_g = 1 - 0 = 1$

$$\Delta H = \Delta E + \Delta n_g RT = \Delta E + RT$$
$$\Delta H > \Delta E$$

57. **(c)** The carbon atom is sp^2 hybridised in ethene while *sp* hybridised in ethyne.

58. **(a)** Trigonal bipyramidal structures (PF_5, P has sp^3d-hybridisation) have two different type of bonding two are axial 90° away from a plane and three are equatorial in the plane. The equatorial bonds are 120° away from each other. Since, the bonding is different, the bond lengths are not expected to be the exactly same. In SF_6, S-atom has sp^3d^2-hybridisation showing octahedral arrangement with each bond angle at 90° to the other and thus, bond lengths are same.

59. **(c)** Helium gas has lower molecular mass and hence it moves faster than neon and strikes the wall more frequently.

$$\mu_{av} = \sqrt{\frac{8RT}{\pi M}}$$
$$\mu_{av} \propto \left(\frac{1}{M}\right)^{1/2}$$

Hence, helium has higher speed than neon.

60. **(d)** The correct decreasing order of anti-knocking value of octane number is $CH_4 > C_2H_6 > C_3H_8 > C_4H_{10}$

Because as the number of C-atoms increases, knocking power increases or anti-knocking power decreases.

Exam held on 18 March, 2016

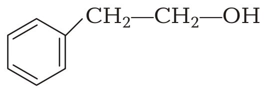
{EXAM DIARY}

CBSE
EXAMINATION PAPER
2016
SOLVED (All India)

General Instructions

- All questions are compulsory.
- Question number 1 to 5 are very short answer questions and carry 1 mark each.
- Question number 6 to 10 are short answer questions and carry 2 marks each.
- Question number 11 to 22 are also short answer questions and carry 3 marks each.
- Question number 23 is a value based question and carry 4 marks.
- Question number 24 to 26 are long answer questions and carry 5 marks each.
- Use log tables, if necessary, use of calculators is not allowed.

1. Write the IUPAC name of the given compound,



2. Write the structure of an isomer of compound C_4H_9Br, which is the most reactive towards S_N1 reaction.

3. What is the reason for the stability of colloidal sols?

4. Give an example each of a molecular solid and an ionic solid.

5. $Pb(NO_3)_2$ on heating gives a brown gas which undergoes dimerisation on cooling. Identify the gas.

6. For a reaction, $H_2 + Cl_2 \xrightarrow{h\nu} 2HCl$

Rate $= k$

(i) Write the order and molecularity of this reaction.

(ii) Write the unit of k.

7. Write the chemical equations involved in the following reactions:

(i) Hofmann-bromamide degradation reaction

(ii) Carbylamine reaction

8. (i) Gas (A) is more soluble in water than gas (B) at the same temperature. Which one of the two gases will have the higher value of K_H (Henry's constant) and why?

(ii) In non-ideal solution, what type of deviation shows the formation of maximum boiling azeotropes?

9. When a coordination compound $CoCl_3 \cdot 6NH_3$ is mixed with $AgNO_3$, 3 moles of AgCl are precipitated per mole of the compound. Write

(i) structural formula of the complex.

(ii) IUPAC name of the complex.

10. Write the structures of the following compounds:

(i) BrF_3 (ii) XeF_4

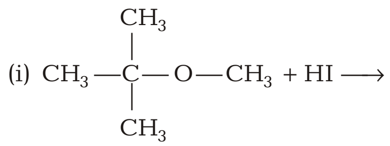
or

What happens when

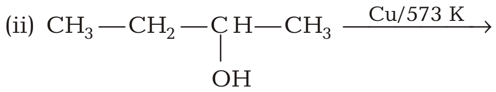
(i) SO_2 gas is passed through an aqueous solution of Fe^{3+} salt?

(ii) XeF_4 reacts with SbF_5?

11. Write the final product(s) in each of the following reactions:



(i) $CH_3-C(CH_3)_2-O-CH_3 + HI \longrightarrow$



(ii) $CH_3-CH_2-CH(OH)-CH_3 \xrightarrow{Cu/573\ K}$

(iii) $C_6H_5-OH \xrightarrow[\text{(ii) } H^+]{\text{(i) } CHCl_3 + aq.NaOH}$

12. How do you convert

(i) chlorobenzene to biphenyl?

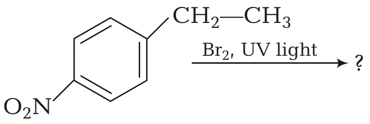
(ii) propene to 1-iodopropane?

(iii) 2-bromobutane to but-2-ene?

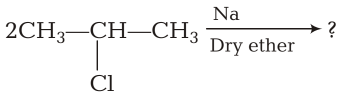
or

Write the major product(s) in the following reactions:

(i)



(ii)



$2CH_3-\underset{\underset{Cl}{|}}{CH}-CH_3 \xrightarrow[\text{Dry ether}]{Na} ?$

(iii) $CH_3-CH_2-Br \xrightarrow{AgCN} ?$

13. (i) Write the structure difference between starch and cellulose.

(ii) What type of linkage is present in nucleic acids?

(iii) Give one example each for fibrous protein and globular protein.

14. (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?

15. Give reasons.

(i) SO_2 is a reducing while TeO_2 is an oxidising agent.

(ii) Nitrogen does not form pentahalides.

(iii) ICl is more reactive than I_2.

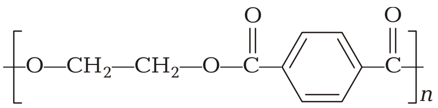
16. (i) For the complex $[Fe(H_2O)_6]^{3+}$, write the hybridisation, magnetic character and spin of the complex. (Atomic number of Fe = 26)

(ii) Draw one of the geometrical isomers of the complex $[Pt(en)_2Cl_2]^{2+}$ which is optically inactive.

17. An element crystallises in a bcc lattice with edge length of 500 pm. The density of the element is 7.5 g cm^{-3}. How many atoms are present in 300 g of the element?

18. (i) What is the role of sulphur in the vulcanisation of rubber?

(ii) Identify the monomers in the following polymer.



(iii) Arrange the following polymers in the increasing order of their intermolecular forces.

Terylene, Polythene, Neoprene

19. For the first order thermal decomposition reaction, the following data were obtained.

$$C_2H_5Cl(g) \longrightarrow C_2H_4(g) + HCl(g)$$

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)

20. Give reasons for the following.

(i) Aniline does not undergo Friedal-Crafts reaction.

(ii) $(CH_3)_2NH$ is more basic than $(CH_3)_3N$ in an aqueous solution.

(iii) Primary amines have higher boiling point than tertiary amines.

21. Define the following terms.

(i) Lyophilic colloid (ii) Zeta potential

(iii) Associated colloids

22. Calculate the boiling point of solution when 4 g of $MgSO_4$ ($M = 120 \text{ g mol}^{-1}$) was dissolved in 100 g of water, assuming $MgSO_4$ undergoes complete ionisation. (K_b for water $= 0.52 \text{ K kg mol}^{-1}$)

23. Due to hectic and busy schedule, Mr Singh started taking junk food in the lunch break and slowly became habitual of eating food irregularly to excel in his field. One day during meeting, he felt severe chest pain and fell down. Mr Khanna, a close friend of Mr Singh, took him to doctor immediately. The doctor diagnosed that Mr Singh was suffering from acidity and prescribed some medicines.

Mr. Khanna advised him to eat home-made food and change his lifestyle by doing yoga, meditation and some physical exercise. Mr Singh followed his friend's advice and after few days, he started feeling better.

After reading the above passage, answer the following.

(i) What are the values (atleast two) displayed by Mr Khanna?

(ii) What are antacids? Give one example.

(iii) Would it be advisable to take antacids for a long period of time? Give reason.

24. (a) Write the structures of *A* and *B* in the following reactions.

(i) $CH_3COCl \xrightarrow{H_2,\ Pd\text{-}BaSO_4} A \xrightarrow{H_2N-OH} B$

(ii) $CH_3MgBr \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } CO_2} A \xrightarrow{PCl_5} B$

(b) Distinguish between

(i) $C_6H_5-COCH_3$ and C_6H_5-CHO

(ii) CH_3COOH and $HCOOH$

(c) Arrange the following in the increasing order of their boiling points.

$CH_3CHO, CH_3COOH, CH_3CH_2OH$

or

(a) Write the chemical reaction involved in Wolff-Kishner reduction.

(b) Arrange the following in the increasing order of their reactivity towards nucleophilic addition reaction.

$C_6H_5COCH_3, CH_3—CHO, CH_3COCH_3$

(c) Why carboxylic acids do not give reactions of carbonyl group?

(d) Write the product in the following reaction

$$CH_3CH_2CH{=}CH—CH_2CN \xrightarrow[\text{(ii) } H_2O]{\text{(i) } (i\text{-Bu})_2 \text{ AlH}}$$

(e) 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. (a) Calculate E°_{cell} for the following reaction at 298 K.

$2Al(s) + 3Cu^{2+}(0.01\text{ M}) \longrightarrow 2Al^{3+}(0.01\text{M}) + 3Cu(s)$

Given: $E_{cell} = 1.98$ V

(b) Using the E° values of A and B, predict which is better for coating the surface of iron $[E^\circ_{(Fe^{2+}/Fe)} = -0.44 \text{ V}]$ to prevent corrosion and why?

Given, $E^\circ_{(A^{2+}/A)} = -2.37 \text{ V} : E^\circ_{(B^{2+}/B)} = 0.14 \text{ V}$

or

(a) The conductivity of 0.001 mol L^{-1} solution of CH_3COOH is 3.905×10^{-5} S cm^{-1}. Calculate its molar conductivity and degree of dissociation (α).

Given, $\lambda^\circ(H^+) = 349.6 \text{ S cm}^2 \text{ mol}^{-1}$

and $\lambda^\circ(CH_3COO^-) = 40.9 \text{ S cm}^2 \text{ mol}^{-1}$

(b) Define electrochemical cell. What happens if external potential applied becomes greater than E°_{cell} of electrochemical cell?

26. (a) Account for the following.

(i) Mn shows the highest oxidation state of + 7 with oxygen but with fluorine, it shows the highest oxidation state of + 4.

(ii) Cr^{2+} is a strong reducing agent.

(iii) Cu^{2+} salts are coloured while Zn^{2+} salts are white.

(b) Complete the following equations.

(i) $2MnO_2 + 4KOH + O_2 \xrightarrow{\Delta}$

(ii) $Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow$

or

The elements of 3d transition series are given as

Sc Ti V Cr Mn Fe Co Ni Cu Zn

Answer the following.

(i) Write the element which shows maximum number of oxidation states. Give reason.

(ii) Which element has the highest melting point?

(iii) Which element shows only + 3 oxidation state?

(iv) Which element is a strong oxidising agent in + 3 oxidation state and why?

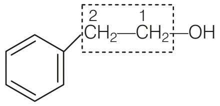
CHEMISTRY IN action

Water Molecules Break Bonds Through Quantum Tunneling

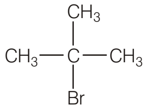
Water, one of the most common substances on Earth, has served up yet another scientific surprise. In its liquid state, water molecules cling to one another through so-called hydrogen bonding, constantly making and breaking bonds as they jumble about. Within the smallest possible 3D droplet of water, which consists of just six molecules, those molecules can rearrange themselves not just one at a time, but in sets of two. These two molecules can simultaneously break their hydrogen bonds with their neighbors and rotate off one another like gears.

The reconfiguration takes place through a subtle effect called quantum tunneling, in which the droplet does not have enough energy to wriggle from one configuration to the other, but simply pops from one to the other as if burrowing through an energy barrier, a team of chemists reports today in Science. And because the dual bond_breaking could play a role in how water behaves in cells and on mineral interfaces, the substance continues to be a font of insight.

Answers *with* Explanation

1. 

2-phenylethan-1-ol

2. 

$CH_3-\underset{Br}{\overset{CH_3}{C}}-CH_3$

3. The reasons for stability of colloidal particles are :

- The presence of equal and similar charges on the colloidal particles that prevents coagulation.
- Colloidal sols are covered by a sheath of liquid due to which these are extensively solvated.

The constant rapid *zig-zag* motion of colloidal particles, known as Brownian movement. This movement of particles prevents them from settling down due to gravity.

4. Molecular solid — Solid CO_2

Ionic solid — $\overset{+}{Na}Cl^-$

5. NO_2 gas, reactions involved are given as below:

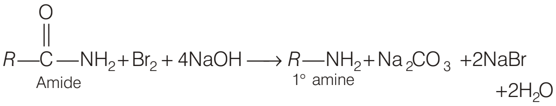
$$2Pb(NO_3)_2 \xrightarrow{\Delta} 2PbO + \underset{\text{(Brown gas)}}{4NO_2} + O_2$$

$$2NO_2 \xrightarrow{\text{On cooling}} N_2O_4$$

6. (i) Since, rate does not depend on concentration of any of the reactants, therefore order of reaction is zero.

Molecularity = 2 (As two molecules of reactants take part in the reaction)

(ii) Unit of k = Unit of rate = $mol\,L^{-1}\,s^{-1}$

7. (i) 

$$\underset{\text{Amide}}{R-\overset{\overset{O}{\|}}{C}-NH_2} + Br_2 + 4NaOH \longrightarrow \underset{1^\circ\text{ amine}}{R-NH_2} + Na_2CO_3 + 2NaBr + 2H_2O$$

Here, R = Alkyl or aryl group

(ii) $$\underset{\substack{\text{Aliphatic or}\\\text{aromatic}\\\text{amine}}}{RNH_2} + CHCl_3 + 3KOH \xrightarrow{\text{Heat}} \underset{\substack{\text{Aliphatic or}\\\text{aromatic}\\\text{isocyanide}}}{R-NC} + 3KCl + 3H_2O$$

8. (i) Gas (B) will have higher value of K_H.

Reason According to Henry's law,

Solubility (S) ∝ Partial pressure (p)

and $p = K_H X$ ... (i) (where, $K_H = \frac{1}{K'}$)

where, K_H = Henry's constant

X = Mole fraction of gas

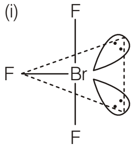
From eq (i), the gas with lower value of K_H will show more solubility than the gas with higher value of K_H.

(ii) In non-ideal solution, a large negative deviation from Raoult's law shows the formation of maximum boiling azeotropes.

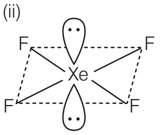
9. (i) Structural formula of the complex = $[Co(NH_3)_6]Cl_3$

$$[Co(NH_3)_6]Cl_3 \xrightarrow{3\,AgNO_3} [Co(NH_3)_6]^{3+} + 3NO_3^- + 3AgCl$$

(ii) $[Co(NH_3)_6]Cl_3$
Hexaamminecobalt (III) chloride.

10. (i) 

BrF_3
(T-shaped)

(ii) 

XeF_4
(Square planar)

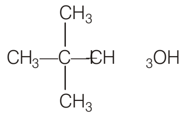
or

(i) SO_2 gas reduces Fe^{3+} to Fe^{2+}.

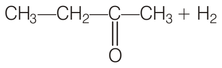
$$SO_2 + 2Fe^{3+} + 2H_2O \longrightarrow 2Fe^{2+} + SO_4^{2-} + 4H^+$$

(ii) XeF_4 reacts with covalent pentafluoride (SbF_5) to form an adduct.

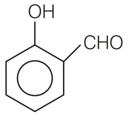
$$XeF_4 + SbF_5 \longrightarrow XeF_4 \cdot SbF_5 \text{ or } [XeF_3^+]\,[SbF_6^-]$$

11. (i) 

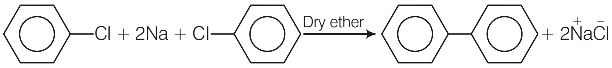
$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-CH\quad {}_3OH$

(ii) 

$CH_3-CH_2-\underset{\overset{\|}{O}}{C}-CH_3 + H_2$

(iii) 

12. (i) **Chlorobenzene to biphenyl**



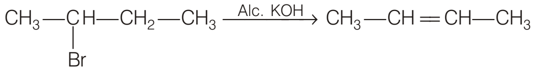
Biphenyl

(ii) **Propene to 1-iodopropane**

$$CH_3CH{=}CH_2 + HBr \xrightarrow{\text{Peroxide}} CH_3CH_2CH_2Br$$

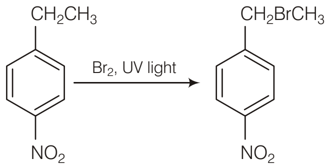
$$CH_3CH_2CH_2Br + NaI \xrightarrow[\text{(Reflux)}]{\text{Dry Acetone}} CH_3CH_2CH_2I + NaBr$$

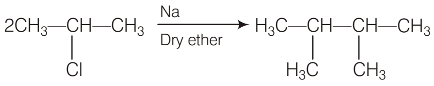
(iii) **2-bromobutane to but-2-ene**



$$CH_3-\underset{Br}{CH}-CH_2-CH_3 \xrightarrow{\text{Alc. KOH}} CH_3-CH{=}CH-CH_3$$

or

(i) 

(ii) 

$$2CH_3-\underset{Cl}{CH}-CH_3 \xrightarrow[\text{Dry ether}]{\text{Na}} H_3C-\underset{H_3C}{CH}-\underset{CH_3}{CH}-CH_3$$

(iii) $CH_3-CH_2-Br \xrightarrow{AgCN} CH_3CH_2NC$

13. (i) Cellulose has β-1, 4-linkages while starch has α-1, 4-linkages between glucose units. Cellulose is mostly found in linear chain of glucose molecules while starch is found in both linear and branched chains.

(ii) The linkage between nucleotide units in nucleic acids is a phosphodiester linkage which connects the 5′-hydroxyl group of one nucleotide to 3′-hydroxyl group of next nucleotide.

(iii) Fibrous protein—Keratin

Globular protein—Haemoglobin

14. (i) Mond's process

(ii) Cryolite improves the electrical conductivity of the cell as Al_2O_3 is the poor conductor of electricity. It is also added as impurity to lower down the melting point of the mixture to about 950°C.

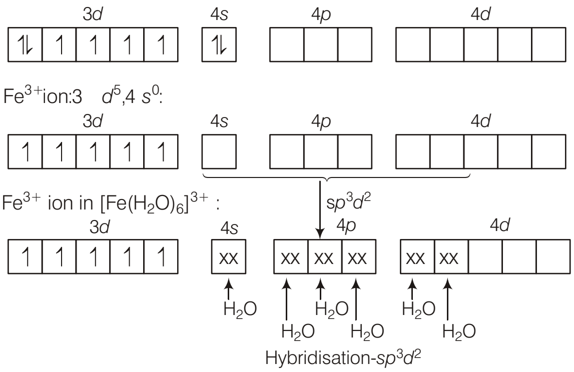
(iii) In slag formation zone of blast furnace, limestone decomposes into lime (CaO) and carbon dioxide (CO_2). CaO acts as a flux and combines with silica to form slag ($CaSiO_3$).

15. (i) SO_2 is a reducing agent because it has empty *d*-orbitals, so it can expands into +4 and +6 oxidation states and acts as a reducing agent. In TeO_2, Te is a heavier element, its electrons opposed to take part in the bond formation due to poor shielding of *d* and *f*-orbital electrons. Thus, +2 and −2 oxidation states are more stable in case of TeO_2 or it acts as an oxidising agent.

(ii) Nitrogen does not have empty *d*-orbitals to expand its octet. Hence, it does not form pentahalides.

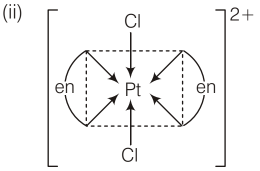
(iii) ICl is more reactive than I_2 because interhalogen bonds are weaker than diatomic bonds (except F_2) due to their different electronegativity. This electronegativity difference polarises the bond between iodine and chlorine and therefore breaks more easily as compared to I_2.

16. (i) Fe atom : [Ar] $3d^6, 4s^2$:



As there are five unpaired electrons present, hence, it is paramagnetic in nature and high spin complex.

(ii)



trans-isomer
(opticallyinactive)

17. Given, edge length $(a) = 500$ pm

$$= 500 \times 10^{-10} \text{ cm}$$

Density $(\rho) = 7.5 \text{ g cm}^{-3}$

Density of unit cell $(\rho) = \dfrac{Z \times M}{a^3 \times N_0}$

where, Z = number of atoms present per unit cell

(For bcc lattice, $Z = 2$)

M = Atomic mass of the element

N_0 = Avogadro's number

$$\therefore \quad 7.5 = \frac{2 \times M}{(500 \times 10^{-10})^3 \times 6.023 \times 10^{23}}$$

$$M = 282.328 \text{ g mol}^{-1}$$

Number of moles present in 300 g of element

$$= \frac{300 \text{g}}{282.328 \text{g mol}^{-1}}$$

$$= 1.062 \text{ mol}$$

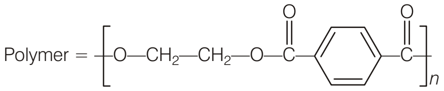
∴ Number of atoms present in 300 g of element

$$= 1.062 \times 6.023 \times 10^{23}$$

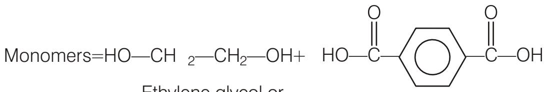
$$= 6.4 \times 10^{23} \text{ atoms}$$

18. (i) In order to improve the physical properties of natural rubber, it is heated with sulphur and a suitable additive at a temperature range between 373 K to 415 K. S-atoms form cross-links at reactive sites of double bond making it stiffer.

(ii)



Dacron or Terylene



Ethylene glycol or
Ethane-1,2-diol

Terephthalic acid or
Benzene-1,4-dicarboxylic acid

(iii) The order of intermolecular forces of different classes of polymers is,

Elastomers < Thermoplastics < Fibres.

Thus, for given polymers increasing order of intermolecular forces is,

Neoprene < Polythene < Terylene .

19.

$$C_2H_5Cl(g) \longrightarrow C_2H_4(g) + HCl(g)$$

Initial pressure	p_i	0	0
After time *t*	$p_i - p$	p	p

Total pressure after time *t*, i.e.

$$p_t = p_i - p + p + p = p_i + p$$

so, $a = p_i$

$$a - x = p_i - (p_t - p_i) = p_i - p_t + p_i = 2p_i - p_t$$

Rate constant for first order reaction is given as,

$$k = \frac{2.303}{t} \log \frac{a}{a - x}$$

$$= \frac{2.303}{300} \log \frac{p_i}{2p_i - p_t}$$

$$= \frac{2.303}{300} \log \frac{0.30}{[2(0.30) - 0.50]}$$

$$= \frac{2.303}{300} \log \frac{0.30}{0.10} = 3.66 \times 10^{-3} \text{ s}^{-1}$$

20. (i) Aniline behaves as a catalyst as a Lewis base and forms a salt with Lewis acid ($AlCl_3$) used in Friedel-Crafts reaction. Due to this, nitrogen atom of aniline acquires a positive charge and hence acts as a strong deactivating group and thus, does not allow the reaction to take place.

(ii) In aqueous solution, with increase in number of methyl group, hydrogen bonding and stabilisation by solvation decreases. Hence, $(CH_3)_2NH$ is more basic than $(CH_3)_3N$.

(iii) In 1° amines, two hydrogen atoms are present to the nitrogen atom. Due to the presence of hydrogen atoms, 1° amine undergoes extensive intermolecular hydrogen bonding. In 3° amine, no hydrogen atom is present to the nitrogen atom. Hence, 1° amines have higher boiling point than 3° amines.

21. (i) **Lyophilic colloid** The colloidal solution in which the particles of the dispersed phase have a great affinity for the dispersion medium is known as lyophilic colloid. These solutions are easily formed and shows reversible nature, e.g. gum, starch and rubber etc.

(ii) **Zeta potential** The potential difference that exists between the stationary layer of compensating charges and the diffuse layer (present in the body of the solution) is called zeta potential. It is involved in many kinds of non-static electrical properties of solid-liquid interfaces and with the help of it, we observe electrical effects in colloids.

(iii) **Associated colloids** There are some substances which at low concentrations behave as normal strong electrolytes, but at higher concentrations exhibit colloidal behaviour due to the formation of aggregates. The aggregated particles thus formed are called micelles. These are also known as associated colloids.

22. Given, $W_A = 100\,g$, $W_B = 4\,g$, $M_B = 120\,g\,mol^{-1}$

Elevation in boiling point, $\Delta T_b = \dfrac{i \times K_b \times 1000 \times W_B}{W_A \times M_B}$

(As $MgSO_4$ undergoes complete ionisation and gives 2 moles of its constituent ions for each mole).

$$= \frac{2 \times 0.52 \times 1000 \times 4}{100 \times 120} = 0.3466\ K$$

∵ Boiling point of water = 373.15 K

∴ Boiling point of solution = (373.15 + 0.34) K = 373.49 K

23. (i) Mr Khanna shows concern for his friend's health.

Mr Khanna is a responsible person. He take responsibility of his friend's health and take him to the doctor.

(ii) **Antacids** Some chemical substances which remove the excess acid from the stomach and raise the pH at an appropriate level are called antacids.

e.g. sodium hydrogen carbonate ($NaHCO_3$).

(iii) No it is not advisable to take antacids for a long period of time. Use of antacids for a long period of time makes the medium alkaline in stomach and trigger the overproduction of acid.

24. (a) (i) $\underset{}{CH_3COCl} \xrightarrow[\text{(Rosenmund reaction)}]{H_2,\ Pd\text{-}BaSO_4} \underset{A}{CH_3CHO} \xrightarrow{H_2N—OH} \underset{B}{CH_3CH{=}N—OH}$

(ii) $CH_3MgBr \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } CO_2} \underset{A}{CH_3COOH} \xrightarrow{PCl_5} \underset{B}{CH_3COCl}$

(b) (i) **Iodoform test**

$$C_6H_5COCH_3 + 4I_2 + 3Na_2CO_3 \longrightarrow \underset{\text{(Yellow ppt.)}}{CHI_3} + C_6H_5COONa + 3NaI + 2CO_2 + H_2O$$

$$C_6H_5CHO + 4I_2 + 3Na_2CO_3 \longrightarrow \text{Do not react}$$

(ii) **Silver mirror test**

HCOOH gives silver mirror test with Tollen's reagent, whereas acetic acid does not give this test.

$$HCOOH + 2[Ag(NH_3)_2]OH \longrightarrow \underset{\text{Silver mirror}}{2Ag} + 2H_2O + CO_2 + 4NH_3$$

$$CH_3COOH + 2[Ag(NH_3)_2]OH \longrightarrow \text{No reaction}$$

(c) The extent of hydrogen bonding for given compounds is,

Acetic acid > Ethanol > Acetaldehyde

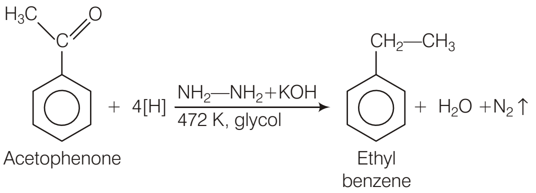
As, hydrogen bonding ∝ Boiling point

Hence, increasing order of boiling point for given compounds is

$$CH_3CHO < CH_3CH_2OH < CH_3COOH$$

or

(a)

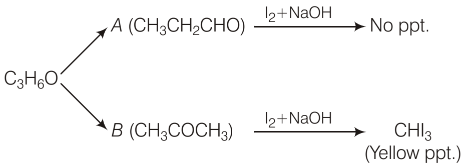


(b) $C_6H_5COCH_3 < CH_3COCH_3 < CH_3CHO$

(c) In carboxylic acids, lone pairs on oxygen atom of $—\ddot{\underset{\cdot\cdot}{O}}H$ group involved in resonance and make the carbon atom of carbonyl group less electrophilic. Hence, carboxylic acids do not give reactions of carbonyl group.

(d) $CH_3CH_2CH{=}CH—CH_2CN \xrightarrow[\text{(ii) } H_2O]{\text{(i) } (i\text{-}Bu_4)_2AlH} CH_3CH_2CH{=}CH—CH_2CHO$

(e)



$A = CH_3CH_2CHO$

$B = CH_3COCH_3$

25. (a) $E_{cell} = E^\circ_{cell} - \dfrac{2.303\,RT}{nF} \log \dfrac{[Al^{3+}]^2}{[Cu^{2+}]^3}$

or

$$1.98 = E^\circ_{cell} - \frac{0.059}{6} \log \frac{(0.01)^2}{(0.01)^3}$$

or

$$E^\circ_{cell} = 1.98 + \frac{0.059}{6} \log 100$$

$$= 1.98 + \frac{0.059}{6} \times 2 = 1.99\ V$$

or $E^\circ_{cell} \simeq 2\ V$

(b) In case of *A*, the protecting film will be effective as long as it is intact. When scratches occur at the coating surface, both the metals are exposed to oxygen and iron is preferably oxidised and rusted. This is because reducing potential of *A* is more than that of iron.

In case of *B*, the article of iron is connected with more active metal like *B*. The active metal has lower reduction potential than iron and will lose electrons in preference to iron. Hence, *B* is better for coating the surface of iron.

or

(a) Given, $\kappa = 3.905 \times 10^{-5}$ S cm^{-1}

$M = 0.001$ mol L^{-1}

$$\text{Molar conductivity } (\Lambda_m^c) = \frac{\kappa \times 1000}{M}$$

$$= \frac{3.905 \times 10^{-5} \times 1000}{0.001} = 39.05 \text{ S cm}^2 \text{ mol}^{-1}$$

At infinite dilution molar conductivity

$$\Lambda^\infty_{CH_3COOH} = \Lambda^\infty_{CH_3COO^-} + \Lambda^\infty_{H^+}$$

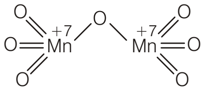
$$= 349.6 + 40.9 = 390.5 \text{ S cm}^2 \text{ mol}^{-1}$$

$$\text{Degree of dissociation} = \frac{\Lambda_m^c}{\Lambda_m^\infty} = \frac{39.05}{390.5} = 0.1$$

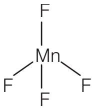
(b) **Electrochemical cell** The device through which chemical energy produced in a redox reaction converts into electrical energy is called electrochemical cell.

The chemical reaction of the cell is reversed and current flows in opposite direction when external potential applied becomes greater than E°_{cell} of the electrochemical cell.

26. (a) (i) Mn has the highest oxidation state of +7 with oxygen atoms Mn forms multiple bonds with oxygen atoms involving two 2*p*-orbitals per oxygen atom and 3*d*-orbitals of Mn. On the other hand, Mn shows the highest oxidation state of +4 with F-atoms because it forms single bonds involving one 2*p*-orbital per fluorine atom and 3*d*-orbitals of Mn.



Mn_2O_7



MnF_4

(ii) Cr^{2+} gets readily convert into Cr^{3+} because in +3 oxidation state, it has stable half-filled t_{2g} orbitals.

(iii) Cu^{2+} shows $3d^9$ electronic configuration while Zn^{2+} shows $3d^{10}$ electronic configuration. Due to the presence of one unpaired electron, Cu^{2+} salts are coloured while Zn^{2+} salts are white.

(b) (i) $2MnO_2 + 4KOH + O_2 \xrightarrow{\Delta} 2KMnO_4 + 2KCl + 2H_2O$

(ii) $Cr_2O_7^{2-} + 14H^+ + 6I^- \longrightarrow 2Cr^{3+} + 3I_2 + 7H_2O$

or

(i) The electronic configuration of Mn is [Ar] $3d^5 4s^2$. Thus, it has 5 unpaired electrons and likely to exhibit maximum number of oxidation states.

(ii) Cr, due to availability of maximum number of unpaired electrons (6 $\bar{e}$s), which results increases in metallic bond strength.

(iii) Sc (Scandium), as it has one 3*d* and two 4*s* electrons. So, it can lose maximum three electrons.

(iv) Mn, because in +3 oxidation state, it has [Ar]$3d^4$ electronic configuration. Hence, it readily gives its electrons to gain stable electronic configuration.

CHEMISTRY IN action

New Super Cloth to Mop up Oil Spills

Oil spills at sea, on the land and in your own kitchen could one day easily be mopped up with a new multipurpose Super cloth (fabric) covered with semi-conducting nanostructures, developed by a team of researchers

The fabric could also potentially degrade organic matter when exposed to light thanks to these semi-conducting properties. This fabric repels water and attracts oil. Scientists have tested it and found it effective at cleaning up crude oil, and separating organic solvents, ordinary olive and peanut oil from water. All steps in its production are easy to carry out and, in principle, production of this fabric could be scaled up to be used on massive oil spills that threaten land and marine ecosystems. To produce the fabric nylon was used, but in principle any fabric could work. The commercially available nylon that already had a seed layer of silver woven into it, makes it easier to carry out the next part of the process i.e., addition of the copper. This fabric is then dipped into a vat where a copper layer was electrochemically deposited onto it. Now with a copper coating, the fabric is converted into a semiconducting material with the addition of another solution that causes nanostructures to grow on the fabric's surface i.e., the key to its enhanced properties. The nanostructures are like tiny rods that cover the surface of the fabric. Water just runs straight off it but the rods attract and hold oil also, when the fabric is saturated it allows the oil to permeate where it then acts like a sieve to separate oil and water.

What is particularly exciting is that it is multifunctional and can separate water from other liquids like a sieve, it is self-cleaning, antibacterial, and being a semiconductor opens up further applicability, Its antibacterial properties arising from the presence of copper could be used to kill bugs while also separating water from industrial waste in waterways or decontaminate water in remote and poor communities where water contamination is an issue. Because it is also a semi-conductor it can interact with visible light to degrade organic pollutants such as those found in waste water streams. The testing has shown the material is chemically robust but still it is needed to investigate whether the nanostructures can withstand tough wear conditions or not.

THERMODYNAMICS

Thermodynamics is more important topic from engineering entrance exams rather than medical entrance exams point of view. In engineering, problems related to different types of enthalpy change or entropy change while in medical, direct formula, spontaneity or phase change related problems are asked. Problem solving strategies for some important topics are given below.

Enthalpy Change (ΔH)

When problems related to enthalpy change are asked, you can go through the following steps:

Step 1 Write down all the balanced chemical reactions including their enthalpy change value.

Step 2 Mark these reactions in terms of equation number.

Step 3 Write down the chemical reaction for which we have to find out enthalpy change value.

Step 4 Arrange the given equations in such a manner that we could get the required equation.

Step 5 For this purpose, you can apply operations such as addition or subtraction of equations and multiplying or dividing by an integer to the equation.

Step 6 Same operations should be applied for given enthalpy change values as well.

Step 7 Finally, you can get the required enthalpy change value.

Alternate

From Step 4 You can go through the following steps :

Step 4 Apply the formula for enthalpy change (ΔH) of required reaction, say

$$aA + bB \longrightarrow cC + dD$$

$$\Delta H = \text{Sum of enthalpies of all products} - \text{sum of enthalpies of all reactants}$$

Step 5 Multiply the enthalpies of products and reactants according to the stoichiometric coefficients of required reaction

$$\Delta H = (c\Delta H_C + d\Delta H_D) - (a\Delta H_A + b\Delta H_B)$$

Step 7 Finally, you will get the required enthalpy change value.

Note Except bond dissociation, enthalpy change for any other process is given as,

Enthalpy change = Sum of enthalpies of all products – sum of enthalpies of all reactants

But for bond dissociation,

Enthalpy change = Sum of enthalpies of all reactants – sum of enthalpies of all products

CHEMISTRY CONCENTRATE

PRACTICE PROBLEMS

- The standard heats of formation for $CCl_4(g)$, $H_2O(g)$, $CO_2(g)$ and $HCl(g)$ are –25.5, – 57.8, – 94.1 and –22.1 kcal mol^{-1} respectively at 298 K. Calculate $\Delta H°$ for the following reaction at 298 K.

  $CCl_4(g) + 2H_2O(g) \longrightarrow CO_2(g) + 4HCl(g)$ [–41.4 kcal]
- The standard enthalpies of formation of $CO_2(g)$, $H_2O(l)$ and glucose(s) at 25° C are –400 kJ mol^{-1}, – 300 kJ mol^{-1} and – 1300 kJ mol^{-1}, respectively. The standard enthalpy of combustion per gram of glucose at 25°C is [– 16.11 kJ g^{-1}]
- Using the data provided, calculate the multiple bond energy (kJ mol^{-1}) of a $C{\equiv}C$ bond in C_2H_2 (take the bond energy of a $C{-}H$ bond as 350 kJ mol^{-1}),

  $2C(s) + H_2(g) \longrightarrow C_2H_2(g)$; $\Delta H = 225$ kJ mol^{-1}

  $2C(s) \longrightarrow 2C(g)$; $\Delta H = 1410$ kJ mol^{-1}

  $H_2(g) \longrightarrow 2H(g)$; $\Delta H = 330$ kJ mol^{-1} [815 kJ mol^{-1}]

Entropy Change (ΔS)

Type 1 When phase transitions occur during a process and entropy change is asked for overall process. Use the following method.

First write down all the reactions involved in the overall process, keeping in mind that during phase transition, temperature does not change.

Suppose a compound $A(s)$ is heated from temperature T_1°C to T_4°C and changes itself into $A(g)$, the reactions involve are,

$$\underset{T_1}{A(s)} \longrightarrow \underset{T_2}{A(s)};\ \Delta S_1$$

$$\underset{T_2}{A(s)} \xrightarrow{\Delta H_{\text{fus}}} \underset{T_2}{A(l)};\ \Delta S_2$$

$$\underset{T_2}{A(l)} \longrightarrow \underset{T_3}{A(l)};\ \Delta S_3$$

$$\underset{T_3}{A(l)} \xrightarrow{\Delta H_{\text{vap}}} \underset{T_3}{A(g)};\ \Delta S_4$$

$$\underset{T_3}{A(g)} \longrightarrow \underset{T_4}{A(g)};\ \Delta S_5$$

ΔS for, $A(s) \longrightarrow A(g)$; will be

$$\Delta S = \Delta S_1 + \Delta S_2 + \Delta S_3 + \Delta S_4 + \Delta S_5$$

Type 2 When one quantity changes during a process and ΔS is asked keeping the other quantity constant, apply

Variable quantity(ies)	Constant quantity(ies)	ΔS
Temperature	Pressure	$2.303\, nC_p \log \frac{T_2}{T_1}$
Temperature	Volume	$2.303 nC_V \log \frac{T_2}{T_1}$
Volume	Temperature	$2.303 nR \log \frac{V_2}{V_1}$
Temperature and pressure	Volume	$2.303 \left(nC_P \log \frac{T_2}{T_1} + nR \log \frac{p_1}{p_2} \right)$
Temperature and volume	Pressure	$2.303 \left(nC_V \log \frac{T_2}{T_1} + nR \log \frac{V_1}{V_2} \right)$

Type 3 When phase change occurs during the process and ΔS is asked, apply

$$\Delta S = \frac{\Delta H}{T}$$

Type 4 When a system at higher temperature T_1 and its surroundings at lower temperature T_2, q amount of heat goes irreversibly from system to surroundings and ΔS is asked, apply

$$\Delta S = q\left[\frac{T_1 - T_2}{T_1 T_2}\right]$$

$$\because \quad T_1 - T_2 = +\text{ ve}, \Delta S > 0$$

Hence, process is spontaneous.

Type 5 When Gibbs free energy change (ΔG), enthalpy change (ΔH) and temperature are given, ΔS is asked, apply

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

CHEMISTRY CONCENTRATE
PRACTICE PROBLEMS

- Calculate entropy change for the transition of liquid water to steam, ΔH_{vap} is 40.8 kJ mol^{-1} at 373 K. [109.38 JK^{-1} mol^{-1}]
- Calculate entropy change when 10 moles of an ideal gas expands reversibly and isothermally from an initial volume of 10 L to 1000 L at 300 K. [191.24 JK^{-1} mol^{-1}]
- Consider the following reaction,

$$Ag_2O(s) \longrightarrow 2Ag(s) + \frac{1}{2}O_2(g)$$

ΔH and ΔS for this reaction are 30.56 kJ mol^{-1} and 66.0 JK^{-1} mol^{-1}, respectively. Calculate the temperature at which free energy change (ΔG) will be zero. [463 K]

Work Done (*W*)

Type 1 When reversible isothermal process is mentioned in the problem and work done is asked to find out, apply

In case of expansion, $W = -nRT \ln\left(\frac{V_2}{V_1}\right)$

In case of compression, $W = nRT \ln\left(\frac{V_2}{V_1}\right)$

Type 2 When irreversible isothermal process is mentioned and work done is asked to find out, apply

In case of expansion, $W = -p_2(V_2 - V_1)$

In case of compression, $W = p_2(V_2 - V_1)$

Type 3 When reversible adiabatic process is mentioned, work done is asked, apply

For both expansion and compression,

$$W = \frac{1}{\gamma - 1}(p_2V_2 - p_1V_1)$$

Type 4 When irreversible adiabatic process is mentioned, work done is asked, apply

For both expansion and compression,

$$W = -p_{\text{ext}} R\left(\frac{p_1T_2 - p_2T_1}{p_1p_2}\right)$$

CHEMISTRY CONCENTRATE
PRACTICE PROBLEMS

- Calculate the work done by 2 moles of an ideal gas at 298 K in reversible isothermal expansion from 10 L to 20 L. [–3434.9 J]
- Two moles of an ideal monoatomic gas are compressed adiabatically and reversibly to occupy a volume of 4.48 dm^3 at NTP. Calculate work done value. ($C_V = 12.45$ JK^{-1}mol^{-1}) [24.775 kJ]

DO YOU KNOW?

Amazing facts with proper explanation.

Do you know, a glass containing virtually transparent coating of titanium dioxide (15 nm thick), has the ability to clean itself?

Pilkington activ™, launched in 2001, was the first type of glass to be produced that has the ability to clean itself. This glass contains a virtually transparent coating of titanium dioxide, 15 nm thick, which is deposited during the manufacturing process. TiO_2 coating is durable, since it is bonded to the glass surface and has two functions that allow it to act as a self-cleaning glass.

Mechanism of self-cleaning glasses First TiO_2 absorbs ultraviolet photons from sunlight. On absorption of a photon, an electron is promoted from the filled valence band to empty conduction band. This promoted electron reacts with oxygen adsorbed on the surface, to produce a superoxide ion (O_2^-).

$$O_2 + e^- \longrightarrow O_2^-$$

Once it has been activated in this way, the photoactive form of TiO_2 acts as an oxidising agent by accepting electrons into the vacancies in the valence band. It obtains these electrons by oxidation of water, converting H_2O into very reactive hydroxyl radicals ($\dot{O}H$).

$$H_2O \longrightarrow \dot{O}H + H^+ + e^-$$

This also takes the TiO_2 back to ground state and completes the catalytic cycle. The hydroxyl radicals and superoxide ions both are strong oxidising agents and are able to oxidise most of the organic molecules present in dirt, converting them eventually to CO_2 and H_2O.

The second way in which the TiO_2 coating leads to self cleaning relates interaction with water molecules. On the surface of the coating, oxygen atoms of TiO_2 are protonated, forming hydrophilic OH groups. These groups interact with water molecules through hydrogen bonds. As a result, rain water spread out onto a thin film on the glass surface and dirt is washed off the window in a sheet of water.

Do you know, memory metal exists in two different solid phases and these phases will remain in their respective phases indefinitely unless these are warmed to 50-60°C?

Memory metal (NiTi or nitinol), illustrates the importance of deformations. If a straight piece of NiTi wire is wound into a spiral, it will remain in the spiral shape indefinitely, unless it is warmed to 50-60°C, at this temperature, it will spontaneously straighten out again.

The high temperature phase has the cubic calcium chloride structure, in which a Ti-atom is embedded in the centre of a cube of Ni-atoms (or *vice-versa*). The low temperature phase has a related but kinked structure, in which one of the angles of the unit cell is no longer 90°. Bending an object at low temperature, creates defects that change the pattern of kinks within the structure.

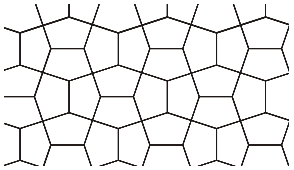
If the object is heated to a temperature greater than 50°C, the material undergoes a transition to the cubic high temperature phase, causing the object to return into its original shape. The shape of the object above 50°C is controlled by a complex set of defects and dislocations that can be relaxed by the thermal motion of the atoms.

Do you know, penta-graphene is the fourth allotrope of carbon?

Till now, we know that carbon exists in many allotropic forms such as graphite, diamond and buckminsterfullerene. In these allotropic forms, hexagons are the primary building blocks except for C_{20} fullerene. Carbon structures made exclusively of pentagons were not known because of many exotic properties of carbon are associated with their unique structures.

In 2014, the researchers at Virginia Commonwealth University and Universities in China and Japan have discovered a new allotrope of carbon named as penta-graphene, on the basis of analysis and simulations.

A 2D penta-graphene is metastable carbon allotrope, composed entirely of carbon pentagons. Theoretical calculations confirm that this new allotrope of carbon is not only dynamically and mechanically stable, but also can withstand temperature as high as 1000 K. Due to its unique configuration, penta-graphene shows an unusual negative Poisson's ratio and ultrahigh ideal strength than can even outperform graphene.



Penta-graphene

Do you know, the percentage of solids in a sample of human blood is normally about 45%?

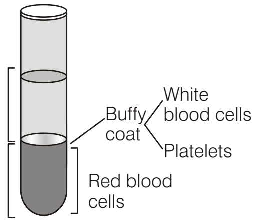
Our blood in living tissues is made up of liquids and solids. The liquid part called plasma is made up of water, salts and proteins. On an approximation, half of our blood is plasma. The solid part (~45%) of our blood contains red blood cells, white blood cells and platelets.

This can be easily demonstrated by placing a specimen of whole blood in a test tube with a small amount of oxalate to prevent clotting. If the sample is centrifuged or allowed to stand for a sufficient length of time, it will be found that the blood cells will settle towards the bottom of the test tube while plasma remains on the top. Plasma has pale yellow colour.

Centrifuged Blood Sample

Composition

1. **Blood plasma** non-cellular portion of the blood-55%
2. **Formed elements** (45%) :
   - (i) Red blood cells, RBCs (erythrocytes) -99% of formed elements
   - (ii) Platelets (thrombocytes)
   - (iii) White blood cells, WBCs (leukocytes)



TARGET BITSAT 2016

TEST Tuner

Comprehensive Simulator Test Series for BITSAT

BITSAT PREP UP

Mock Questions with Complete Solutions

Instructions

- This test consists of 40 questions in chemistry and each question is allotted 3 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/3 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. Which pair of the following chlorides does not impart colour to the flame?

(a) $MgCl_2$ and $CaCl_2$
(b) $BeCl_2$ and $SrCl_2$
(c) $BeCl_2$ and $MgCl_2$
(d) $CaCl_2$ and $BaCl_2$

2. Both Be and Al become passive on treatment with conc. HNO_3 due to

(a) non-oxidising nature of HNO_3
(b) the formation of an inert layer of the oxide on the surface of the metals
(c) non-reacting nature of the metals
(d) None of the above

3. 0.15 g of an organic compound containing phosphorus, gave 0.32 g of $Mg_2P_2O_7$ by the usual analysis. The percentage of phosphorus in the compound is

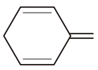
(a) 61.20%
(b) 60.20%
(c) 59.58%
(d) 58.59%

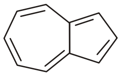
4. The structure of ethyne shows

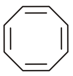
I. σ-overlaps
II. π-overlaps
III. cylindrical nature of electron cloud

(a) Only II
(b) I and II
(c) Only III
(d) All of these

5. Which of the following systems are not aromatic?


I


II


III

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

6. BF_3 behaves as a Lewis acid and on treatment with NH_3, gives an adduct. The hybridisation of N and B in this adduct

(a) changes from sp^2 to sp^3 for both N and B
(b) changes from sp^2 to sp^3 for N and remains same for B
(c) remains same for N but changes from sp^2 to sp^3 for B
(d) changes from sp^3 to sp^2 for N and sp^2 to sp^3 for B

7. Which of the following relation is correct according to Charles' law?

I. $\left(\frac{\delta V}{\delta T}\right)_p = K$
II. $\left(\frac{\delta T}{\delta V}\right)_p = \frac{1}{V}$
III. $V \propto \frac{1}{T}$
IV. $\left(\frac{\delta T}{\delta V}\right)_p = K$

Choose the correct option.

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

8. Total volume of atoms present in a face-centred cubic unit cell of a metal is (r is atomic radius)

(a) $\frac{20}{3}\pi r^3$
(b) $\frac{24}{3}\pi r^3$
(c) $\frac{12}{3}\pi r^3$
(d) $\frac{16}{3}\pi r^3$

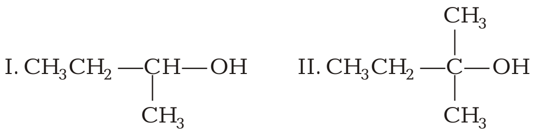
9. For a cell reaction, involving a two-electron change, the standard emf of the cell is found to be 0.295 V at 25°C. The equilibrium constant of the reaction at 25°C will be

(a) 10×10^{10}
(b) 1×10^{10}
(c) 1×10^{-10}
(d) 10×10^{-10}

10. For an elementary reaction, $2A + B \longrightarrow 3C$, the rate of appearance of C at time t is 1.3×10^{-4} mol $L^{-1}s^{-1}$. The rate of reaction at this time is

(a) 3.44×10^{5} mol $L^{-1}s^{-1}$
(b) 3.44×10^{-5} mol $L^{-1}s^{-1}$
(c) 4.33×10^{-5} mol $L^{-1}s^{-1}$
(d) 4.33×10^{5} mol $L^{-1}s^{-1}$

11. The order of dehydration of the following alcohols with H_2SO_4 is



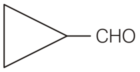
I. $CH_3CH_2-\underset{\displaystyle CH_3}{\underset{|}{CH}}-OH$ II. $CH_3CH_2-\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle CH_3}{\underset{|}{C}}}}-OH$

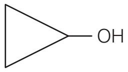
III. $CH_3CH_2-CH_2-OH$

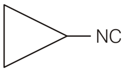
(a) I > II > III
(b) II > I > III
(c) II > III > I
(d) III > II > I

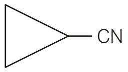
12. Identify the final product from the following reaction:

Cyclopropane carboxylic acid $\xrightarrow[\Delta]{NH_3} A \xrightarrow{KOH/Br_2} B \xrightarrow{CHCl_3/KOH} C$

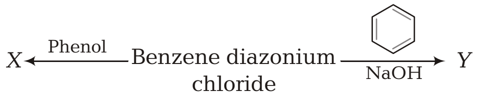
(a)


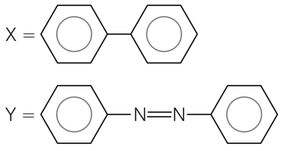
(b)


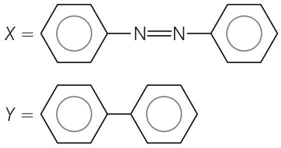
(c)


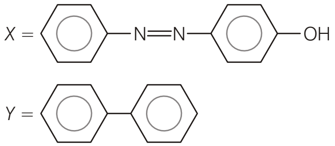
(d)


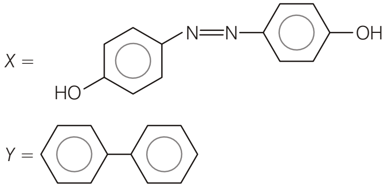
13. $NaNO_2$ /HCl causes diazotisation of aniline and results in the formation of diazonium salt. Identify X and Y in the following reaction sequence.



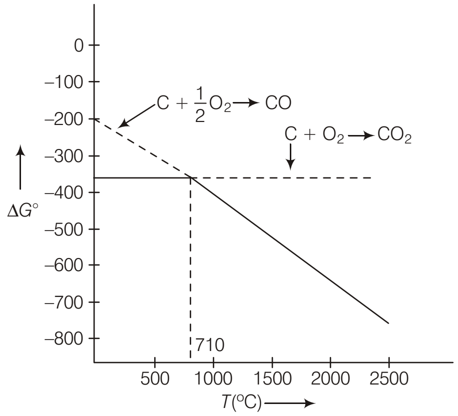
(a)


(b)


(c)


(d)


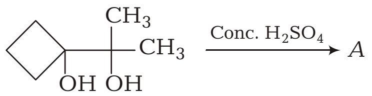
14. Consider the following Ellingham diagram for carbon.



Which of the following statements is incorrect about the Ellingham diagram?

(a) Upto 710°C, the reaction of formation of CO_2 is energetically more favourable but above 710°C, the formation of CO is preferred
(b) Carbon can be used to reduce any metal oxide at a sufficiently high pressure
(c) Carbon reduces many oxides at elevated temperature because $\Delta G°$ *versus* temperature line has a negative slope
(d) $\Delta S°\left[C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g)\right] < \Delta S°$ $[C(s) + O_2(g) \longrightarrow CO_2(g)]$

15. Identify the correct product formed during the following reaction,



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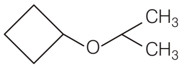
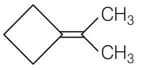


(b)


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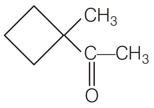

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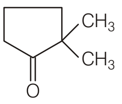


16. A swimmer coming out from pool is covered with a film of water weighing about 18 g. Calculate the internal energy of vaporisation at 100°C.

[$\Delta_{vap} H°$ for water at 373 K = 40.66 kJ mol^{-1}]

(a) 35.67 kJ mol^{-1}
(b) 37.56 kJ mol^{-1}
(c) 36.57 kJ mol^{-1}
(d) 38.75 kJ mol^{-1}

17. The major achievement of Bohr atomic model is that it explains

(a) finer details of atomic spectra
(b) splitting of spectral lines in the presence of magnetic and electric fields
(c) spectra of hydrogen or hydrogen like species
(d) intensity of various spectral lines

18. A person adds 1.71 g of sugar ($C_{12}H_{22}O_{11}$) in order to sweeten his tea. The number of carbon atoms added are (molecular mass of sugar = 342)

(a) 3.6×10^{22} *(b)* 7.2×10^{21} *(c)* 0.05 *(d)* 6.6×10^{22}

19. Consider the two gaseous equilibria at 298 K

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g);\ K_1$$

$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g);\ K_2$$

The equilibrium constants are related by

(a) $K_2 = K_1$ *(b)* $K_2 = K_1^2$

(c) $K_2 = \frac{1}{K_1^2}$ *(d)* $K_2 = \frac{1}{K_1}$

20. In the Arrhenius equation, $k = A \cdot \exp^{\left(-\frac{E_a}{RT}\right)}$, the rate constant

- *(a)* decreases with increasing activation energy and increases with increasing temperature
- *(b)* increases with increasing activation energy and temperature
- *(c)* decreases with decreasing activation energy and temperature
- *(d)* increases with increasing activation energy and decreasing temperature

21. Which of the following statements is wrong?

- *(a)* P^{33} is used in the treatment of leukemia
- *(b)* I^{131} is used in the treatment of thyroid gland cancer
- *(c)* Co^{59} cannot be used in the treatment of cancer
- *(d)* Excessive use of radioactive elements is responsible for cancerous growth

22. General configuration of ultimate and penultimate shell is $(n-1)s^2\,(n-1)p^6\,(n-1)d^x ns^2$. If $n = 4$ and $x = 5$, the number of protons in the nucleus would be

(a) less than 24 *(b)* 25

(c) 24 *(d)* more than 25

23. When hydrogen sulphide is passed through acidified solution of $KMnO_4$, the permanganate solution is decolourised. In this reaction, change of oxidation state of manganese is found to be from

(a) +7 to +2 *(b)* +7 to +4

(c) +2 to +7 *(d)* +4 to +7

24. 0.5% aqueous solution of KCl was found to freeze at −0.24°C. Calculate the degree of dissociation of the solute at this concentration.

(Given, K_f for water = 1.86 K kg mol^{-1})

(a) 0.92 *(b)* 0.86

(c) 0.25 *(d)* 0.63

25. The stabilisation of a dispersed phase in a lyophobic colloid is due to

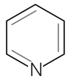
- *(a)* the adsorption of charged substances on dispersed phase
- *(b)* the large electro-kinetic potential developed in the colloid
- *(c)* the formation of an electrical layer between two phases
- *(d)* the viscosity of the medium

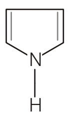
26. 0.5 F of electricity is passed through 500 mL of copper sulphate solution. The amount of copper which can be deposited will be

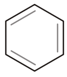
(a) 63.5 g *(b)* 31.75 g

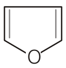
(c) 15.80 g *(d)* unpredictable

27. Which of the following aromatic compounds is least reactive towards electrophilic substitution reaction?

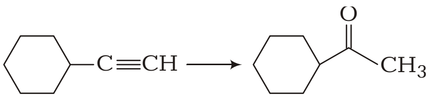
(a)


(b)


(c)


(d)


28. The reagents used to convert



are

- *(a)* (i) O_3/Red P (ii) $AlCl_3$ (iii) MeCOOH
- *(b)* (i) H_2SO_4 + $HgSO_4$ (ii) H_2O, Heat
- *(c)* O_3/Zn-AcOH (ii) H_2SO_4 + $HgSO_4$ (iii) H_2O, Heat
- *(d)* (i) CH_3COOH (ii) H_2O_2 + $\bar{O}H/H_2O$

29. In the Hofmann-bromamide reaction, CO is lost as

(a) CO_2 *(b)* $HCO_3^{\ominus}$

(c) CO_3^{2-} *(d)* CO

30. Which of the following statements is correct?

- *(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)* α-methyl butyric acid is a stronger acid than β-methyl butyric acid

31. The compound 1-(N-ethyl-N-methyl) propanamine forms non-superimposable mirror images. But this compound does not show optical activity because of the

- *(a)* absence of a chiral N-atom
- *(b)* presence of a chiral N-atom
- *(c)* presence of lone pair on N-atom
- *(d)* rapid flipping of one form into the other

32. 1 mg radium has 3.20×10^{18} atoms. Its half-life period is 1620 yr. How many radium atoms will disintegrate from 1 milligram of pure radium in 4860 yr?

(a) 2.0×10^{18}

(b) 2.5×10^{18}

(c) 2.8×10^{18}

(d) 2.3×10^{18}

33. Which one of the following reactions of xenon compounds is not feasible?

- *(a)* $XeO_3 + 6HF \longrightarrow XeF_6 + 3H_2O$
- *(b)* $3XeF_4 + 6H_2O \longrightarrow 2Xe + XeO_3 + 12HF + 1.5O_2$
- *(c)* $2XeF_2 + 2H_2O \longrightarrow 2Xe + 4HF + O_2$
- *(d)* $XeF_6 + RbF \longrightarrow Rb[XeF_7]$

34. 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

35. Which one of the following ionic species will impart colour to an aqueous solution?
(a) Cu^+ (b) Zn^{2+} (c) Cr^{3+} (d) Ti^{4+}

36. Ammonia forms the complex ion $[Cu(NH_3)_4]^{2+}$ with copper ions in alkaline solution but not in acidic solution. What is the reason for it?
(a) In acidic solution, hydration protects copper ions
(b) In alkaline solution, insoluble $Cu(OH_2)$ is precipitated
(c) Copper hydroxide is an amphoteric substance
(d) In acidic solution, protons coordinate with ammonia molecules forming $\overset{+}{N}H_4$ ions and NH_3 molecules are not available

37. Heating of an aqueous solution of aluminium chloride to dryness will give
(a) $Al(OH)Cl_2$ (b) Al_2O_3 (c) Al_2Cl_6 (d) $AlCl_3$

38. Which one 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

39. Which base is found only in nucleotides of RNA?
(a) Adenine (b) Uracil
(c) Guanine (d) Cytosine

40. Artificial silk is a
(a) polypeptide (b) polysaccharide
(c) polythene (d) polyvinyl chloride

Answers *with* Explanation

1. **(c)** Be and Mg atoms have very high ionisation enthalpies and their valence electrons are not excited to higher energy states by the energy of flame. The chlorides of these elements do not give any colour to the flame.

2. **(b)** HNO_3 being a strong oxidising agent oxidises both Al and Be to thin layers of Al_2O_3 and BeO, respectively. These layers protect Al and Be metals from further attack of HNO_3. The reactions involved are

$$2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$$
$$Be + [O] \longrightarrow BeO$$
$$2Al + 3[O] \longrightarrow Al_2O_3$$

3. **(c)** Given, the mass of the organic compound = 0.15 g

Mass of $Mg_2P_2O_7$ formed = 0.32 g

1 mole of $Mg_2P_2O_7$ molecules contain 2 moles of P atoms or 222 g of $Mg_2P_2O_7$ molecules contain 62 g of atoms of P [Molecular weight of

$$Mg_2P_2O_7 = (2\times 24 + 2\times 31 + 16\times 7)\text{ g}] = 222\text{ g}$$

Atomic weight of P = 31 g

$\therefore$ 0.32 g of $Mg_2P_2O_7$ will contain P

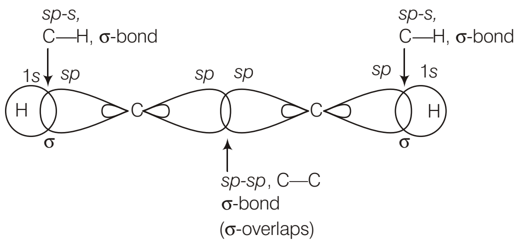
$$= \left(\frac{62}{222}\times 0.32\right)\text{g}$$

But this is the amount of phosphorus present in 0.15 g of the organic compound.

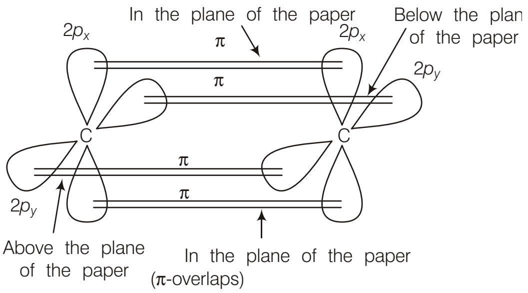
$$\therefore \%\text{ of phosphorus} = \frac{62}{222}\times\frac{0.32}{0.15}\times 100 = 59.58\%$$

4. **(d)** Structure of ethyne H—C≡C—H

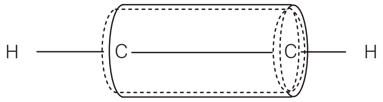
I.



II.

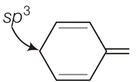


III.



Cylindrical nature of electron cloud

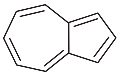
5. **(c)** I.



; Non-aromatic

Due to the presence of one sp^3-hybridised carbon, the system is not planar. It contains 6 π-electrons but the system is not fully conjugated as all the 6 π-electrons do not form cyclic electron cloud that should surround all the atoms of the ring.

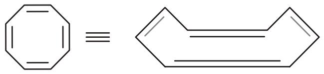
II.



; Aromatic

This system contains $(4n+2)\pi$-electrons where, $n = 2$, i.e. it contains 10 π-electrons and hence, according to Huckel's rule, it is an aromatic compound.

III.



; Non-aromatic

It is not planar but is tub-shaped. Further, it has only 8π-electrons. Therefore, the system is not aromatic since, it does not contain a planar cyclic electron cloud having $(4n+2)$ π-electrons.

6. **(c)** Due to incomplete octet of B in BF_3, it behaves as a Lewis acid. When it reacts with electron rich species like NH_3, it gives an addition product.

$$\underset{sp^3}{NH_3} + \underset{sp^2}{BF_3} \longrightarrow \underset{\text{Adduct}}{H_3N \rightarrow BF_3} \equiv H_3\underset{sp^3}{\overset{+}{N}}—\underset{sp^3}{\overset{-}{B}}F_3$$

Hence, the hybridisation of N remains same (sp^3) but hybridisation of B changes from sp^2 to sp^3.

7. **(b)** According to Charles' law,

$V \propto T$ at constant p

$\Rightarrow \quad V = KT$

$\therefore \quad \left(\frac{\delta V}{\delta T}\right)_p = K$

$T \propto V$ at constant p

$\Rightarrow \quad T = KV$

$\therefore \quad \left(\frac{\delta T}{\delta V}\right)_p = K$

Also, $\quad \frac{V}{T} = K$

$\Rightarrow \quad \left(\frac{1}{T}\right)(V) = K$

Differentiating with respect to V at constant pressure, we get

$$\frac{1}{T} + V\left(-\frac{1}{T^2}\right)\frac{dT}{dV} = 0$$

$$\frac{1}{T} - \frac{V}{T^2}\frac{dT}{dV} = 0$$

or $\quad \frac{dT}{dV} = \frac{1}{V}$

At constant pressure, $\left(\frac{\delta T}{\delta V}\right)_p = \frac{1}{V}$

8. **(d)** Total number of atoms in face-centred cubic unit cell = 4

(At corners = $8 \times \frac{1}{8} = 1$; On faces = $6 \times \frac{1}{2} = 3$)

$\because$ Volume of one sphere $= \frac{4}{3}\pi r^3$

$\therefore$ Volume of four spheres

$$= 4 \times \frac{4}{3}\pi r^3 = \frac{16}{3}\pi r^3$$

9. **(b)** $\log K_{eq} = \frac{E^\circ_{cell} \times n}{0.0591} = \frac{0.295 \times 2}{0.059} = 10$

$\therefore \quad K_{eq} = 1 \times 10^{10}$

10. **(c)** $2A + B \longrightarrow 3C$

$$\text{Rate} = -\frac{1}{2}\frac{d[A]}{dt} = -\frac{d[B]}{dt} = +\frac{1}{3}\frac{d[C]}{dt}$$

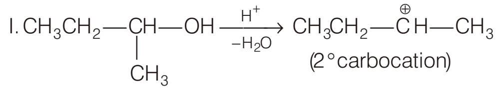
$\because \quad \frac{d[C]}{dt} = 1.3 \times 10^{-4}$ mol $L^{-1}s^{-1}$ (Given)

$\therefore$ Rate of reaction $= \frac{1}{3}\frac{d[C]}{dt}$

$$= \frac{1}{3} \times 1.3 \times 10^{-4} \text{ mol L}^{-1}\text{s}^{-1}$$

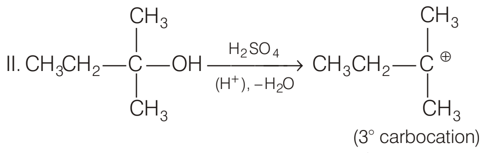
$$= 4.33 \times 10^{-5} \text{ mol L}^{-1}\text{s}^{-1}$$

11. **(b)**



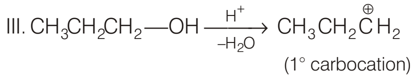
$$\text{I. } CH_3CH_2—\underset{CH_3}{\underset{|}{C}H}—OH \xrightarrow[-H_2O]{H^+} CH_3CH_2—\overset{\oplus}{C}H—CH_3$$

(2° carbocation)



$$\text{II. } CH_3CH_2—\underset{CH_3}{\underset{|}{\overset{\overset{CH_3}{|}}{C}}}—OH \xrightarrow[(H^+),\,-H_2O]{H_2SO_4} CH_3CH_2—\underset{CH_3}{\underset{|}{\overset{\overset{CH_3}{|}}{C}}}{}^{\oplus}$$

(3° carbocation)



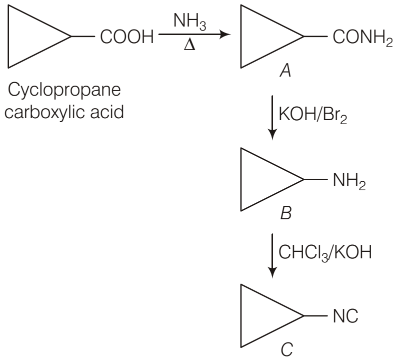
$$\text{III. } CH_3CH_2CH_2—OH \xrightarrow[-H_2O]{H^+} CH_3CH_2\overset{\oplus}{C}H_2$$

(1° carbocation)

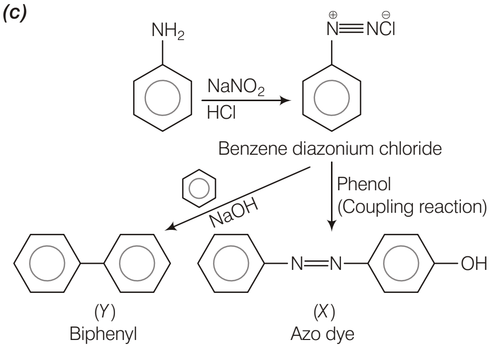
Since, stability of carbocation follows the order: 3° > 2° > 1°.

Therefore, the correct order of dehydration is II > I > III.

12. **(c)**



13. **(c)**



14. **(d)** Since, $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

where, ΔG° = Standard Gibbs' free energy of the reaction

ΔS° = Standard entropy of the reaction

ΔH° = Standard enthalpy of the reaction

T = Temperature

From the above equation, it is clear that ΔG° will be more negative when ΔS° is less negative (or ΔS° is high).

In the diagram, ΔG° value for $C + \frac{1}{2}O_2 \longrightarrow CO$ is less negative than that for

$$C + O_2 \longrightarrow CO_2.$$

Therefore, ΔS° would be higher for

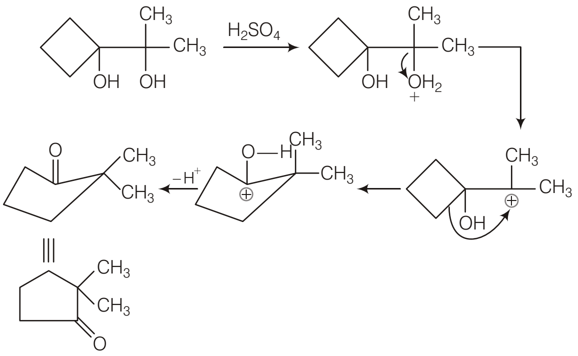
$$C + \frac{1}{2}O_2 \longrightarrow CO$$

than that for $C + O_2 \longrightarrow CO_2$

Hence, $\Delta S^\circ\left[C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g)\right] >$

$$\Delta S^\circ\,[C(s) + O_2(g) \longrightarrow CO_2(g)].$$

15. **(d) Pinacol-pinacolone rearrangement** The diol is converted into α-hydroxy ketone, when reacted in the presence of acid, is believed to proceed through rearrangement of carbocation as shown,



The carbocationic rearrangement is due to relief from angle strain.

16. **(b)** We can represent the process of evaporation as

$$18\text{ g } H_2O(l) \xrightarrow{\text{Vaporisation}} 18\text{ g } H_2O(g)$$

Number of moles in 18 g $H_2O(l) = \dfrac{18\text{ g}}{18\text{ g mol}^{-1}} = 1$ mol

$$\Delta_{vap}U° = \Delta_{vap}H° - p\Delta V = \Delta_{vap}H° - \Delta n_g RT$$

Assume steam behaves as an ideal gas

$$\Delta_{vap}U° = (40.66) - (1)(8.314 \times 10^{-3})(373)$$
$$= 40.66 - 3.10 = 37.56 \text{ kJ mol}^{-1}$$

17. **(c)** Spectra of hydrogen or hydrogen like species such as He^+, Li^{2+} were successfully explained by Bohr model.

18. **(a)** Number of moles of sugar $= \dfrac{1.71}{342} = 0.005$ mol

∵ 1 mole of sugar contains $= 12 \times 6.02 \times 10^{23}$ atoms of carbon

0.005 mole of sugar will contain $= 12 \times 0.005 \times 6.02 \times 10^{23}$

$$= 0.36 \times 10^{23} = 3.6 \times 10^{22} \text{ C-atoms}$$

19. **(c)** Given reactions,

$$SO_2(g) + \frac{1}{2}O_2(g) \rightleftharpoons SO_3(g);\ K_1 \qquad \ldots(i)$$
$$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g);\ K_2 \qquad \ldots(ii)$$

We can get equation (ii) if we reversed equation (i) and also multiplying it by 2.

If the reaction (i) is reversed, the equilibrium constant becomes inversed, i.e. $\dfrac{1}{K_1}$. If the equation (having equilibrium constant $\dfrac{1}{K_1}$) is multiplied by 2, the equilibrium constant for the new equation becomes the square of $\dfrac{1}{K_1}$, i.e. $\dfrac{1}{K_1^2}$

$$\therefore \qquad K_2 = \frac{1}{K_1^2}$$

20. **(a)** $k = A \cdot \exp^{\left(-\frac{E_a}{RT}\right)}$

$$\ln k = \ln A - \frac{E_a}{RT} \text{ or } \log K = \log A - \frac{E_a}{2.303RT}$$

From the above relation, it can be concluded that the rate constant decreases with increasing activation energy. It increases with the increase in temperature.

21. **(a)** I^{131} is used in the treatment of thyroid gland cancer. Co^{59} is a stable isotope and is not radioactive. Co^{60} is used in the treatment of cancer. Similarly, it is not P^{33} but P^{32} which is used in the treatment of leukemia.

22. **(b)** The element having outer electronic configuration $3s^2 3p^6 3d^5 4s^2$, has atomic number 25. Therefore, the number of protons is 25.

23. **(a)** $2K\overset{+7}{Mn}O_4 + 3H_2SO_4 + 5H_2S \longrightarrow K_2SO_4 + 2\overset{+2}{Mn}SO_4 + H_2O + 5S$

24. **(a)** Observed molecular mass of KCl $= \dfrac{1000 \times K_f \times W_2}{\Delta T_f \times W_1}$

Given, $K_f = 1.86 \text{ K kg mol}^{-1}, W_2 = 0.5\text{ g}, W_1 = 100\text{ g}, \Delta T_f = 0.24$

So, observed molecular mass of KCl

$$= \frac{1000 \times 1.86 \times 0.5}{0.24 \times 100}$$
$$= 38.75 \text{ g mol}^{-1}$$

Normal molecular mass of KCl $= 39 + 35.5 = 74.5 \text{ g mol}^{-1}$

van't Hoff factor $= \dfrac{\text{Normal molecular mass}}{\text{Observed molecular mass}} = \dfrac{74.5}{38.75} = 1.92$

$$\underset{(1-\alpha)}{KCl} \rightleftharpoons \underset{\alpha}{K^+} + \underset{\alpha}{Cl^-}$$

Total number of particles $= 1 - \alpha + \alpha + \alpha = 1 + \alpha$

$$i = 1 + \alpha$$
$$1.92 = 1 + \alpha$$

So, $\alpha = 1.92 - 1 = 0.92$, i.e. 92% dissociated.

25. **(c)** The stabilisation of a dispersed phase in a lyophobic colloid is due to the formation of an electrical layer between two phases.

26. **(c)** $Cu^{2+} + 2e^- \longrightarrow Cu \qquad \ldots(i)$

According to Faraday's first law,

when an electric current is passed through an electrolyte, amount of substance deposited is directly proportional to the quantity of electric charge passed through the electrolyte.

From Eq. (i),

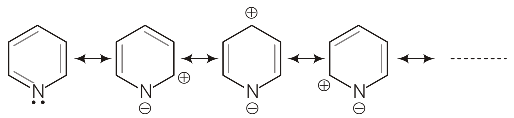
∵ 1 mol or 63.5 g of Cu is obtained by passing 2 F of electricity.

Mass of Cu obtained by passing 1 F of electricity $= \dfrac{63.5}{2}$ g

∴ Mass of Cu obtained by passing 0.5 F of electricity

$$= \frac{63.5}{2} \times 0.5 = 15.80 \text{ g}$$

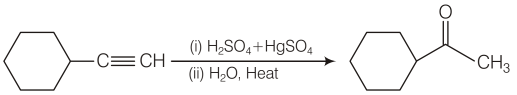
27. **(a)** Pyridine is least reactive towards electrophilic substitution (S_E) because pyridine is resonance stabilised.



Because of withdrawal of electrons from the ring by N-atom, the ring is deactivated, thereby resembling the benzene ring with nitrobenzene. So, it is least reactive towards S_E reactions. (b) and (d) are resonance structures. So, S_E reaction takes place easily.

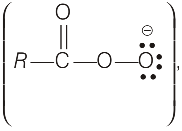
28. **(b)** $R—C{\equiv}CH$ is converted to ketone by catalytic hydration with reagents

(i) $H_2SO_4 + HgSO_4$ and (ii) H_2O, heat.

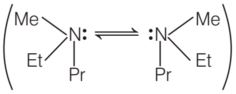


29. **(c)** In Hofmann-bromamide reaction, CO is lost as CO_3^{2-}.

$$RCONH_2 + Br_2 + 4KOH \longrightarrow RNH_2 + 2KBr + K_2CO_3 + H_2O$$

30. **(b)** Benzoic acid is a weaker acid than peroxy benzoic acid. The conjugate base of peroxy acid is peroxy anion , in which negative charge is not resonance stabilised, as it is resonance stabilised in $RCOO^{\ominus}$. The peroxy anion is much more basic and less acidic than carboxylic acids.

31. **(d)** Due to nitrogen, inversion or rapid flipping of one form into other.



32. **(c)** Number of half-lives in 4860 yr $= \frac{4860}{1620} = 3$

Amount of radium left after three half-lives

$$= 1 \times \left(\frac{1}{2}\right)^3 = 0.125 \text{ mg}$$

Amount of radium disintegrated = (1 – 0.125) g = 0.875 g

Number of atoms which have disintegrated

$$= 0.875 \times 3.20 \times 10^{18} = 2.8 \times 10^{18} \text{ atoms}$$

33. **(a)** XeF_6 has much tendency to hydrolyse. The reverse reaction is more spontaneous.

$$XeF_6 + 3H_2O \longrightarrow XeO_3 + 6HF$$

34. **(b)** Basicity of lanthanide hydroxides decreases along the lanthanide series from left to right.

35. **(c)**

Metal ion	Outer electronic configuration
Cu^+	$3d^{10}, 4s^0$
Zn^{2+}	$3d^{10}, 4s^0$
Cr^{3+}	$3d^3, 4s^0$
Ti^{4+}	$3d^0, 4s^0$

As only Cr^{3+} has unpaired electrons. Hence, it will impart colour to the aqueous solution.

36. **(d)** $\overset{+}{N}H_4$ does not act as a ligand due to lack of electron pair on nitrogen atom.

37. **(b)** Aqueous solution of $AlCl_3$ is acidic due to hydrolysis

$$AlCl_3 + 3H_2O \rightleftharpoons Al(OH)_3 + 3HCl$$

On strongly heating, $Al(OH)_3$ is converted into Al_2O_3.

$$2Al(OH)_3 \xrightarrow{\Delta} Al_2O_3 + 3H_2O$$

38. **(d)** Anhydrous calcium chloride is used in the laboratory for fast drying of neutral gases.

39. **(b)** RNA contains four bases. Three (adenine, guanine, and cytosine) are the same as those in DNA, but the fourth base in RNA is uracil instead of thymine (present in DNA).

40. **(b)** Chemically treated cellulose (a polysaccharide) is known as silk.

CHEMISTRY IN action

Researchers Take Small Step Toward Silicon-based Life

For life on Earth, carbon is king. All organisms build their cells from carbon-based molecules. Scientists and science fiction authors have long speculated that because silicon atoms bond to other atoms in a manner similar to carbon, silicon could form the basis of an alternative biochemistry of life. Yet even though silicon is widely available on Earth and makes up 28% of the planet's crust (versus 0.03% for carbon), the element is almost entirely absent from life's chemistry. Researchers reported that they have evolved a bacterial enzyme that efficiently incorporates silicon into simple hydrocarbons_a first for life. Down the road, organisms able to incorporate silicon into their cells could lead to a novel biochemistry for life, although for now creating actual silicon-based creatures remains a long way off.

The bacterium is so-called thermophilic bacterium, which grows in hot springs. Like many organisms, the bacterium contains an enzyme called cytochrome c, which shuttles electrons to other proteins, making it widely useful in biochemistry. In some cases, however, enzymes in thermophilic bacteria expand their roles to carry out other reactions on the side. So the Caltech researchers tested their microbe and found that in rare cases its cytochrome c also added silicon to hydrocarbons.

For now, the silicon-spiked hydrocarbon compounds, called organosilanes, probably aren't useful either to the bacteria or to industry. They're short and stubby, unlike the long chainlike versions that chemical companies make for uses such as adhesives, caulks, and sealants.

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BITSAT PREP UP

Mock Questions with Complete Solutions

Instructions

- This test consists of 40 questions in chemistry and each question is allotted 3 marks for correct response.
- Candidates will be awarded marks as stated above for correct response of each question. 1/3 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. Which of the following changes are accompanied during the process of adsorption?

(a) Decrease in entropy
(b) Decrease in enthalpy
(c) Decrease in free energy
(d) All of the above

2. What is the energy change for the following nuclear reaction?

$$ {}_0n^1 \longrightarrow p + {}_{+1}e^0 $$

If $m_p = 1.00728$ u, $m_n = 1.00867$ u

(a) 16.76×10^{10} J
(b) 0.1242×10^{12} J
(c) 15.36×10^{8} J
(d) 12.86×10^{12} J

3. The four quantum numbers of the 19th electron for Ti (Z = 22) are

(a) $n = 4, l = 1, m = 0, s = +1/2$
(b) $n = 4, l = 0, m = 0, s = +1/2$
(c) $n = 3, l = 2, m = +2, s = +1/2$
(d) $n = 4, l = 2, m = -1, s = +1/2$

4. An ore contains 1.34% of the mineral argentite, Ag_2S, by mass. How many grams of this ore would have to be processed in order to obtain 1.00 g of pure solid silver, Ag?

(a) 74.6 g
(b) 85.7 g
(c) 107.9 g
(d) 134.0 g

5. Which of the following statements is not correct?

(a) In an exothermic reaction, the enthalpy of products is less than that of the reactants
(b) $\Delta H_{fus} = \Delta H_{sub} - \Delta H_{vap}$
(c) A reaction for which $\Delta H^\circ < 0$ and $\Delta S > 0$, is possible at all temperatures
(d) ΔH is less than ΔE for combustion of carbon to carbon dioxide

6. Derivatives of barbituric acid act as

(a) tranquilisers
(b) antibiotics
(c) antipyretics
(d) analgesics

7. Which of the following, on reaction with nitrous acid, followed by treatment with NaOH produces a blood-red colouration?

(a) RCH_2NO_2
(b) R_3CNO_2
(c) R_2CHNO_2
(d) $PhNO_2$

8. An organic compound gives a fruity smell, this compound on distillation in presence of dilute alkali, yields a product capable of giving positive iodoform test. Hence, the compound is

(a) methyl formate
(b) isopropyl acetate
(c) methyl propionate
(d) *n*-propyl formate

9. Which of the following statements is/are correct about σ-and π-molecular orbitals?

I. π-bonding orbitals are ungerade.
II. π-antibonding orbitals are ungerade.
III. σ-antibonding orbitals are gerade.

Choose the correct option.

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

10. In 21.6 carat gold, the percentage of gold is

(a) 70%
(b) 90%
(c) 21.8%
(d) 10%

11. The E°_{red} of Sn, Fe and Zn are -0.14 V, -0.44 V and -0.76 V, respectively. Which one of the following statements is correct?

(a) Corrosion of zinc can be prevented by coating with iron
(b) Corrosion of zinc can be prevented by tin coating
(c) Corrosion of tin can be prevented by coating with zinc
(d) Corrosion of iron can be prevented by coating with tin

12. Glycerol on treatment with excess HI gives
(a) 1, 2, 3-triiodopropane
(b) 1, 3-diiodopropane
(c) 2-iodopropane
(d) 3-iodopropane

13. Which of the following is the correct reactivity order for substitution reaction?
(a) Vinyl chloride > allyl chloride > isopropyl chloride
(b) Allyl chloride > isopropyl chloride > vinyl chloride
(c) Vinyl chloride > isopropyl chloride > allyl chloride
(d) Isopropyl chloride > vinyl chloride > allyl chloride

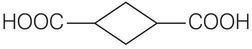
14. The latent heat of vaporisation of water is 9700 cal/mol. If the boiling point of water is 100°C, find out the ebullioscopic constant of water.
(a) 0.516 K (b) 1.026 K
(c) 10.26 K (d) 1.832 K

15. The rate of a reaction becomes four times when temperature is raised from 293 K to 313 K. The activation energy for such a reaction would be
(a) 50.855 kJ mol^{-1}
(b) 52.876 kJ mol^{-1}
(c) 54.855 kJ mol^{-1}
(d) 56.855 kJ mol^{-1}

16. Consider the reaction,

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

in a closed container at equilibrium. What would be the effect of addition of $CaCO_3$ on the equilibrium concentration of CO_2?
(a) Increases
(b) Decreases
(c) Data is not sufficient to predict
(d) Remains unaffected

17. Which of the following compounds will exhibit geometrical isomerism?
(a) $C_6H_5CH{=}NOH$
(b) $CH_3CH{=}CHCH_3$
(c) 

(d) All of the above

18. Toluene, on oxidation with $KMnO_4$ gives
(a) benzaldehyde
(b) phenol
(c) nitrotoluene
(d) benzoic acid

19. A compound of carbon, hydrogen and nitrogen contains three elements in the ratio of 9 : 1 : 3.5. The empirical formula of the compound is
(a) C_2H_4N (b) C_3H_4N
(c) C_3H_6N (d) C_2H_6N

20. IUPAC name of the isomer of $CH_3{-}CH{=}NOH$ would be
(a) methanamide
(b) 1-amino-2-propanone
(c) ethanamide
(d) None of the above

21. When equal volumes of the following solutions are mixed, precipitation of AgCl ($K_{sp} = 1.8 \times 10^{-10}$) will occur only with
(a) 10^{-4} M (Ag^+) and 10^{-4} M (Cl^-)
(b) 10^{-5} M (Ag^+) and 10^{-5} M (Cl^-)
(c) 10^{-5} M (Ag^+) and 10^{-6} M (Cl^-)
(d) 10^{-10} M (Ag^+) and 10^{-10} M (Cl^-)

22. In which of the following isolations, no reducing agent is required?
(a) Aluminium from bauxite (b) Mercury from cinnabar
(c) Zinc from zinc blende (d) Iron from haematite

23. When gold is dissolved in aqua-regia, which of the following compounds is formed?
(a) Aurous chloride (b) Chloroauric acid
(c) Auric chloride (d) None of these

24. The oxide that gives hydrogen peroxide on treatment with dilute acid is
(a) PbO_2 (b) Na_2O_2 (c) MnO_2 (d) TiO_2

25. The shape of XeF_4 is
(a) tetrahedral (b) square planar
(c) octahedral (d) trigonal planar

26. Which method of purification is represented by the following equation?

$$Ti + 2I_2 \xrightarrow{773\ K} TiI_4 \xrightarrow{1075\ K} Ti + 2I_2$$

(a) Poling (b) van-Arkel
(c) Cupellation (d) Zone refining

27. In a closed vessel, the following equilibrium exists at 85°C,

$$H_2O(l) \rightleftharpoons H_2O(g)$$

For the above reaction to proceed in forward direction, which condition is correct?
(a) $\Delta S > 0$ (b) $\Delta H > 0$
(c) $\Delta H - T\Delta S = 0$ (d) $\Delta H - T\Delta S > 0$

28. The bond angle in water is 104.5° instead of 109.5°, this is because of the presence of
(a) two lone pairs of electrons
(b) two hydrogen bonds
(c) hydrogen bonding in the molecule
(d) two covalent bonds

29. Caesium is the most reactive metal among alkali metals because
(a) it exerts considerable attractive force on valence electrons
(b) it is a heavier metal
(c) its incomplete shell is nearest to the nucleus
(d) its valence electron has the highest principal quantum number than the valence electron of any of the others

30. Which of the following is the correct relationship for the same gas at two different temperatures with two different rms velocities?
(a) $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$ (b) $\frac{v_2}{v_1} = \sqrt{\frac{T_1}{T_2}}$
(c) $\sqrt{\frac{v_1}{v_2}} = \frac{T_1}{T_2}$ (d) $\sqrt{\frac{v_2}{v_1}} = \frac{T_1}{T_2}$

31. 10 g of sample of mixture of $CaCl_2$ and NaCl is treated to precipitate all the calcium as $CaCO_3$. This $CaCO_3$ is heated to convert all the Ca to CaO and the final mass of CaO is found to be 1.62 g. The per cent by mass of $CaCl_2$ in the original mixture is

(a) 32.1% *(b)* 16.2% *(c)* 21.8% *(d)* 12.0%

32. The number of α and β-particles emitted in the following nuclear reaction are

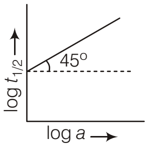
$${}_{90}Th^{228} \longrightarrow {}_{83}Bi^{212}$$

(a) 4α and 1β *(b)* 3 α and 7β
(c) 8α and 1β *(d)* 4α and 7β

33. For the half-cell reaction, $Cu^{2+} + 2e^- \longrightarrow Cu$, graph between E_{red} *versus* $\log[Cu^{2+}]$ is a straight line with intercept 0.34 V. The electrode oxidation potential of the half-cell Cu/Cu^{2+} (0.1 M) will be

(a) 0.34 *(b)* 0.34 + 0.0591/2
(c) – 0.34 – 0.0591/2 *(d)* – 0.34 + 0.0591/2

34. Following is the graph between $\log t_{1/2}$ and $\log a$ (a = initial concentration) for a given reaction at 27°C. Hence, order of reaction is



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

35. For a reaction,

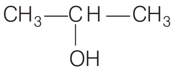
$$A(s) + 2B^+(aq) \longrightarrow A^{2+}(aq) + 2B$$

K_c has been found to be 10^{12}. The $E°_{cell}$ is

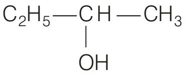
(a) 0.354 V *(b)* 0.708 V *(c)* 0.0098 V *(d)* 1.36 V

36. The lowest rate of esterification of acetic acid catalysed by acid will be observed with the alcohol

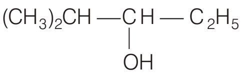
(a) CH_3OH

(b)


$CH_3—\underset{OH}{\underset{|}{C}}H—CH_3$

(c)


$C_2H_5—\underset{OH}{\underset{|}{C}}H—CH_3$

(d)


$(CH_3)_2CH—\underset{OH}{\underset{|}{C}}H—C_2H_5$

37. The correct increasing order for the polarisability of halide ions is

(a) $F^- < I^- < Br^- < Cl^-$ *(b)* $Cl^- < Br^- < I^- < F^-$
(c) $I^- < Br^- < Cl^- < F^-$ *(d)* $F^- < Cl^- < Br^- < I^-$

38. What will be the temperature when the rms velocity is four times of that at 300 K?

(a) 300 K *(b)* 900 K *(c)* 4800 K *(d)* 1200 K

39. Which one of the following pairs is not correctly matched?

(a) Terylene → Condensation polymer of terephthalic acid and ethylene glycol
(b) Perspex → A homopolymer of methyl methacrylate
(c) Teflon → Thermally stable cross-linked polymer of phenol and formaldehyde
(d) Synthetic rubber → A copolymer of butadiene and styrene

40. Which among the following is the wrong statement for Cannizzaro reaction?

(a) In Cannizzaro reaction, the oxidation number of carbon of —CHO increases as as well as decreases
(b) Cannizzaro reaction is a disproportionation process
(c) Cannizzaro reaction is responded only by the first member of alkanal series
(d) Aldehydes without α-hydrogen give Cannizzaro reaction

Answers *with* Explanation

1. **(d)** For adsorption, ΔH = –ve (always exothermic), ΔS = – ve (as the randomness decreases in the process). Hence, at low temperatures, adsorption is spontaneous as ΔG is negative. When, $|T\Delta S| > |\Delta H|$ then ΔG = –ve.

2. **(b)** Total mass of the reactant, ${}_0n^1$ = 1.00867 u
Total mass of the products = 1.00728 u
Loss in mass = (1.00867 – 1.00728) u = 0.00139 u
Energy released by the loss of mass of 0.00139 u

$$= 0.00139 \times 931 \text{ MeV}$$
$$= 0.00139 \times 931 \times 9.6 \times 10^{10} \text{ J}$$
$$= 12.42 \times 10^{10} \text{ J or } = 0.1242 \times 10^{12} \text{ J}$$

3. **(b)** Electronic configuration of Ti (Z = 22) is

$$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^2$$

Since, 19 th electron lies in 4s-orbital, therefore
$n = 4, l = 0, m = 0, s = +1/2$

4. **(b)** $\underset{248\text{ g}}{Ag_2S} \equiv \underset{2\times108\text{ g}}{2Ag}$

2×108 g of Ag is obtained from Ag_2S = 248 g

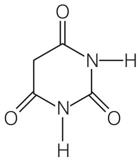
1 g of Ag will be obtained from $Ag_2S = \frac{248 \times 1}{2 \times 108} = \frac{248}{216}$ g

But, the ore contains only 1.34% Ag_2S.

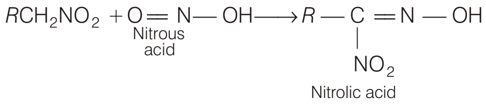
Thus, 1 g of Ag is obtained from ore $= \frac{248}{216} \times \frac{100}{1.34}$ g = 85.68 g

5. **(d)** For any reaction to be spontaneous, the value of ΔH should be negative. Combustion of carbon to carbon dioxide is a spontaneous process for which ΔH = –ve.

6. **(a)** The drugs that are given to the patients suffering from anxiety and mental tension are called tranquilisers. They help the individual to work according to the capacity by removing symptoms of emotional distress.

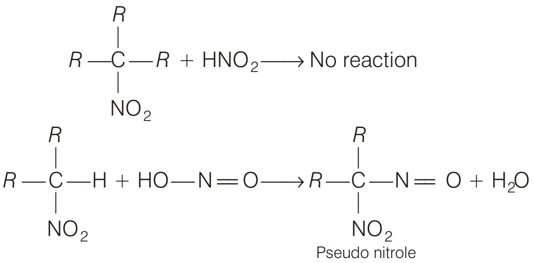


Barbituric acid

7. **(a)**


$$RCH_2NO_2 + \underset{\text{Nitrous acid}}{O{=}N—OH} \longrightarrow \underset{\text{Nitrolic acid}}{R—\underset{NO_2}{\underset{|}{C}}{=}N—OH}$$

Nitrolic acid dissolves in NaOH to give blood-red colouration.



$$R{-}\overset{\overset{\Large R}{|}}{\underset{\underset{\Large NO_2}{|}}{C}}{-}R + HNO_2 \longrightarrow \text{No reaction}$$

$$R{-}\overset{\overset{\Large R}{|}}{\underset{\underset{\Large NO_2}{|}}{C}}{-}H + HO{-}N{=}O \longrightarrow R{-}\overset{\overset{\Large R}{|}}{\underset{\underset{\Large NO_2}{|}}{C}}{-}N{=}O + H_2O$$

Pseudo nitrole does not dissolve in NaOH, but give blue colouration.

$$PhNO_2 + HNO_2 \longrightarrow \text{No reaction}$$

8. **(b)**

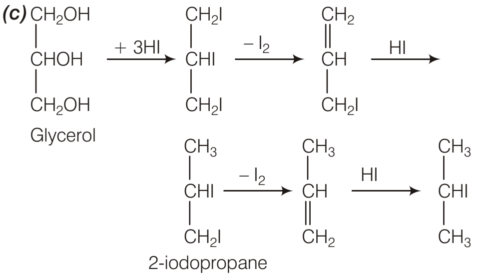
9. **(a)** According to molecular orbital theory, π-bonding orbitals are ungerade.

10. **(b)** 21.6 carat gold contains 21.6 parts of gold in 24 parts of weight of alloy. Percentage of gold in 21.6 carat gold is

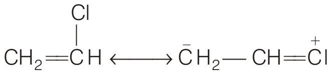
$$= \frac{21.6}{24} \times 100 = 90\%$$

11. **(c)** E°_{red} 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 can be easily prevented by coating with Zn.

12. **(c)**



13. **(b)** Vinyl chloride (most stable) is relatively less reactive due to resonance.



$$CH_2{=}\overset{\overset{\Large Cl}{|}}{C}H \longleftrightarrow \overset{-}{C}H_2{-}CH{=}\overset{+}{Cl}$$

While allyl chloride is very reactive due to stabilisation of allyl carbonium ion by resonance.

$$CH_2{=}CH{-}\overset{+}{C}H_2 \longleftrightarrow \overset{+}{C}H_2{-}CH{=}CH_2$$

Isopropyl chloride is in between them in reactivity.

14. **(a)** $K_b = \dfrac{R \cdot T_b^2 M}{1000 \cdot L_V} = \dfrac{2 \times 373 \times 373 \times 18}{1000 \times 9700} = 0.516\text{K}$

15. **(b)** From Arrhenius equation,

$$\log \frac{k_2}{k_1} = \frac{E_a}{2.303R}\left(\frac{T_2 - T_1}{T_1 \cdot T_2}\right)$$

Hence,

$$\log 4 = \frac{E_a}{2.303 \times 8.314}\left(\frac{313 - 293}{293 \times 313}\right)$$

or $\quad 2 \times 0.3010 \times 2.303 \times 8.314 = E_a\left(\dfrac{20}{91709}\right)$

or $\quad E_a = \dfrac{11.527}{0.000218} = 52876.1\ \text{J mol}^{-1}$

$$= 52.876\ \text{kJ mol}^{-1}$$

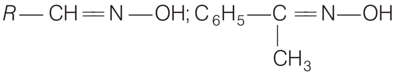
16. **(d)** This is a heterogeneous equilibrium. Hence, equilibrium constant for this is

$$K_C = [CO_2]$$

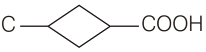
Hence, $CaCO_3$ has no effect on equilibrium concentration.

17. **(d)** All the compounds that have restricted rotation about a bond, show geometrical isomerism.

Oximes of the type

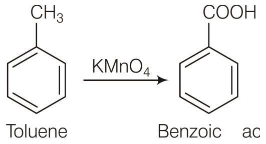


$$R{-}CH{=}N{-}OH;\ C_6H_5{-}\underset{\underset{\Large CH_3}{|}}{C}{=}N{-}OH$$

and cyclic compounds like 

show geometrical isomerism.

18. **(d)**



19. **(b)** The percentage (or mass) ratio = 9 : 1 : 3.5

$\therefore$ Mole ratio $= \dfrac{9}{12} : \dfrac{1}{1} : \dfrac{3.5}{14}$

$= 0.75 : 1 : 0.25$

or $\quad = 3 : 4 : 1$

Hence, empirical formula = C_3H_4N

20. **(c)** CH_3CONH_2 is the isomer of the given structure and its IUPAC name is ethanamide.

21. **(a)** When ionic product at a time is greater than K_{sp}, electrolyte precipitates.

Ionic product is greater than K_{sp}, only in condition mentioned in option (a), hence, precipitation occurs.

$$AgCl \rightleftharpoons Ag^+ + Cl^-$$

$$K = [Ag^+][Cl^-]$$

$$K = 10^{-4} \times 10^{-4} = 10^{-8}$$

$$10^{-8}\ \text{M} > 10^{-10}\ (K_{sp})$$

22. **(b)** Isolation of mercury from cinnabar is an auto-reduction process. In this process, no external reducing agent is required. The sulphide ores of less electropositive metals like, Hg, Pb, Cu etc., are heated in air to convert sulphide part of the ore into oxide or sulphate which then reacts with the remaining sulphide ore to give the metal and sulphur dioxide.

$$2HgS + 3O_2 \longrightarrow 2HgO + 2SO_2$$

$$2HgO + HgS \longrightarrow 3Hg + SO_2$$

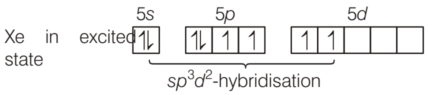
23. **(b)** Reaction of gold with in aqua-regia is

$$Au + 3HNO_3 + 4HCl \longrightarrow \underset{\text{Chloroauric acid}}{HAuCl_4} + 3NO_2 + 3H_2O$$

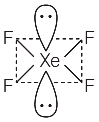
24. **(b)** Peroxides, on treatment with dilute acids, give hydrogen peroxide.

$$\underset{\substack{\text{Sodium}\\\text{peroxide}}}{Na_2O_2} + 2HCl \longrightarrow \underset{\substack{\text{Hydrogen}\\\text{peroxide}}}{H_2O_2} + 2NaCl$$

25. **(b)** Xe in excited state



Due to the presence of two lone pair of electrons, it is square planar in shape.



26. ***(b)*** van-Arkel method is used for the purification of titanium (Ti).

27. ***(a)*** For the reaction mentioned in the problem to proceed in forward direction, it has to be spontaneous.

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

For spontaneity, $\Delta G = -\text{ve}; \quad \Delta H = -\text{ve}$

$$\Delta S = +\text{ve}$$

28. ***(a)*** The bond angle in water is 104.5° instead of 109.5°, this is because of the presence of two lone pairs of electrons.
Lone pair-lone pair repulsion is much greater than lone pair-bond pair repulsion and hence, this repulsion causes the change in shape.

29. ***(d)*** When valence electron(s) is in the highest quantum shell, the ionisation energy is lowest and hence, reactivity is highest.

30. ***(a)*** For the same gas at two different temperatures, the ratio of rms velocities will be, $\frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$.

31. ***(a)*** $CaCl_2 + NaCl = 10\,g$

Let, weight of $CaCl_2 = x$ g

$$\underset{1\text{ mol}}{CaCl_2} \longrightarrow \underset{1\text{ mol}}{CaCO_3} \longrightarrow \underset{1\text{ mol}}{CaO}$$

$$\frac{x}{111}\text{mol} \qquad \frac{x}{100}\text{mol} \qquad \frac{x}{56}\text{mol}$$

Moles of CaO $= \frac{1.62}{56}$

$$\therefore \qquad \frac{x}{111} = \frac{1.62}{56}$$

$$x = 3.21\,g$$

$$\%\text{ of }CaCl_2 = \frac{3.21}{10} \times 100 = 32.1\%$$

32. ***(a)*** Number of α-particles

$$= \frac{\text{Mass number of emitter} - \text{mass number of end-product}}{4}$$

$$= \frac{228 - 212}{4} = \frac{16}{4} = 4$$

Number of β-particles

$= 2 \times$ α-particles – (difference in atomic number)

$= 2 \times 4 - (90 - 83) = 8 - 7 = 1$

Hence, α - and β-particles emitted are 4 and 1 respectively.

33. ***(d)*** $Cu^{2+} + 2e^- \longrightarrow Cu$

$$E_{Cu^{2+}/Cu} = E^\circ_{Cu^{2+}/Cu} - \frac{0.059}{2}\log\frac{1}{[Cu^{2+}]}$$

$$= E^\circ_{Cu^{2+}/Cu} + \frac{0.059}{2}\log[Cu^{2+}]$$

Intercept $= 0.34 \Rightarrow E^\circ_{Cu^{2+}/Cu} = 0.34$

$$E_{Cu^{2+}/Cu} = 0.34 + \frac{0.059}{2}\log 0.1 = \left(0.34 - \frac{0.059}{2}\right)\text{V}$$

$$E_{Cu/Cu^{2+}} = -E_{Cu^{2+}/Cu} = \left(-0.34 + \frac{0.059}{2}\right)\text{V}$$

34. ***(d)*** $t_{1/2} \propto \left(\frac{1}{a}\right)^{n-1}$ or $t_{1/2} = k(a)^{1-n}$

$$\log t_{1/2} = \log k + (1-n)\log a$$

(It represents straight line equation, $y = c + mx$)

Slope $= (1-n) = \tan 45^\circ = 1$

$\therefore \qquad (1-n) = 1$

$\Rightarrow \qquad n = 0$

35. ***(a)*** We know that,

$$\Delta G^\circ = -2.303\,RT\log K_C$$

$$= -2.303\,RT\log 10^{12}$$

$$= -12 \times 2.303\,RT \qquad \ldots\text{(i)}$$

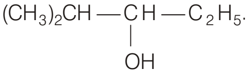
Also, $\Delta G^\circ = -nFE^\circ_{\text{cell}} \qquad \ldots\text{(ii)}$

or $\quad -12 \times 2.303\,RT = -nFE^\circ_{\text{cell}} \qquad$ [from (i) and (ii)]

or $\quad E^\circ_{\text{cell}} = \left(\frac{2.303RT}{nF} \times 12\right)\text{V}$

$$= \left(\frac{0.059}{2} \times 12\right)\text{V} \qquad (n = 2)$$

$$= 0.354\text{ V}$$

36. ***(d)*** In esterification reaction, the oxygen of alcohol donates its lone pair to positively charged C-atom of carbonium ion. But this attack does not occur readily in bulky alcohol such as  $(CH_3)_2CH—\underset{\substack{|\\ OH}}{CH}—C_2H_5$.
Hence, the rate of esterification of acetic acid catalysed by acid get lowered.

37. ***(d)*** The increasing order for the polarisability of halide ions is $F^- < Cl^- < Br^- < I^-$
The size of I^- is greater than all the halide anions. As a result, the electrons are loosely packed and can be easily polarisable.

38. ***(c)*** μ (rms velocity) $= \sqrt{\frac{3RT}{M}}$

Hence, $\quad \mu \propto \sqrt{T}$

For case I, at temperature T,

$$\mu = \sqrt{\frac{3RT}{M}} \qquad \ldots\text{(i)}$$

For case II, at temperature T',

$$4\mu = \sqrt{\frac{3RT'}{M}} \qquad \ldots\text{(ii)}$$

From Eqs. (i) and (ii),

$$\frac{\mu}{4\mu} = \sqrt{\frac{T}{T'}}$$

or $\quad \frac{1}{4} = \sqrt{\frac{300}{T'}} \qquad (T = 300\text{ K})$

or $\quad T' = 4800\text{ K}$

39. ***(c)*** Teflon is thermally stable polymer of tetrafluoroethylene $(F_2C{=}CF_2)$.

$$nF_2C{=}CF_2 \xrightarrow{\text{Polymerisation}} \left[\!-F_2C—CF_2-\!\right]_n$$

40. ***(c)*** Cannizzaro reaction is shown by aldehydes lacking of α-hydrogen (non-enolisable aldehydes) and seen as self oxidation-reduction, i.e. disproportionation. Thus, the reaction is given by aromatic aldehydes, HCHO, R_3CCHO and heterocyclic aldehydes etc.

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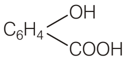
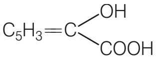
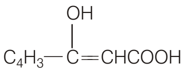
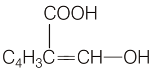
Quizzer (No.18)

1. A compound B ($C_{10}H_{12}O_3$) was insoluble in water, dil. HCl and dil. $NaHCO_3(aq)$, it was soluble in dil.NaOH. A solution of B in dil. NaOH was boiled and the distillate was collected in a solution of NaOI, where a yellow precipitate formed. The alkaline residue in the flask was acidified with dil. H_2SO_4, a solid (C) precipitated. When this mixture was boiled, C gets steam-distilled and was collected. C was found to have formula $C_7H_6O_3$. It dissolved in *aq*. $NaHCO_3$ with evolution of gas. Identify C.

(a) 
$C_6H_4(OH)(COOH)$

(b) 
$C_5H_3{=}C(OH)(COOH)$

(c) 
$C_4H_3{-}\overset{\overset{\displaystyle OH}{|}}{C}{=}CHCOOH$

(d) 
$C_4H_3\overset{\overset{\displaystyle COOH}{|}}{C}{=}CH{-}OH$

2. Dry air is passed through a solution containing 20 g of a non-volatile solute in 250 g water. The air was then passed through pure water and then through a U-tube containing anhyd. $CaCl_2$. The mass loss in solution was 26 g and the mass gain in U-tube was 26.48 g. What is apparent molecular weight of solute? If solute is A_2B_3 and dissociates in $2A^{3+}$ and $3B^{2-}$ ions, calculate degree of dissociation of A_2B_3. Atomic masses of A and B are 24 and 36 $g mol^{-1}$ respectively.

(a) 20% (b) 30% (c) 25% (d) 28%

3. A blood-volume determination was carried out on a patient by injection with 20.0 mL of blood that had been radioactively labelled with Cr-51 to an activity of 4.10 μCi/mL. After a brief period to allow for mixing in the body, blood was drawn from the patient for analysis. Unfortunately, a mix up in the laboratory prevented an intermediate analysis and it was not until 17.0 days later that a scintillation measurement on the blood was made. The radiation level was then determined to be 0.00935 μCi/mL. If ^{51}Cr has $t_{1/2} = 27.7$ days. What is the volume of blood in the patient?

(a) 5.93 L (b) 6.02 L (c) 5.73 L (d) 5.20 L

4. Gold metal is extracted from its ore by treating the crushed rock with an aerated cyanide solution. Use any of the following data at 25°C and calculate $\Delta G°$ for this reaction, K_f for $[Au(CN)_2]^- = 6.2 \times 10^{38}$, K_a for HCN $= 4.9 \times 10^{-10}$ and standard reduction potential are

$$O_2(g) + 4H^+(aq) + 4e^- \longrightarrow 2H_2O(aq);\ E° = 1.229\text{ V}$$
$$Au^{3+}(aq) + 3e^- \longrightarrow Au(s);\ E° = 1.498\text{ V}$$
$$Au^{3+}(aq) + 2e^- \longrightarrow Au^+(aq);\ E° = 1.401\text{ V}$$

(a) – 387.0 kJ (b) – 400.0 kJ
(c) 387.0 kJ (d) 400.0 kJ

5. Ozone is prepared in laboratory by passing electric discharge to oxygen gas, $3O_2(g) \longrightarrow 2O_3(g)$

Assume that an evacuated vessel of steel with a volume of 10.00 L is filled with 32.00 atm of O_2 at 25°C and an electric discharge is passed through the vessel, causing some of the oxygen to be converted into ozone. As a result, pressure inside the vessel drops to 30.64 atm at 25°C. Calculate the final mass per cent of ozone in the vessel.

(a) 9.08% (b) 12.7% (c) 22.4% (d) 90.7%

6. Chromium forms three isomeric compounds A, B and C with per cent compositions 19.52% Cr, 39.91% Cl and 40.57% H_2O. When a sample of each compound was dissolved in water and aqueous $AgNO_3$ was added, a precipitate of AgCl formed immediately. A 0.225 g sample of compound A gave 0.363 g of AgCl, 0.263 of B gave 0.283 g of AgCl and 0.358 g of C gave 0.193 g of AgCl. Which of the three compounds is likely to be the violet one?

(a) A (b) B
(c) C (d) None of these

7. A non-stoichiometric iron oxide with the empirical formula Fe_xO, (where x is a number slightly less than 1) can be regarded as FeO in which some of Fe sites are vacant. It has a density 5.75 g cm^{-3}, a cubic unit-cell with an edge length of 431 pm and a face-centred cubic arrangement of oxygen atoms.

Using X-rays with a wavelength of 70.93 pm, at what angle would third-order diffraction be observed from the planes of atoms that coincide with the faces of the unit cells?

(a) 20.0° *(b)* 14.3° *(c)* 16.7° *(d)* 15.5°

8. Consider the following statements.

I. The ejection of a beta particle always means that a different element is formed because a neutron has been converted into a proton.

II. The smaller is the binding energy per nucleon, the greater is the stability of the nucleus.

III. All nuclei are thermodynamically unstable with respect to iron-56.

IV. One of the species in the uranium-238 series in radon-222, an alpha emitter.

Choose the correct option regarding correct statements.

(a) I, II and III *(b)* II, III and IV

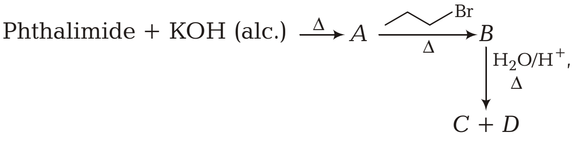
(c) I, III and IV *(d)* All of these

9. A black coloured compound *A* on reaction with dil. H_2SO_4 gives a gas *B* which on passing in a solution of an acid *C* gives a white turbidity *D*. Gas *B* when passed in an acidified solution of compound *E* gives a precipitate *F* which is soluble in dil. HNO_3. After boiling this solution when an excess of NH_4OH is added, a blue coloured compound *G* is formed. To this solution on addition of acetic acid and *aq.* $K_4[Fe(CN)_6]$, a chocolate precipitate *H* is obtained. On addition of an aqueous solution of $BaCl_2$ to an aqueous solution of *E*, a white precipitate insoluble in HNO_3 is obtained. Identify the compound *H*.

(a) $Cu_2[Fe(NH_3)_6]$ *(b)* $Cu_2[Fe(CN)_6]$

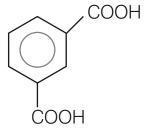
(c) CuS *(d)* $[Cu(NH_3)_4(NO_3)_2]$

10. Consider the following reaction,

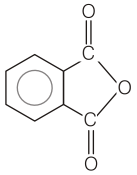


The product *D* is

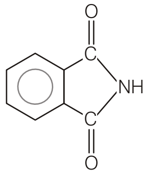
(a)



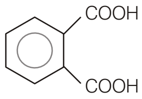
(b)



(c)



(d)



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2.	○	○	○	○	7.	○	○	○	○
3.	○	○	○	○	8.	○	○	○	○
4.	○	○	○	○	9.	○	○	○	○
5.	○	○	○	○	10.	○	○	○	○

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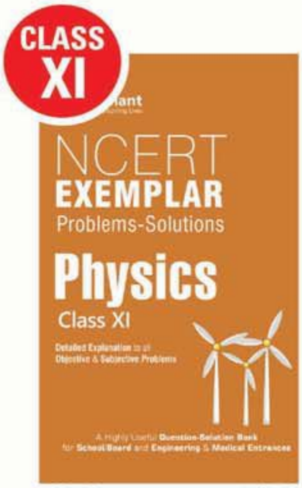

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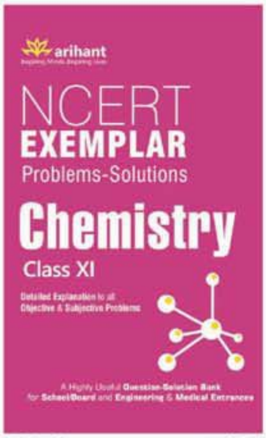

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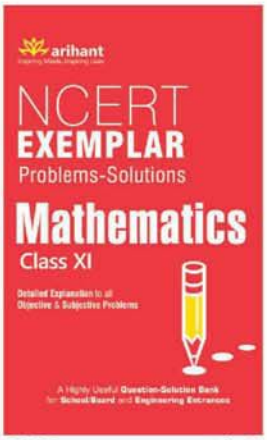

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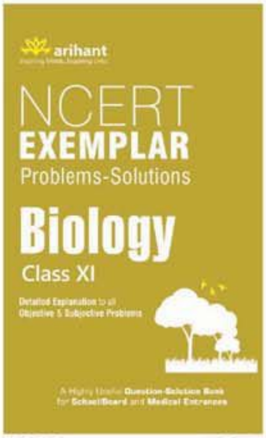

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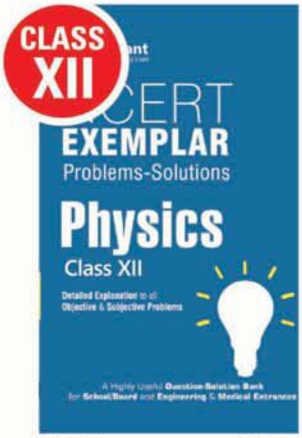

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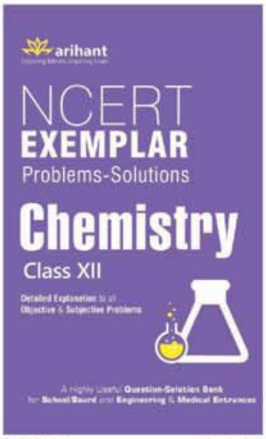

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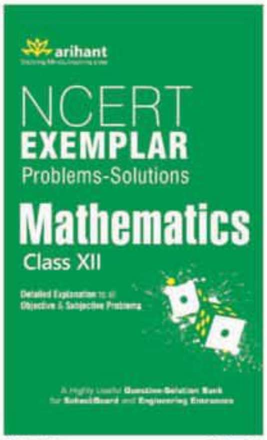

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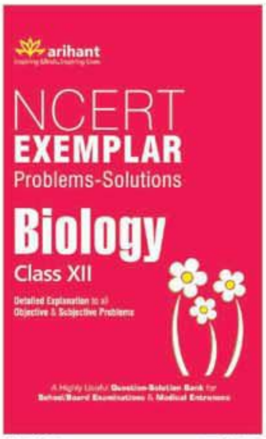

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