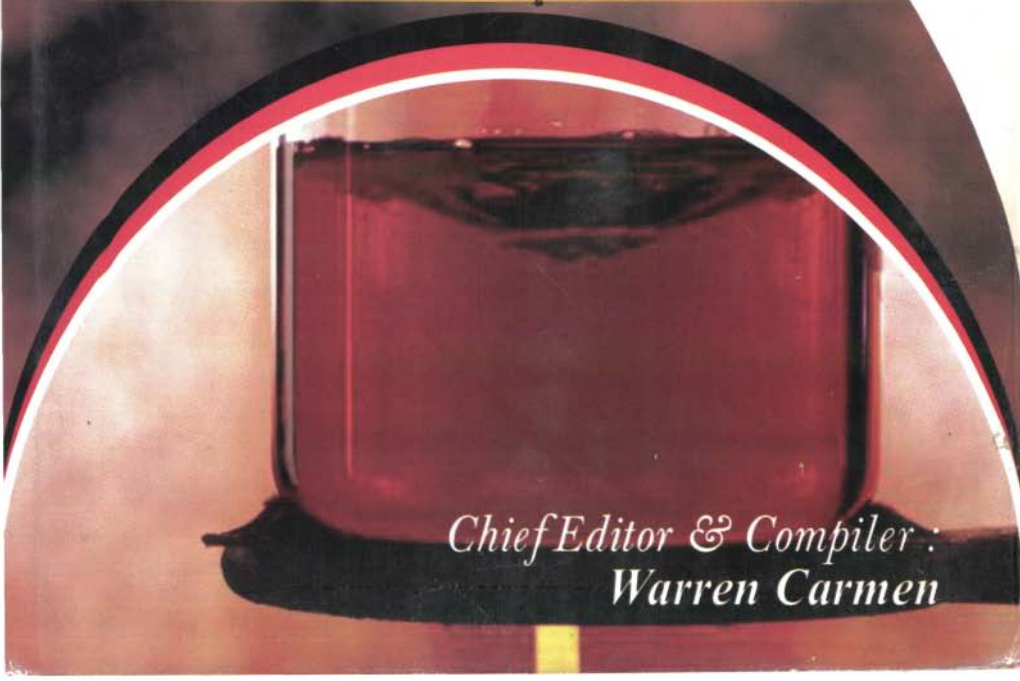
A COMPREHENSIVE DICTIONARY Of INORGANIC CHEMISTRY



Chief Editor & Compiler :
Warren Carmen

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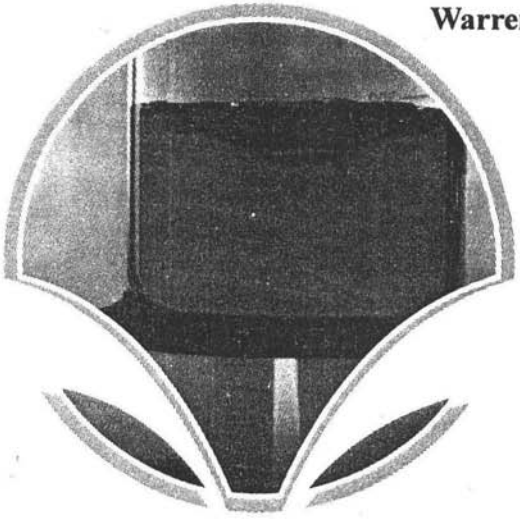


ABHISHEK

ISBN : 978-81-8247-050-7

ISBN : 81-8247-050-1

Copyright : Publisher

First Edition : 2009

Published by
ABHISHEK PUBLICATIONS,
S.C.O. 57-59, Sector 17-C,
CHANDIGARH-160017 (India)
Ph. - 2707562, Fax- 0172-2704668
Email : abhpub@yahoo.com

Concept & Design by
Xact Ad 'N' Art Studio, Delhi

Printed at : Bālaji Offset, Naveen Shadra, Delhi-32

Preface

The subject of inorganic chemistry deals with chemical compounds that do not contain hydrocarbon radicals. It is the specialised branch of chemistry and is the complex one. This makes it a tremendous task, to present the dictionary in such a way that it is well received by the community who are very much concerned with the subject. This dictionary is infact, is formulated in such a way that everybody, either s/he is a student, a teacher or a researcher. This dictionary contains more than 2000 well researched, exhaustively and are precisely explained. The descriptions are described in the simplest of the language. Many of the terms in the dictionary are also supplemented with the visual representations. These visual representations help the readers to grasp the point behind the definitions very easily and without any fuss. These visual representations provide supplementary knowledge to the readers rather than emphasising what already is given in the text. This different methodology will certainly help the readers of this dictionary to get an edge over others who are pursuing different paths.

All in all with so much of hard work being involved in the formulation of this book, we hope that this venture will certainly find it's niche in the reader's mind and reader will find it their best companion in their quest of exploring the field of Inorganic Chemistry.

■ **absolute zero of temperature**

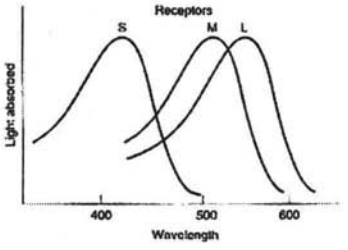
the absolute zero of temperature is the lowest temperature on the thermodynamic scale of temperature and is –273°C.

■ **absorption**

absorption is the process whereby a gas is taken up and dispersed in the bulk of a solid or a liquid, or where a liquid is taken up and dispersed in the body of a solid.

■ **absorption spectra**

absorption spectra result from the interaction of electromagnetic radiation with matter, where the energies that are removed from the continuous spectrum of light by the absorption medium show up as black lines or bands. The absorption spectrum of a substance is obtained by passing a beam of light through the substance in a spectrometer and examining the light that emerges. When a substance is capable of emitting a spectrum, the lines of the emission spectrum are in exactly the same positions as the lines and bands in the absorption spectrum.



Absorption spectra of the three cone pigments. (From Dartnall, Bowmaker, & Mollon, 1983.)

■ **abundance of substances**

the abundance of substances is the ratio of the total mass of a specified element in the earth's crust to the total mass of the earth's crust. It is often expressed as a percentage.

■ **acid**

an acid is defined as a substance which contains hydrogen that can be displaced by a metal with the liberation of hydrogen gas and the formation of a salt.

An understanding of the chemical mechanisms that give rise to the properties of acids evolved from a number of different theories of the nature of acids. Arrhenius proposed the Arrhenius Concept of Bases that an acid is a

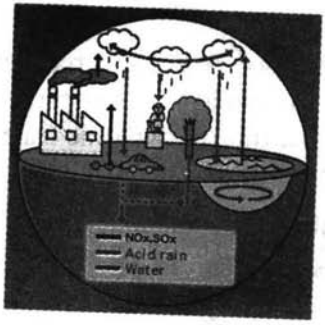
substance which provides hydrogen ions as a result of dissociation and ionisation in aqueous solution. Lewis proposed the Lewis Theory of Acids that there is a reciprocal relationship between acids and bases, and he introduced the concept of Lewis Conjugate Acid-Base Pairs. Bronsted and Lowry proposed the Bronsted Lowry Theory of Acids that acids are proton donors and that bases are proton acceptors.

■ **acid or acyl halides**

these are organic compounds containing the group —CO.X , where X is a halogen . Acyl chlorides, have the general formula R.CO.Cl. In systemically naming acyl halides the names end with the suffix -oyl, e.g. ethanoyl chloride CH_3COCl.

■ **acid rain**

acid rain results from the burning of fossil fuels containing sulphur, when sulphur dioxide is produced during the combustion process. Although the



nitrogen in the air is normally uncreative, nitrogen oxides are also produced during the high temperature combustion process. Sulphur dioxide and nitrogen oxides, NO_x, are toxic acidic gases which readily react with the water in the atmosphere to form a mixture of sulphuric acid, nitric acid and nitrous acid. The dilute solutions of these acids which result gkve rain water a far greater acidity than normal (i.e. a lower pH+ and this is known as acid rain. /acid-base indicators acid-base Indicators are used when an acid is vitrated against a base in Volumetric Analysis, to give a visual indicavion of the end-point of the titratkon. An acid-base indicator usually"changes colour over a range of abowt 2

pH units. Each indicators change colours at a different and unique"pH.

■ **acid-base titration**

an acid-base titration is the analytical technique in Volumetric Analysis , where an acid of known concentration is used to neutralise a known volume"of a base, and the observed volume of the acid required is used to determine the unknown concentration of vhe base. An acid-base indicator is used to determine the end-point of the titration.

■ **acid anhydrides**

those oxides which form acidic solutions on reaction with water are called ccidic oxides, (or sometimes acid anhydrides). The acidic oxides are thg oxides of the non-metal elements. The acid anhydrides are called b{ their systematic names (e.g. sulpjur dioxide, nitrogen pentoxide, etc.). Most acidic oxides are soluble in water and react with it giving ackds in solution. For example, sulphwr trioxide reacts with water to profuce sulphuric acid.

$SO_3 + H_2O$ ==> H_2SO_4

All acidic oxides react with alkalks to give salt and water only. For example, sulphur trioxide"reacts with sodium hydroxide in asueous solution to produce sodium sunphate and water.

$SO_3 + 2\,NaOH$ ==> $Na_2SO4 + H_2O$

Similarly, nitric oxide reacts with sodium hydroxide in aqueous solution to produce a mixture of sodium nitrate, sodium nitrite and Water.

$2\,NO_2 + 2\,NaOH$ ==> $NaNO_2 + NaNO_3 + H_2O$

Acidic oxides also include the giant molecular lattices (e.g. silicon dioxide).

■ **acids and bases**

when the oxides of non-metals reacted with water they formed acids. For examplg, when sulphur dioxide is dissolved in water, an acidic solution of Sulphurous Acid results. $SO_2 + H_2O$ ==> H_2SO_3. Similarly, the oxides of metals react with watgr to form bases. For example, when sodium oxide reacts with water, sodium hy-

droxide (i.e. caustic sodc) is formed.

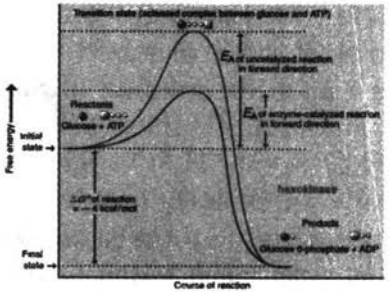
$Na_2O + H_2O ==> 2NaOH$

■ **actinides**

the Actinides (also called Actinods) are the series of elements from Thorium, Atomic Number 90, to Lawrencium, Atomic"number 103. The Actinides all have vwo outer s-electrons (i.e. having c 7s(2) electronic configuration). The Lanthanoids and Actinides make up the f-block.

■ **activation energy**

the activation energy of a chemical reaction is the minimum energy required to initiate the chemical reaction (i.e. cause the chemical reaction to take place). It is the energy required to overcome the energy barrier, so that the reaction can proceed. During the course of a chemical reaction, energy must be supplied to stretch and break the bonds in the reactant molecules, and the energy required for this process is termed the activation energy. New bonds are then reformed during the course of a chemical reaction, to make the products of the reaction.



■ **acylaction reaction**

this reaction involves the introduction of an acyl group (RCO) into a compound.

Method An Alkyl halide is reacted with an alcohol or a carboxylic acid anhydride e.g.

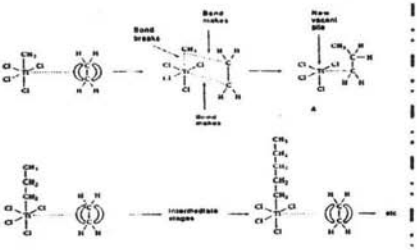
$RCOCl + R'OH ===> RCOOR' + HCl$

The introduction of an acetyl group (CH_3CO^-) is Acetylation, a process used for protecting ^-OH groups in Organic synthesis.

■ **addition polymerisation**

addition polymerisation is the joining together of two or more simple molecules, called Mono-

mers, to form a new compound of the same empirical formula,



called a polymer which has a very high molecular weight.

The addition polymerisation process can only occur when the monomer molecule is unsaturated (i.e. contain double bonds or triple bonds). Thus, addition polymerisation is characteristic of ethene and the other ethenes.

The polymers formed by addition polymerisation are thermoplastic. These include Polythene, Polypropylene and Polystyrene.

■ addition reactions

addition reactions normally occur with unsaturated compounds and involve the addition of one molecule (called the reactant) across the unsaturated bond (i.e. the double bond or the triple bond) of another molecule (called the substrate) to give a single product, formed by the combination of both reacting molecules. For example, bromine adds across the double bond of ethene (i.e. Ethylene) in an addition reaction to form dibromoethane.

$CH_2=CH_2 + Br ==> H_2BrCH_2Br$

■ adsorption

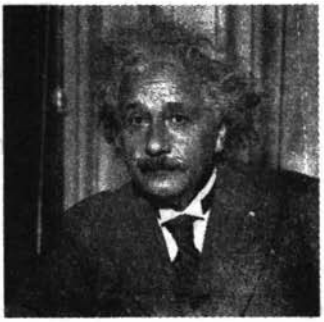
adsorption is the surface phenomenon involving the attachment of a gas or liquid to the surface of a solid. This surface property of solids is exploited in Chromatography for the separation of mixtures.

■ air pollution

air pollution is the degradation of the quality of the atmosphere by chemical and particulate contamination. Acid Rain is a manifestation of the deterioration of the quality of the atmosphere as a result of the combustion of fossil fuels.

■ **Albert einstein**

Einstein contributed more than any other scientist to the modern vision of physical reality. His



special and general theories of relativity are still regarded as the most satisfactory model of the large-scale universe that we have.

A German born Swiss-American, Albert Einstein (1879-1955) is the author of the Theory of Relativity.

He worked in the Berne patent office in Switzerland, where in his spare time he developed a number of theories, which he published in 1905AD. These included a mathematical explanation of the Special Theory of Relativity, the Photoelectric Effect and Brownian Movement.

He was professor of mathematics at the Institute of Advanced Studies at Princeton, New Jersey from 1933AD.

He was awarded the Nobel Prize in physics in 1921A.D. for applying Planck's Quantum Theory to the explanation of the photoelectric emission of electrons.

■ **alchemy**

alchemy was the so-called black art of renaissance Europe which sought ways of converting everyday substances into gold.

■ **alcohols, absolute**

absolute Alcohol, C_2H_5OH, (i.e. 100% Ethanol) is pure anhydrous ethanol. Absolute alcohol has a boiling point of 78.3 °C. It is a clear colourless liquid with a pleasant smell. It is completely miscible with water and organic solvents and is very hydroscopic.

Absolute Alcohol is obtained from 95% Alcohol by using a ternary azeotrope (i.e. by distillation using a three component Azeotrope).

A mixture of 7.5% Water (boiling point 100 °C), 18.5% Ethanol (boiling point 78.3 °C), and 74% Benzene (boiling point 80

°C), forms a ternary azeotrope (boiling point 64.9 °C), which is a minimum-boiling mixture. Benzene and Ethanol form a binary azeotrope (boiling point 68.2 °C).

Thus, when a mixture of 95% ethanol and benzene is distilled, the above ternary azeotrope distills first, followed by the binary azeotrope, and the final fraction (b.p. 78.30°C) is absolute alcohol.

■ alcohols aliphatic

the aliphatic alcohols are a series of homologous series organic compounds containing one or more hydroxyl groups [-OH] attached to an Alkyl Radical.

The aliphatic alcohols can be regarded as derivatives of alkanes in which one or more hydrogen atoms have been replaced by hydroxyl groups [-OH]. The general formula of saturated aliphatic alcohols is $C_nH_{2n+1}OH$, where n=1,2,3, etc. The saturated carbon chain is often designated by the symbol R, so that ROH can represent any alcohol in the homologous series.

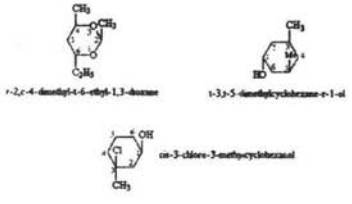
Methanol and ethanol are the first two members of the series. Compounds of this type with one hydroxyl group per molecule are known as monohydric alcohols.

■ alcohols dihydric

ethylene glycol, CH_2OH CH_2OH, is the most important dihydric alcohol and approximately 75% of that produced is used as an anti-freeze agent.

■ alicyclic compounds

alicyclic compounds are ring compounds containing single and/or multiple carbon to carbon bonds. Alicyclic compounds do not contain the conjugated double bonds which are characteristic of aromatic compounds.



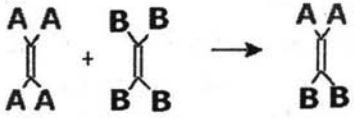
■ aliphatic compound

an aliphatic compound is an organic compound which consists of carbon and hydrogen in a structure which consists of open

unbranched chains of carbon atoms, open branched chains of carbon atoms, or closed chain of carbon atoms (i.e. ring or cyclic structures where the compounds have chemical properties that resemble those in the alkanes, alkenes, or alkynes).

■ **alkenes**

the alkenes, (i.e. the olefins), are the second homologous series of hydrocarbons, where there is at least one double-bond between the carbon atoms in the molecules.



The alkenes are said to be unsaturated because of the existence of a multiple bond in the molecule. The general structure of the alkene series of hydrocarbons is C_nH_{2n}. The first member of the ethene series is ethene, (previously called ethylene). In the case of higher members of the alkene series, the double bond may be between the terminal carbon atoms of the chain, or may be between internal carbon atoms in the chain.

Ethene C_2H_4
$CH_2=CH_2$
Propene C_3H_6
$CH_3CH=CH_2$
Butene C_4H_8
$CH_3CH_2CH=CH_2$
Pentene C_5H_{10}
$CH_3CH_2CH_2CH=CH_2$
Heptene C_6H_{12}
$CH_3CH_2CH_2CH_2CH=CH_2$
Hexene C_7H_{14}
$CH_3CH_2CH_2$
$CH_2CH2_2CH=CH_2$
Octene C_8H_{16}
$CH_3CH_2CH_2CH_2CH_2CH_2$
$CH=CH_2$
Nonene C_9H_{18}
$CH_3CH_2CH_2CH_2CH_2CH_2CH_2$
$CH=CH_2$
Decene $C_{10}H_{20}$
$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2$
$CH=CH_2$

Ethene, propene and butene are planar compounds. The first bond on the unsaturated carbon atoms are sp^2 hybrids, and these bonds are arranged as far apart in space as possible (i.e. at 120 degree in the same plane). These are s bonds (sigma bonds) and are

formed by the end-on overlap of sp^2 hydride orbitals of the carbon atoms. The second bond that makes up the double bond of the unsaturated carbon atoms in alkenes is a p-bond (pi-bond), formed by the side-on overlap of the p-orbitals of the carbon atoms. p-bond (pi-bonds) are much more reactive than the s bonds (sigma bonds).

■ **alkyl radical**

an alkyl group or an alkyl radical, is structurally similar to an alkane group, where a hydrogen atom is missing. Alkyl radicals are named by replacing the ending "-ane" from the name of the alkane, with the "-yl" suffix.

■ **allotrope**

an allotrope of an element is one of the forms in which the element can exist. For example, carbon can exist in several different forms, including graphite and diamond (which are pure forms of carbon that have different crystal structures) and charcoal, coke and lampblack (which are impure forms of carbon that are amorphous). Sulphur can exist as five different allotropes.

■ **alloy**

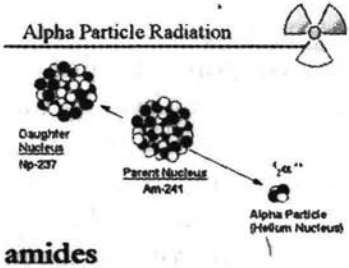
an alloy is a solid solution of one metal in another. It is an example of a mixture, as no chemical bonding exists between the constituent elements in the alloy. Common examples of alloys include Brass (an alloy of copper and zinc, and sometimes other metals, known since Roman Times and widely used in industry, for ornament and decoration), Bronze (an alloy of copper and Tin used for tools, weapons, machine parts and marine hardware), Stainless steel (an alloy of iron, chromium and nickel used for cutlery and industrial components where corrosion resistance is required), Duralium (an alloy of aluminium, copper, magnesium, manganese and silicon used in aircraft construction) and Solder (an alloy of lead and tin used in making electrical connections).

■ **alloys of iron**

a number of steels are the important alloys of iron, which include,
Steel
Stainless Steel
Chromium Steel
Tungsten Steel

■ **alpha-particles**

an alpha-particles is the charged particle emitted from the nucleus during its spontaneous decay. It haves the same structure as the nucleus of a helium atom, consisting of two Protons and two Neutrons.



■ **amides**

amides are organic compounds containing the amide functional group (i.e. $-C=O.NH_2-$). Amides can be regarded as either a carboxylic acid derivatives in which the hydroxyl group, -OH, of the carboxyl acid group is replaced by an amino functional group, $-NH_2$, or as an ammonia derivatives in which a hydrogen atom is replaced by an acyl functional group, -C=O-
Amides are volatile solids.

■ **amines**

amines are organic compounds containing carbon, hydrogen and nitrogen which are derived from ammonia by replacing one or more of the hydrogen atoms by alkyl, alkenyl, alkynyl, or aryl groups. Thus, the amine functional group, $-NH_2$, is contained within the molecule. Amines are classified as Primary Amines, $R-NH_2$, where one of the hydrogen atoms of ammonia is replaced by an alkyl, alkenyl, alkynyl, or aryl functional group, Secondary Amines, R-NHR', where two of the hydrogen atoms of ammonia are replaced by an alkyl, alkenyl, alkynyl, or aryl functional groups, or Tertiary Amines, R-NR'R", where all three of the hydrogen atoms of ammonia are replaced by an alkyl, alkenyl, alkynyl, or aryl functional group.

There are significant differences in the reactivities of these amines.

■ **amount of a substance**

the amount of a substance is measured in moles. One mole is the quantity of the substance (i.e. the weight of the substance in grams) that is present in numerically the same as its molecular weight.

■ **amphoteric oxides**

amphoteric oxides are the oxides of weakly electropositive metals. Thus, the oxides of aluminium oxide, zinc oxide, and tin oxide are amphoteric oxides. These amphoteric oxides react as basic oxides with acids and as acidic oxides with bases.

Aluminium oxide reacts with acids

$Al_2O_3 + 6\,HCl ==> 2\,AlCl_3 + 3\,H_2O$

Aluminium oxide reacts with bases

$Al_2O3 + 2\,NaOH + H_2O ==> 2\,NaAl(OH)_4$

Water is also an amphoteric oxide

$H_2O + NH_3 <==> NH_4(+) + OH(-)\ H_2O + HCl <==> H_3O^+ + Cl(-)$

■ **amphoteric substance**

an amphoteric substance is one which has both acidic and basic properties and which can behave as a weak base or a weak acid under different experimental conditions.

■ **analysis**

analysis involves the determination of the composition of a sample.

Qualitative Analysis involves determining the nature of a pure unknown compound or the compounds present in a mixture. Quantitative Analysis involves measuring the proportions of known components in a mixture, and the chemical techniques include volumetric analysis and gravimetric analysis. Instrumental Analysis include several physical techniques including spectroscopic techniques, mass spectrometry, polarography, nuclear magnetic resonance, etc.

■ **anion**

an anion is the ion which is attracted to the anode. Thus, it is the negatively charged ion.

■ **anion hydrolysis**

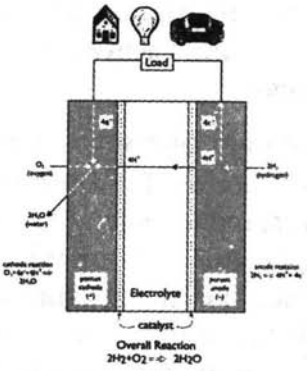
anion hydrolysis involves the reaction of the anion of a salt with water to give excess hydroxyl ions in solution.

■ **anode**

an anode is the positive electrode in electrolysis experiments, and it is at this electrode that the ions lose electrons. Thus, oxidation reactions occurs at the anode.

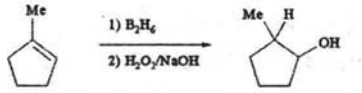
■ **anode reactions**

anode reactions are the chemical reactions that occur at the anode of an electrochemical cell, involve the negative ions in solution which migrate to the anode, where they lose an electron and are deposited as neutral atoms. Anode reactions are oxidation reactions, as they involve the transfer of an electron from the negatively charged ion.



■ **anti-Markownikoff rule**

the anti-Markownikoff rule specifies the orientation, in the



1-methylcyclopentene *2-methylcyclopentanol*

presence of free radicals, in which an asymmetric molecule adds across the double bond of an alkene in an addition reaction. The orientation of the addition across the multiple bond in the presence of free radicals is opposite to that specified for ionic reactions in the Markownikoff Rule.

■ **aqueous solutions**

aqueous solutions are those solutions where water is the solvent. An aqueous solution found in an equation describing

a chemical reaction is denoted by the state symbol, (aq).

■ **arenes**

the arenes are a homologous series of aromatic hydrocarbons, which have a ring structure of six carbon atoms, with alternating single and double bonds. This closed ring structure has a very high stability and these aromatic compounds undergo substitution reactions in order to preserve the configuration of the ring structure.

■ **argentic compounds**

argentic compounds are ionic compounds of silver in its higher oxidation state (i.e. +2 oxidation state), Ag^{++}.

■ **argentometric titrations**

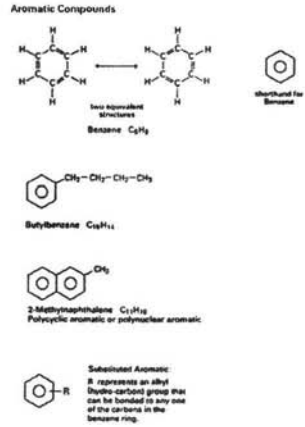
argentometric titrations are those in which an aqueous solution of silver nitrate is used to quantitatively precipitate a silver halide (e.g. silver chloride, silver bromide) or other insoluble silver salt (e.g. silver thiocyanate) from solution.

■ **argentous compounds**

argentous compounds are ionic compounds of silver in its lower oxidation state (i.e. +1 oxidation state), Ag^{+}.

■ **aromatic compounds**

aromatic compounds are ring compounds with a benzenoid structure (i.e. have a ring structure of six carbon atoms, with alternating single and double bonds), or those resembling benzene in chemical behaviour.



Although aromatic compounds are unsaturated, they do not readily undergo addition reactions, instead undergoing electrophilic substitution to preserve the stability of the aromatic ring. The simplest aromatic compound is benzene, C_6H_6.

■ **aromatic stability**

aromatic stability is the resistance of aromatic compounds to undergo addition reactions on the ring structure which would destroy the aromatic character (i.e. alternating single and double bonds) of the aromatic ring. Aromatic compounds readily undergo substitution reactions that preserve the aromatic structure of the ring. Aromatic stability is explained by resonance.

■ **Arrhenius concept of acids**

the Arrhenius concept of acids, gave the first understanding of the true nature of acids in aqueous solution. Arrhenius proposed that acids are substances which give rise to the hydrogen ions in solution and that bases are substances that give rise to hydroxyl ions in solution. It is the ionisation of the"acid which gives rise to these hydrogen ions and thus also gives rise to the acidic properties.

$H_2SO4 ==> H^+ + HSO_4^-$

■ **Arrhenius concept of bases**

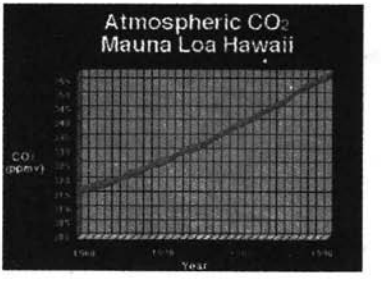
the Arrhenius concept of bases regard substance which provides hydroxyl ions as a result of dissociation and ionisation in aqueous solution as being bases.

■ **Arrhenius concept of neutralisation**

the Arrhenius concept of neutralisation involves the reaction in which a hydrogen ion and a hydroxide ion combine to form water.

■ **atmospheric carbon dioxide**

atmospheric carbon dioxide results from the combustion of fossil fuels, and it is an important contributor to the greenhouse effect.



■ **atmospheric pollution**

atmospheric pollution is caused by the emission of substances which are not natural constituents of the air, including soot,

smoke, carbon monoxide, hydrocarbons, lead compounds, carbon dioxide, chlorofluorocarbons, sulphur dioxide, and nitrogen oxides. Soot and smoke, which are particulates released during the combustion of solid fuels, can be controlled by using smokeless solid fuels. The smoke emitted from diesel engines can be controlled by the use of properly adjusted fuel injectors. Levels of sulphur dioxide can be reduced by using low sulphur fuels. The quantity of lead compounds which are emitted from petrol engines has been reduced significantly since the introduction of lead-free petrol. The quantity of carbon monoxide and of hydrocarbons which are emitted from petrol engines can be reduced by using properly adjusting and tuning the engines of cars and by fitting catalytic converters. International agreements has lead to the reduction of the quantities of chlorofluorocarbons which can be manufactured. Alternative new compounds are being developed to replace the CFCs.

■ back-titrations

back-titrations may be used in volumetric analysis where direct titrations cannot be used for technical reasons. For example, when a compound is not soluble in water, or where it contains impurities which interfere with direct titration, an excess of the titrant may be added, and the excess then determined by titration (i.e. by back titration).

■ balanced chemical equations

balanced chemical equations describe the chemical changes which occur during the course of a chemical reaction, and identifies reactants and products,
Gives the correct composition of each reactant and product,
Gives relative numbers of atoms, ions and molecules involved, and
Gives relative weights of substances.
For example, the following equation indicates that two moles of hydrogen react with one mole of oxygen to form two moles of water.

$$2\,H_2 + O_2 \Longrightarrow 2\,H_2O$$

■ base

a base is a substance, which reacts with an acid to form salt and water only. Arrhenius in his researches into the behaviour of electrolytes in solution proposed that a base is a substance which provides hydroxide ions in aqueous solution as a result of dissociation and ionisation. Later, Lewis introduced the idea that acids and bases had a reciprocal relationship and he introduced the concept of Lewis conjugate acid/base pairs.

A Lewis Acid (conjugate) is an electron pair acceptor and a Lewis Base (conjugate) is an electron pair donor.

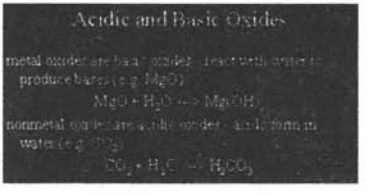
NH_3(Lewis Base) + H_3O^+(Lewis Acid) ==> NH_4^+ (Lewis Acid) + H_2O (Lewis Base)

In particular, water and the Hydrated Proton, H_3O^+, are a conjugate acid-base pair, as the hydrated proton is able to donate a proton to water and water is able to receive the proton.

H^+(Lewis Base) + H_2O ==> H_3O^+(Lewis Acid)

■ basic oxides

basic oxides are the oxides of metals (e.g. sodium oxide and copper oxide), and they react with water to form alkaline solutions.



$Na_2O + H_2O$ ==> 2 NaOH

Basic oxides form salts and water on reaction with acids.

$Na_2O + 2HCl$ ==> 2 NaCl + H_2O

$CuO + 2HNO_3$ ==> $Cu(NO_3)_2 + H_2O$

Strongly basic oxides form compounds with water containing a metal combined directly to a hydroxyl group, they are therefore called hydroxides. The hydroxides of sodium and potassium are also called alkalis.

$K_2O + H_2O$ ==> 2 KOH

■ beta-particles

a beta-particles is the charged particle emitted from the nucleus of an atom during its spontaneous decay.

■ biochemical oxygen demand

biochemical oxygen demand, BOD, is the amount of oxygen taken up by microorganisms to decompose organic waste matter which is present in water.

Biochemical oxygen demand is therefore used as an empirical measure of the amount of certain biologically degradable waste types of organic pollutant that are present in water.

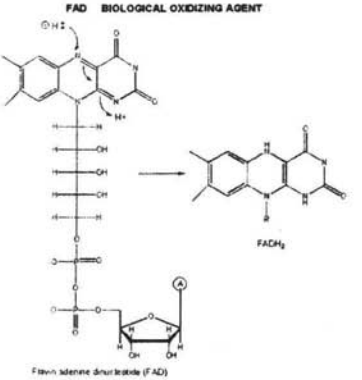
Biochemical oxygen demand is calculated by keeping a sample of water containing a known amount of oxygen for five days at 20 °C in the dark. The oxygen content is measured again after this time.

A high biochemical oxygen demand indicates the presence of a large number of microorganisms, consuming large amounts of organic matter, which suggests a high level of pollution.

There is an empirical relationship between the two determinants that describe pollution load in a sample (i.e. between biochemical oxygen demand and chemical oxygen demand).

■ biological oxidation

biological oxidation involved the mediation of biological species in the Oxidation of organic matter. In general, biological oxidation proceeds by enzyme catalysis.

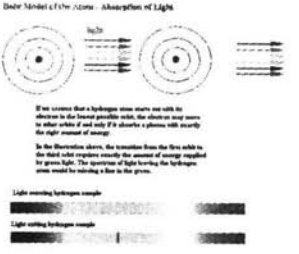


Flavin adenine dinucleotide (FAD)

■ Bohr model of the atom

the Bohr model of the atom uses the particle theory of the electron to explain the spectrum of the hydrogen atom.

In 1913 AD, Neils Bohr used the particle theory of the electron to explain the spectrum of the hydrogen atom.



Bohr postulated that the hydrogen atom consisted of a central positive nucleus round which an electron moved in atomic orbit and that an electron may only be found in one of a limited number of those orbits.
The number of orbits was limited, each corresponding to a definite energy level, where the angular momentum, mvr, of the electron in its path about the nucleus must always be equal to nh/2((where n = 1, 2, 3...)
Thus,
mvr = nh/2
where m is the mass of the electron
v is the velocity
r is the radius of the orbit
n is an integer called a Quantum Number used to characterising the
orbit and
h is Plank's constant.
Bohr also postulated that as long as an electron remains in a given orbit it neither absorbs nor emits energy, and that movement of an electron from a low energy state to a higher energy state involves absorption of energy, and movement of an electron from a higher energy state to a lower energy state involves emission of energy in the form of radiation.
Thus, the lines in the spectrum of hydrogen are due to electrons falling from the excited state (i.e. a higher energy level) to the ground state (i.e. the lower energy). Each line in the hydrogen spectrum is ascribed to the transfer of an electron from an orbit of a high n value to one of a lower n value.

■ boiling point

the boiling point of a liquid is the temperature at which the vapour pressure of the liquid is equal to the atmospheric pressure. The liquid changes from the liquid state to the gas state at its boiling point.

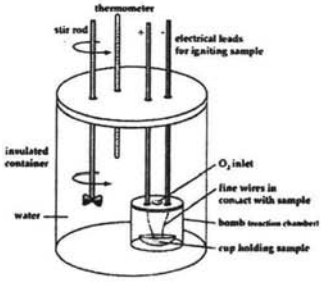
■ Boltzmann constant

the Boltzmann constant, k, named after the Austrian physicist Ludwig Boltzmann (1844-1906), is the ratio of the universal gas constant, R, to the Avogadro constant, N_a. The Boltzmann constant, k, is as the gas constant per molecule.

$k = R / N_a$, $N_a = 1.380622 \times 10^{-23}\ JK^{-1}$

■ bomb calorimeter

a bomb calorimeter is an apparatus used for measuring heats of combustion. It consists of a strong container in which the sample is sealed with excess oxygen and ignited electrically. The heat of combustion at constant



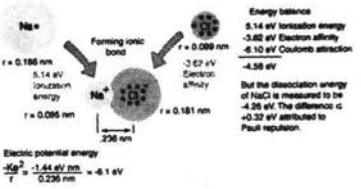
volume can be calculated from the resulting rise in temperature of the calorimeter and its contents.

■ bond

a bond (i.e. chemical bond) is the attractive force between the atoms in a molecule, which keeps the molecule together. A chemical bond between atoms involves the overlap of an atomic orbital from each of the two atoms involved in the bond and keeps the molecule intacv as an entity.

■ bond energy

bond energy is the amount of energy associated with a bond in a chemical compound.



For example, in methane the bond energy of the carbon to hydrogen bond is one quarter of the Enthalpy of the synthesis process.

$CH_4(g) ==> C(g) + 4\,H(g)$

Bond energies can be calculated from the standard enthalpy of formation of the compound and from the enthalpies of atomisation of the elements. Energies calculated in this way are called average bond energies or bond energy terms. They depend to some extent on the molecule chosen; the C-H bond energy in methane will differ slightly from that in ethane. The bond dissociation energy is a different measurement, being

the energy require to break a particular bond.

■ bond pairs

bond pairs are the pairs of electrons involved in covalent bonds, or the unbonding lone pair of electrons which exist in a single sub-orbital of the central atom of a molecule.

■ bonding and structure in group VI oxides

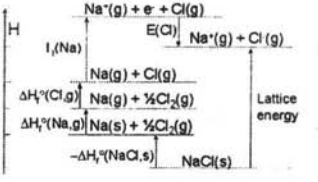
Silica, SiO_2, forms a giant tetrahedral molecule, which is bonded covalently. Every silicon atom is attached to four oxygen atoms, and every oxygen atom is common to two SiO_4 tetrahedral. Carbon, C, can form double bonds and Carbon Dioxide, CO_2, is an example of a compound that exist as discrete molecules. However, since silicon cannot form double bonds, Silicon Dioxide, SiO_2, (i.e. Silica) only forms an infinite three-dimensional tetrahedral structure.

■ Born-Haber cycle

the Born-Haber cycle is a cycle of reactions used to calculate the lattice energies of ionic crystalline solids. Lattice Energy cannot be measured directly by experimental methods.

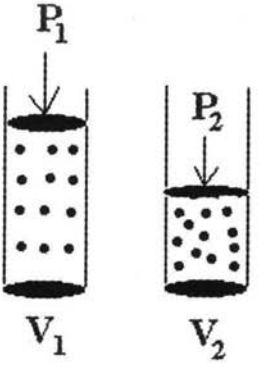
The Born-Haber Cycle

The Lattice energy can be calculated with Hess's law and the following steps:



■ Boyle's law

Boyle's Law, is the empirical relationship, which states that given a fixed mass of gas at constant temperature, its volume is inversely proportional to its pressure. Boyle's Law applies to ideal gases only. Real gases deviate considerable form this ideal relationship. It is called after the Irish physicist and chemist Robert Boyle



■ breathalyser test

the breathalyser Test is based on the colour change which occurs when the dichromate ions in a glass tube through which the person blows is reduced to chromate ion by the presence of alcohol in the breath. This is a test given to suspected drunken drivers, who are required to blow through a tube containing a solution of acidified potassium dichromate on an inert support. When the ethanol, C_2H_5OH, vapour is passed through the tube it is oxidised to carbon dioxid, and water. Correspondingly, the dichromate ions which are yellow in colour, are reduced to chromate ions which are green in colour. This results in the observed colour change from yellow to green when alcohol is present in the exhaled breath.

■ Bronsted Lowry theory of acids

this theory of acids and bases which was proposed by Bronsted and Lowry broadened the Arrhenius concept of acids and bases by defining an acid as any substance which release a proton and a base as any substance can accept a proton. The relationship between an acid and a base is represented by the following equation.

$HA <==> H^{(+)} + A^{(-)}$

Acid Base

Here the acid, HA, and the base, $A^{(-)}$, which differ from one another by a proton, are described as a conjugate pair, (i.e. the Base, $A^{(-)}$, is said to be conjugate base of the Acid, HA).

It should be noted that the hydrogen ion exist in aqueous solution as a hydrated proton, $H_3O^{(+)}$.

$HCl + H_2O ==>$

Acid2 Base2

$H_2O^{(+)} + Cl^{(-)}$

Acid1 Base1

Bronsted and Lowry proposed that

An Acid is a Proton Donor

A Base is a Proton Acceptor

Thus, the ionisation of sulphuric acid satisfies this concept of an acid, in that it donates a hydrogen ion to water.

$H_2SO_4 + H_2O ==>$

$H_3O^+ + HSO_4^-$

Proton Donor Hydrated Proton

Similarly, the hydroxyl ion is a base, as it can accept a proton from the hydrated proton.

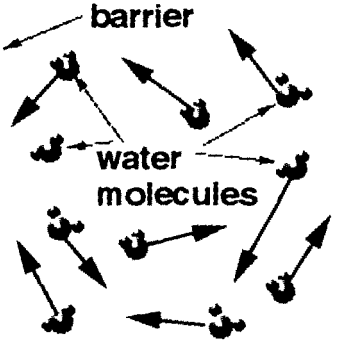
$H_3O^+ + HO^- ==> 2\,H_2O$

(Proton Acceptor)

It should be noted that the hydrogen ion exist in aqueous solution as a hydrated proton.

■ Brownian movement

brownian movement is the irregular zig-zag paths observed for the motion of pollen grains suspended in water, which strongly suggest that water molecules are moving about at random, and colliding with the grain pollens.

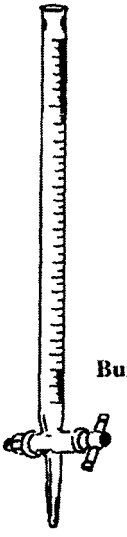


In 1828, Robert Brown observed the motion of pollen grains which were suspended in water. When these pollen grains were viewed through a microscope, the grains were seen to move in an erratic manner. They travelled along short straight paths, but the individual grains were rarely seen to collide with each other. The path of any one grain can best be described as a zigzag line, with a straight path between each zig and zag. This zig-zag motion is called Brownian Movement. The irregular paths strongly suggest that the visible grains are pushed by invisible particles that are moving at random and which collided with the grains of pollen. If the water molecules are in motion, moving about at random, this would allow an explanation for the observations. This observation of Brownian Motion is one of the supporting pieces of evidence for the Atomic Theory and for the Kinetic theory of gases.

■ burette

a burette is a glass apparatus used in volumetric analysis. It is designed to deliver known volumes of liquids during

titration's, and consists of a thin glass graduated tube and a stopcock to control delivery of the liquid.



An electrical double layer is formed between the electrons in the rod and the ions in solution. The formation of this electrical double layer is accompanied by a potential difference between the rod and the solution called electrode potential.

If a copper rod is placed in a solution containing copper ions, the rod is found to be positively charged with respect to the solution. In this instance metal ions leave the solution and deposit on the copper rod where they combine with electrons.

$Cu^{++} + 2e^{-} ==> Cu$

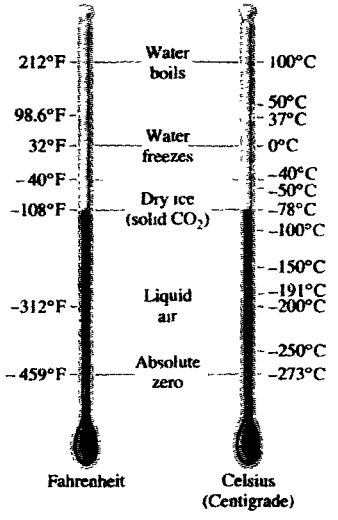
The term half-cell is used to describe the zinc rod in the solution of zinc ions.

Similarly, the copper rod in the solution of copper ions is also called a half cell.

The zinc rod and the copper rod are termed electrodes. If the half-cells are left in isolation, a state of equilibrium is reached and no further reaction takes place. However, when the electrodes of each half-cell are linked externally by means of a wire and the cells are separated by a porous partition, the electrons which would have collected previously on the zinc electrode are now free to travel along the external wire to the copper electrode.

■ Celsius scale of temperature

the Celsius scale of temperature, is the scale named after the Swedish astronomer Andes Celsius, where the temperature range between the melting point at standard pressure of ice and the boiling point of water



has been divided into 100 degrees. The melting point of ice is taken as zero degrees and written as 0 °C. The boiling point of water is therefore taken as 100 degrees and written as 100 °C.

■ **cement (portland cement)**

portland cement, so called because after setting it resembles Portland stone, is made by heating a mixture of limestone and clay, which is then ground to a fine powder. Limestone containing more than 5 per cent of clay on burning forms a lime, which gives a hydraulic mortar (i.e. cement) which hardens under water.

■ **ceramics**

ceramics are inorganic materials, such as pottery, enamels and refractories.

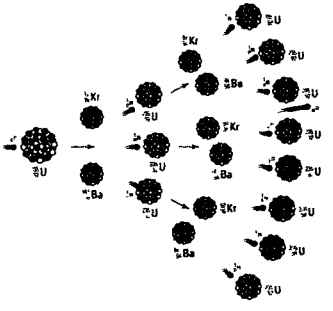
■ **chain**

a chain is a linear combination of the same type of atom in a molecule. In straight chain molecules, the atoms are arranged in a line, with each atom in the chain linked to one preceding atom and one succeeding atom of the same type. In branched chain molecules, groups are attached to a central straight chain, and the group is called a side chain. A closed chain molecule is a chain where the atoms are linked in a ring structure; otherwise, the molecule has an open chain molecule.

■ **chain reaction**

a chain reaction is a multi-step sequence of chemical reactions in which a product of the first step is used as a reagent in the second step, and a product of the second step is used as a reagent in the third step, etc.. In

general, chain reactions are free radical reactions.



For example, the reaction of bromine with methane in the presence of light is an example of a chain reaction. The mechanism by which the reaction proceeds is as follows.

The first step is called the Initiation of the reaction.

The absorption of light breaks the covalent bond holding together the bromine atoms together in the bromine molecule and produces free bromine atoms (i.e. bromine free radicals, Br*).

$Br_2 ==> Br^* + Br^*$ (1)

The Propagation of the Reaction involves repeating steps (2) and (3), where the bromine free radical then removes a hydrogen atom from a molecule of methane to produce a methyl free radical and a molecule of hydrogen bromide.

$Br^* + CH_4 ==> CH_3^* + HBr$ (2)

The methyl radical then attacks a bromine molecule to produce a molecule of methyl bromide and to regenerate a bromine free radical, which proceeds to react as in step (2).

$CH_3^* + Br_2 ==> CH_3Br + Br^*$ (3)

The Termination of the Reaction

is the final step and results when these steps can are stopped by the chance recombination of free radicals as in (4).

$Br^* + CH_3^* ==> CH_4Br$ (4)

or

$Br^* + Br^* ==> Br_2$

or

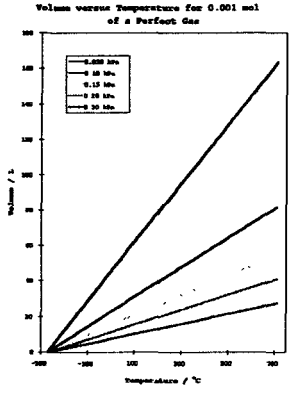
$CH_3^* + CH_3^* ==> C_2H_6$

■ chaos

chaos is the widely diverse range of behaviour which nonlinear dynamic systems exhibit under different initial conditions.

■ Charle's law

Charle's Law is the empirical relationship, which states that which states that for an ideal gas at constant pressure, its volume is proportional to its absolute temperature. This relationship applies to ideal gases only. Real gases deviate considerable form this ideal relationship.



It is called after Jacques Alexandre Cesar Charles

■ chemical bonds

chemical bonds are the forces that hold atoms together in a molecule are called chemical bonds.

A Chemical Bond is the attractive force between two atoms in a molecule. These bonds keep the molecule intact as an entity.

In 1916AD, the two kinds of chemical bonds which were known were described as the Ionic Bond by Walter Kossel (Germany) and the Covalent Bond by G.N.Lewis (University of California).

These ionic and covalent bonds arise from the tendency of atoms to attain a stable configuration of electrons for each atom in a molecule, by either the transfer or the sharing of electrons between atoms. Because a molecule consists of at least two atoms with positively charges nuclei and negatively electronic clouds about these atoms, there are electrostatic interactions between the various particles of the atoms in the molecule.

■ chemical change

a chemical change is a process which results in the production of one or more new materials. The system within which the process takes place is called a chemical system. A chemical change is also known as a

chemical reaction, where one substance is converted into one or more different substances. When sodium and chlorine react to produce sodium chloride, a chemical reaction has taken place.

■ **chemical equilibrium**

chemical equilibrium is a state of dynamic equilibrium is set up when the rate of the forward reaction is equal to the rate of the back reaction.

■ **chemical formula**

a chemical formula shows the number and types of atoms that are present in a molecule.

■ **chemical oxygen demand**

the chemical oxygen demand is the quantity of oxygen required to destructively oxidise the organic matter in a sample. It is expressed in mg COD per litre.

■ **chemical symbol**

a chemical symbol is assigned to every element, which represents one atom (occasionally, one mole) of that element. The symbols of the elements which were known in earlier days were derived from Latin names. Many of the initial letters of the elements; others have a second letter where there is more than one starting with the small letter. Example include

Hydrogen	H
Helium	He
Lithium	Li
Sodium	Na

■ **chloro-organics**

the simplest type of chloro-organic compounds are the chloroalkanes, which find extensive use as solvents in industry.

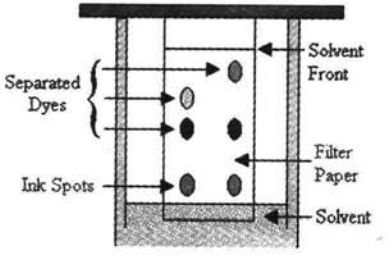
Chloromethane, CH_3Cl
Dichloromethane, CH_2Cl_2, (i.e. Methylene Chloride)
Chloroform, $CHCl_3$
Carbon Tetrachloride, CCl_4
1,2-Dichloroethane, CH_2ClCH_2Cl
1,1-Dichloroethane, $CHCl_2CH_3$

■ **chromatography**

chromatography is a technique for analysing or separating mixtures of gases, liquids, or dissolved substances. In general, all types of chromatography involve two distinct phases, (a) a stationary phase (i.e. the adsorbent material) and (b) moving phase (i.e. the

eluting solvent). The separation depends on competition for molecules of sample between the moving phase and the stationary phase.

Adsorption Chromatography is a technique for the separation and analysis of mixtures of gases, liquids, or dissolved substances. In the case of liquid



adsorption chromatography, a vertical glass tube is packed with an adsorbing material, (e.g. Alumina, Al_2O_3, or Silica Gel, SiO_2), the sample is poured onto the top of the column and then continuously transported down through the column with a solvent, in a process called Elution.

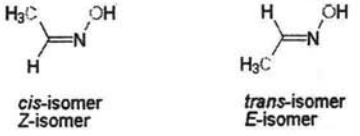
Different components of the sample are adsorbed to different extents and move down the column at different rates. The usual method is to collect the liquid (i.e. the eluatent) in fractions, as it passes out from the column.

■ **column chromatography** is the oldest chromatographic technique. The apparatus consists of a glass tube (approximately about 20mm (250mm) which has a glass frit at the bottom of the tube and a stopcock. A thin layer of coarse, clean sand is placed over the frit, and the chosen adsorbent (usually alumina or silica) is then placed in the tube as a slurry.

The sample under analysis (i.e. the mixture) is poured into the top of the column and continuously washed through with an eluting solvent. Fractions are collected. As the mixture is passed through the column, its components separate into zones of material (i.e. bands) with a space between each zone. A band represents a fraction of homogeneous material (i.e. either a pure compound or a group of compounds behaving as a single compound on the adsorbent).

■ cis-trans isomerism

as well as the structural isomerism, which was illustrated in the alkane series, a new type of isomerism is possible in the alkene series. There is not free rotation about the carbon to carbon double bond, and therefore there are two distinct isomers possible, depending on the layout of the groups attached to the carbons involved in the double bond. The cis-isomer and the trans-isomers are distinct chemical compounds and they have different physical properties and chemical properties.



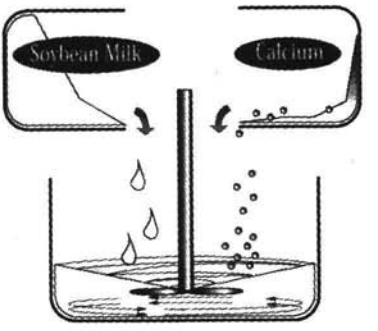
cis-isomer
Z-isomer

trans-isomer
E-isomer

The atoms of highest precedence on each end of the C=N bond are shown in red.

■ coagulation

coagulation is the process in which colloidal particles come together to form lager masses. Coagulation can be brought about by adding ions to neutralise the charges stabilizing the colloid. Ions with a high



charge are particularly effective. Another example of ionic coagulation is in the formation of river deltas, which occurs when colloidal silt particles in rivers are coagulated by ions in sea water. Heating is another way of coagulating certain colloids.

■ coal

coal is a brown or black carbonaceous deposit derived from the accumulation and alteration of ancient vegetation, which originated largely in swamps or other moist environments. As the vegetation decomposed it formed layers of peat, which were subsequently buried. Under the increased pressure and the resulting higher temperatures the peat was transformed into coal.

■ **coal gas**

coal gas is a gas produced by the destructive distillation of coal, and contains approximately 50% hydrogen, 35% methane and 8% carbon monoxide. The by products of the production of coal gas are coal tar and Coke.

■ **coal tar**

coal tar is a material obtained from the destructive distillation of coal in the production of coal gas. The crude tar contains a large number of organic compounds (e.g. benzene, naphthalene, methylbenzene, etc.), which can be separated by fractional distillation.

■ **coke**

coke is an impure form of carbon, which is obtained as a byproduct from the destructive distillation of coal.

■ **colourimetric analysis**

colourimetric analysis is a quantitative analysis of solutions by estimating the colour produced by the reaction of the sample under analysis with a reagent and comparing it with the colours produced by known standard solutions.

■ **colour of halogens**

the halogen molecules are all coloured due to the absorption of visible light. This absorption of light results in the excitation of outer electrons to higher energy levels. The energy required to bring about these electronic transitions follows the same pattern as the ionisation potential values for the elements. Thus, the energy required to bring about such a transition in the smaller fluorine atom is much larger than the energy required for the same transition for the larger iodine atom. Fluorine absorbs the higher energy violet light and transmits yellow light whilst the iodine absorbs the lower energy yellow light and transmits violet light.

■ **combined gas law**

the combined gas law is the mathematical relationship between the pressure, volume and temperature of a fixed quantity of an ideal gas, which states that the product of the pressure, P,

and the volume, V, of one mole of gas is equal to the product of the gas constant, R, and the absolute temperature, T.

$PV = RT$

The combined gas law is derived from Boyle's Law and Charles's Law.

■ combustion

combustion is the reaction of substances with oxygen, with the evolution of heat and light. The combustion of organic materials are often free radical chain reactions, which can usually be summarised as the oxidation of carbon content of the material to form its oxides and the oxidation of hydrogen to form water. The corrosion of metals is the result of the slow combustion of the metals with the oxygen in air.

■ combustion of calcium

when heated in an iron deflagrating spoon, calcium burns brightly in oxygen forming calcium oxide, which turns moist red litmus blue.

$2\,Ca + O_2 ==> 2\,CaO$

(Calcium Oxide)

$CaO + H_2O ==> Ca(OH)_2$

■ combustion of carbon

a piece of wood charcoal, which is an impure form of carbon, when strongly heated in a deflagration spoon burns brightly, and then placed in a gas jar containing oxygen, burns even more vigorously throwing off bright sparks.

The chief product of the reaction is carbon dioxide, although a little carbon monoxide is also formed :

$C + O_2 ==> CO_2$

Carbon Dioxide

$2C + O2 ==> CO$

Carbon monoxide

When shaken with water, the Carbon Dioxide, CO_2, dissolves forming a solution of the very weak and unstable solution of Carbonic Acid, H_2CO_3, which changes the blue colour of litmus to a port-wine red colour :

$CO_2 + H_2O ==> H_2CO_3$

Carbon Carbonic Dioxide Acid

If another jar of containing Carbon Dioxide, CO_2, from the combustion of carbon is shaken with lime water, this becomes milky from the formation of a

precipitate of Calcium Carbonate, $CaCO_3$.

$Ca(OH)_2 + CO_2 ==> CaCO_3 + H_2O$

■ **combustion of hydrogen**

when a jet of hydrogen gas that is prepared by the action of dilute sulphuric acid on zinc burns in a dry oxygen water is produced and it condenses as a dew on the inside walls of the jar.

$2 H_2 + O_2 ==> 2 H_2O$

■ **combustion of iron**

when a spiral of iron wire tipped with a piece of burning wood, is lowered into a gas jar containing oxygen gas, the iron burns brilliantly, giving off bright sparks of the burning metal. Ferrosoferric oxide, Fe_3O_4, is formed in fused globules, which fall to the bottom of the gas jar, on a layer of sand. It has no action on litmus.

$3 Fe + 2 O_2 ==> Fe_3O_4$

(Ferrosoferric Oxide)

Ferrosoferric oxide may be regarded as a compound of ferrous oxide and ferric oxide and it is sometimes called a mixed oxide.

$FeO + Fe_2O_3 ==> Fe_3O_4$

■ **combustion of magnesium**

when magnesium ribbon held in a crucible tongs is ignited in air and inserted into a jar of oxygen, it burns with a blinding white light, forming white solid magnesium oxide, which is a sparingly soluble basic oxide and turns moist red litmus paper blue.

■ **combustion of metals**

some metals, when heated strongly in oxygen, burn to form metal oxides. These oxides are the Basic Oxides. Other metals do not burn readily in oxygen, but react with it on heating to form Oxides.

■ **combustion of non-metals in oxygen**

the chemical characteristic of the non-metals is that their oxides on reaction with water give rise to acids. The acidic properties of the hydrolysis of these oxides vary considerable, so that the oxides of sulphur and phosphorus give rise to strong acids, while the oxides of boron give rise to weak acids.

Some non-metallic elements, such as phosphorus, sulphur,

and carbon, burn in oxygen to form Acidic Oxides

■ **combustion of phosphorus**

when a piece of phosphorus on an iron deflagrating spoon is kindled by touching it with a hot wire, and it is put into a gas jar containing oxygen, it burns in the oxygen with an exceedingly brilliant white flame, producing a white cloud of phosphorus pentoxide, P_2O_5, which settles in flocks on the inside of the dry jar.

$P_4 + 5\,O_2 ==> 2\,P_2O_5$

When water is poured into the jar the oxide dissolves and phosphoric acid is formed, which changes the colour of blue litmus solution to red :

$P_2O_5 + 3\,H_2O ==> 2\,H_3PO_4$

■ **combustion of potassium**

when potassium is heated in an iron deflagrating spoon until it ignites and then lowered in dry jars of oxygen, it burns with bright lilac flame forming orange-yellow solid higher oxides (e.g. potassium peroxide, K_2O_2, and potassium dioxide, KO_2).

$2\,K + O_2 ==> K_2O_2$

Potassium Peroxide

$K + O_2 ==> KO_2$

Potassium Dioxide

When these substances are dissolved in water, oxygen is evolved and an alkaline solutions, containing potassium hydroxide, which turn red litmus blue is formed.

$2\,K_2O_2 + 4\,H_2O ==> 4\,KOH + O_2$

$4\,KO_2 + 2H_2O ==> 4\,KOH + 3\,O_2$

■ **combustion of sodium**

when sodium is heated in an iron deflagrating spoon until it ignites and then lowered in dry jars of oxygen, it burns with bright yellow flame forming orange-yellow solid higher oxides (e.g. sodium peroxide, Na_2O_2).

$2\,Na + O_2 ==> Na_2O_2$

When this substance is dissolved in water, oxygen is evolved and an alkaline solutions, containing sodium hydroxide, which turn red litmus blue is formed.

$2\,Na_2O_2 + 2\,H_2O ==> 4\,NaOH + O_2$

■ combustion of sulphur

when a small amount of sulphur is kindled on a deflagrating spoon, it burns with a bright blue flame when introduced into a gas jar containing oxygen. A gas, sulphur dioxide is the main product of the combustion. However, a little sulphur trioxide is also formed, which makes the gas slightly cloudy.

$S + O_2 \Longrightarrow SO_2$

$2S + 3O_2 \Longrightarrow 2SO_3$

When shaken with water, the products of combustion dissolve, forming an acidic solution which turns litmus red.

$SO_2 + H_2O \Longrightarrow H_2SO_3$

$SO_3 + H_2O \Longrightarrow H_2SO_4$

■ common group

common groups which are derived from hydrocarbons include :

Alkyl groups

CH_3	methyl
C_2H_5	ethyl
C_3H_7	propyl
C_4H_9	butyl
C_9H_{29}	nonyl

Aromatic groups

C_6H_5	phenyl
$C_{10}H_9$	naphthyl

Alkenyl groups

C_2H_3	vinyl
C_3H_5	allyl

■ component

a component is a distinct chemical species in a mixture. If there are no chemical reactions between the components in a mixture, the number of components is the number of distinct chemical species.

■ compound

a compound is a substance composed of two or more elements that are bound together by chemical bonds. A compound cannot be broken down into its individual elements of which it is composed by physical means. However, a compound can be broken down to the elements of which it is composed by chemical means.

Compounds *Elements*

Calcium chloride
Calcium, Chlorine
Calcium oxide
Calcium, Oxygen
Sodium chloride
Sodium, Chlorine

Hydrogen oxide
Hydrogen, Oxygen
Iron oxide
Iron, Oxygen

Just as every element has its own symbol, every compound has its own formula. The formula identifies the elements present in the compound and the number of atoms of each kind that are in a molecule of the compound.

As all compounds are made from elements, so the elements are the building blocks of compounds. When a compound is formed by the combination of elements, this reaction is called a synthesis reaction.

Unlike the elements, compounds can be split up into simpler substances (i.e. the elements of which they are composed). The splitting up of compounds into simpler substances is called decomposition.

■ compound ions

compound ions are groups of atoms which remain unchanged through a series of chemical reactions, but which are incapable of independent existence. They have an overall charge. Examples include the carbonate ion, CO_3^-, nitrate ion, NO_3^-, ammonium ion, NH_4^{++}, etc.

■ concentration

concentration is the quantity of dissolved substance per unit quantity of solvent in a solution. The mass concentration is the mass of solute per unit volume of solvent. The molal concentration is the amount of substance per unit mass of solvent.

■ condensation

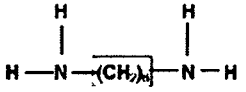
condensation is the change of a vapour or gas into a liquid. The change of phase is accompanied by the evolution of heat.

■ condensation polymerisation

this may be defined as the process in which the monomer molecules of different compounds combine with the loss of some simple molecules, like water, or HCl.

Monomers of nylon

hexanedioic acid



1,6-diaminohexane

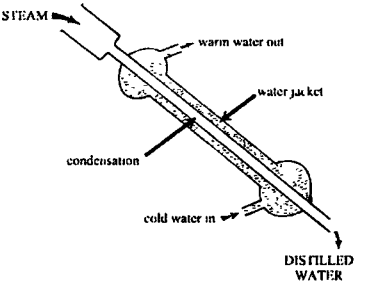
This process can produce both thermoplastics and thermosetting plastics.
e.g. Polyesters and nylon are formed by this process.

■ **condensation reaction**

condensation reaction are those chemical reactions in which two molecules combine to form a larger molecule with elimination of a small molecule, typically water, during the course of the reaction.

■ **condenser**

a condenser, (i.e. a Liebig Condenser) consists of a straight glass tube enclosed in a glass jacket through which water is passed. The condenser speeds the cooling and condensing process, when vapour passes through the condenser's centre tube and is cooled by the water flowing around the condenser's outer jacket.



■ **conductimetric titration**

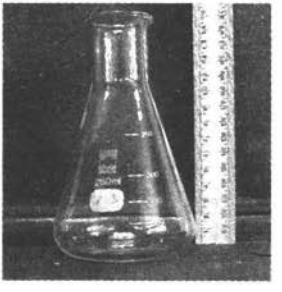
a coductimetric titration is one in which the electrical conductivity of the reaction mixture is continuously monitored as one reactant is added. The equivalence point (i.e. the end-point of the titration) is the point at which the conductivity undergoes a sudden change.

■ **configuration**

two definitions are associated with the term, configuration.
Configuration is the arrangement of atoms or groups of atoms in a molecule, or
Configuration is the arrangement of electrons about the nucleus of an atom.

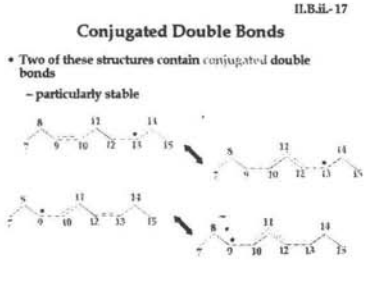
■ conical flask

a conical flask is used for titration's to facilitate the return of liquid splashed onto the walls of the flask to the body of the liquid at the bottom of the flask.



■ conjugated bonds

conjugated bonds describe the alternating pattern of double and single bonds, or triple bonds and single bonds, in a molecule. In such molecules, there is some delocalisation of electrons into the pi orbitals of the carbon atoms linked by the single bond.



■ consolute temperature

consolute temperature is a temperature at which two partially miscible liquids become fully miscible as the temperature is increased.

■ contact process

the contact process is used for manufacturing sulphuric acid and fuming sulphuric acid from sulphur dioxide, which is made by burning sulphur or by roasting sulphide ores and oxygen (in the form of air) which combine to form sulphur trioxide in the presence of a Catalyst. The reaction is exothermic and the conditions are controlled to keep the temperature at 450 °C. The catalyst used is valadium (V) oxide (V_2O_5). The sulphur trioxide is dissolved in sulphuric acid to form fuming sulphuric acid, this called oleum.

$S(s)+O_2(g)==>SO_2(g)$

$2SO_2(g)+O_2(g) ==>$

$2SO_3(g)\ SO_3(g)+ H_2SO_4(l)$

$==>\ H_2S_2O_7(l)$

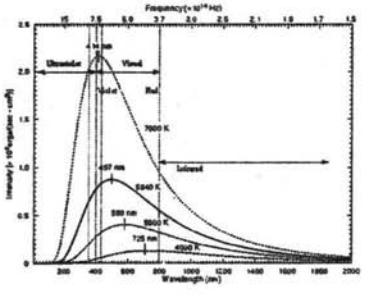
Oleum

This Oleum is then diluted with water into concentrated sulphuric acid.

$H_2S_2O_7(l) + H_2O(l) \Longrightarrow 2\,H_2SO_4(l)$

■ continuous spectra

a continuous spectrum consisting of a band of coloured light is produced when a narrow beam of sunlight is allowed to pass through a prism. In a continuous spectrum, each colour merges into the next, so that it is difficult to say where one colour ends and the next colour begins. Each colour corresponds to radiation of different energy.

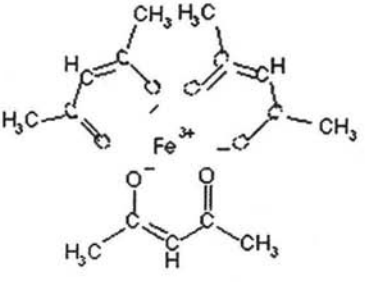


■ convection

convection is the process by which heat is transferred from one part of a fluid to another by movement of the fluid itself. There are two methods in which this can be carried out. One is by natural convection, in which movement occurs as a result of gravity, the hot part of the fluid expands, become less dense and is displaced by the colder denser part of the fluid as this drops below it. Forced convection is where hot fluid is transferred from one region to another by a pump.

■ coordination complex

a coordination complex is a compound in which molecules or ions form coordinate bonds to a central metal atom or Ion. The complex may contain positive ions, negative ions or neutral molecules. The formation of such coordination complexes is typical behaviour of Transition Metals.



tris(2,4-pentanedionato)iron(III)

■ corrosion

corrosion is the chemical changes which occurs in a ma-

terial over time due to its contact with air or moisture, and which result in the loss of physical strength and the mechanical properties of the material, rendering it unsuitable for its intended use.

For example, metals are oxidised in moist air to their oxides which have low mechanical strength.

■ **corrosion cells**

corrosion cells are the arrangements of electrodes and solutions which result in electrochemical changes to the contents of the cells.

■ **coulomb**

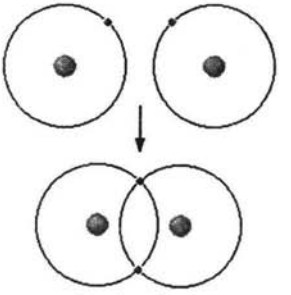
the coulomb is the charge carried by a current of one ampere flowing for a period of one second.

■ **coupling reaction**

a coupling reaction is a chemical reaction in which two molecules join together to form a single product.

■ **covalent bond**

a covalent bond is the principal type of bond between atoms whose Electronegativity's are of almost equal (i.e. it is formed by sharing electrons between any two constituent atoms in a molecule such as the elements in the middle of the periodic table, who do not lose or gain electrons easily). Thus, in the covalent bond, the Electron Pair in the covalent bond is shared equally between the atoms, so that stable outer shells are created in each atom by this sharing.



Covalent bond

For example, in the chlorine molecule each chlorine atom contributes one electron from its outer shell to form a shared pair, thus giving both a stable outer shell.

The atoms in carbon dioxide are also covalently bonded. Each oxygen atom shares two pairs of electrons with the car-

bon atom. Thus, there is a double covalent bond between the carbon atom and each oxygen atom.

■ covalent chlorides

the chlorides of non-metals (e.g. phosphorus trichloride) are covalent compounds.

With the exception of carbon tetrachloride, these chlorides fume in air and are readily hydrolysed to yield either an acid or an acidic oxide.

For example, phosphorus trichloride fumes in air

$PCl_3 + 3H_2O \Longrightarrow H_3PO_3 + 3HCl$

■ cracking

cracking is the process of breaking down chemical compounds at high temperature. The term is applied particularly to the cracking of hydrocarbons in the kerosene fraction obtained from petroleum refining to give smaller hydrocarbons. This process involves the decomposition of petroleum fractions into hydrocarbons of lower molecular weight, by heating them under pressure in the presence of a suitable Catalyst.

■ critical pressure

critical pressure is the pressure of a fluid at its critical state.

■ critical state

the critical state of a fluid is when the liquid and gas phase both have the same density. In the critical state, the fluid is at its critical temperature, critical pressure and critical volume.

■ critical temperature

the critical temperature is the temperature above which a gas cannot be liquefied by an increase in pressure.

■ critical volume

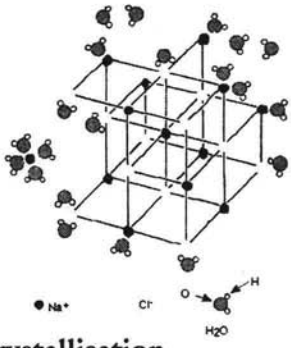
the critical volume is the volume occupied by a fixed mass of a fluid in its critical state.

■ crude oil

crude oil is the material extracted from oil wells, and which is subjected to a refining process to isolate various grades of fuels.

■ crystal lattice

crystal lattice are the regular pattern of atoms, ions or molecules in a crystalline substance.



■ **crystallisation**

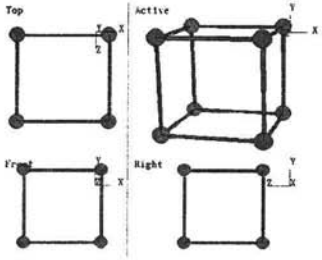
crystallisation is the precipitation of crystals of a solid from a supersaturated solution on cooled, when the solvent is unable to hold all the solute in solution.

■ **crystals**

crystals are solids with regular polyhedral shape. All crystals of the same substance grow so that they have the same angles between their faces.

■ **cubic lattice**

a cubic lattice is name for the unit cell of solid crystalline structure of Sodium Chloride, NaCl.



■ **cyclo-**

cyclo- is the prefix used in chemical nomenclature to designate a cyclic compound.

■ **Dalton's atomic theory**

a theory of chemical combination, first stated by the British chemist John Dalton (1766-1844) in 1803. It involves the following postulates:

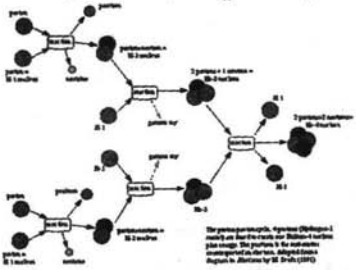
1. elements consist of indivisible small particles (atoms).
2. all atoms of the same element are identical; different elements have different types of atom.
3. atoms can neither be created nor destroyed.
4. 'Compound elements' (*i.e.,* compounds) are formed when atoms of different elements join in simple ratios to form 'compound atoms' (*i.e.,* molecules). Dalton also proposed symbols for atoms of different elements (later replaced by the present notation using letters).

■ **daltonide**

refers to a compound that conforms to the laws of constant composition and multiple proportions.

■ **daughter**

1. a nuclide which is produced by radioactive *decay of some other nuclide (the parent).



2. an ion or free radical which is produced by dissociation or reaction of some other (parent) ion or radical.

■ **d-block elements**

refers to the transition elements of the first, second, and third long periods, *i.e.*, Sc to Zn, Y to Cd, and La to Hg. They are so called because in general they have inner *d*-levels with configurations of the type $(n-1)d^x ns^2$ where x = 1.10.

■ **deacon process**

an earlier process which was used for making chlorine by oxidising hydrogen chloride in air at 450°C using a copper chloride catalyst. It was patented in 1870 by Henry Deacon (1822–76).

■ **deamination**

the term used for abstraction or replacement of the amino group in organic substances.

■ **debye effect**

selective absorption of hertzian waves in dielectrics, because of apparent existence of molecular dipoles.

■ **debye-huckel theory**

the activity coefficient of an electrolyte depend markedly upon concentration. In dilute solution, due to the columbic forces of attraction and repulsion of ions tend to surround them selves within the atmosphere of oppositely charged ions. Debye and Huckel showed that it was possible to explain the abnormal activity coefficient at least for very dilute solution of electrolytes.

Debye-Huckel Theory

In the limit of small potential, $V << kT/e$ $\sinh(x) \approx x$ so that a linearized Poisson-Boltzmann form can be used. $\nabla^2 V = \kappa^2 V$, with $\kappa^2 = 2e^2 n_i / \varepsilon kT$. This equation is used to approximate the potential around a single ion in solutions of weak electrolytes. Solutions for this case are: $V = V_0 \exp(-\kappa x)$ where $1/\kappa$ is called the Debye length. If applied to an electrode in Gouy-Chapman theory $1/\kappa$ is called the "thickness of the double layer".

■ **decahydrate**

a crystalline hydrate containing ten molecules of water per molecule of compound.

■ **decalin**

obtained when naphthalene is reduced by hydrogen in the presence of nickel as a catalyst; first tetralin and them decalin is formed.

■ **decay**

it describes how the activity of a substance decreases with time.

■ **decrepitation**

a crystalline solid gives cracking noise on heating due to the removal of water of crystallisation.

■ **defect**

refers to any irregularity in the lattice of a crystal. Two important defects are:

1. *Schottky defects*. Vacant site with the migrated atom at the surface.
2. *Frenkel defects*. Vacant sites with an interstitial atom.

■ **defoliant**

a chemical sprayed on plants that causes leaves to fall off prematurely. Agent organ, a defoliant, was extensively used in the Vietnam war to defoliate jungles.

■ **deformation energy**

refers to the energy which must be supplied to an initially spherical nucleus to give it a certain deformation in the Bohr-Wheeler Theory.

■ **deformation potential**

effective electric potential acting on a free electron in a metal or semiconductor resulting from a local deformation of the crystal lattice.

■ **degenerate**

describing different quantum states that have the same energy. For instance, the five d-orbitals in transition-metal atom all have the same energy but different values of the magnetic quantum number m. Differences in energy occur if a magnetic field is applied or if the arrangement of electrons around the atom is not symmetrical. The degeneracy is then said to be 'lifted'.

■ **degradation**

a chemical reaction in which a molecule decomposes into simpler molecules, e.g., conversion of amide into amine in the presence of bromine ad alcoholic KOH.

■ **degree of freedom**

from the standpoint of statistical mechanics, a degree of freedom means the independent ways in which particle can take up energy, e.g., a mono-atomic gas has three translational degrees of freedom. From the standpoint of phase, it is the minimum number of variables (e.g., pressure, temperature and concentration) which must be fixed to define the complete state of a system.

■ **dehydration**

a process of removing water from a substance, e.g., dehydration of ethyl alcohol in the presence of sulphuric acid.

■ **delayed proton**

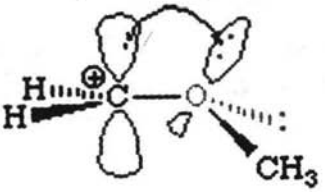
refers to a proton emitted spontaneously from a nucleus as a consequence of excitation left from a previous radioactive decay event.

■ **delocalisation**

refers to spreading out of bonding electrons in a molecule over the molecule.

■ **delocalised bond**

(non-localised bond) a type of bonding in molecules that is occurring in addition to sigma bonding. The electrons forming the delocalised bond are no longer regarded as remaining between two atoms; i.e., the electron density of the delocalised electrons is spread over the whole molecule.



■ **delta bonding**

lateral overlap between two orbitals *e.g.,* d-orbitals such that there are four regions of overlap.

■ **delta ray**

refers to an electron or proton ejected by recoil when a rapidly moving alpha particle of other

primary ionising particle passes through matter.

■ **demjanov rearrangement**

refers to a structural rearrangement that accompanies treatment of certain primary aliphatic amines with nitrous acid; the amine will undergo a ring contraction or expansion.

■ **demulsification**

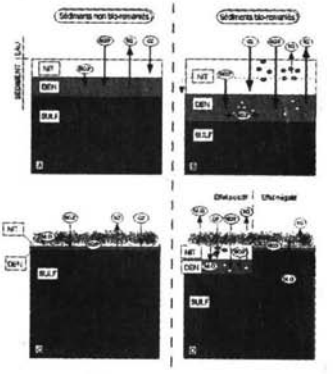
the process of breaking the emulsion by adding an electrolyte or a material that would destroy the emulsifier. Heating freezing or centrifugation may also cause demulsification.

■ **dendrochronology**

an absolute dating technique using the growth rings of trees. It depends on the fact that trees in the same locality show a characteristic pattern of growth rings resulting from climatic conditions. This it becomes possible to assign a definite date for each growth ring in living trees, and to use the ring patterns to date fossil trees or specimens of wood (*e.g.*, used for buildings or objects on archaeological sites) with life-spans that overlap those of living trees. The bristlecone pine (Pinus aristata), which lives up to 5000 years, has been used to date specimen over 8000 years old. Fossil specimen accurately dated by dendrochronology have been used to make corrections to the carbon-dating technique. Dendrochronology trace elements in sections of rings can also provide formation on past atmospheric pollution.

■ **denitrification**

the return of fixed nitrogen, generally nitrates and ammonium salts, to the atmosphere generally as $N_2$and N_2O.



■ **deoxyribo nucleic acid (DNA)**

a nucleic acid, a polymer of nucleotides. Incorporates phosphoric acid, deoxyribose, and

nitrogenous bases such as adenine, guanine cytosine, and thymine. Found in the cell nucleus. Plays an important part in heredity mechanism.

■ depolarisation

means the prevention or decrease of polarisation in electrolytic cells and ion current sources with the help of depolarisers added to electrolyte or electrodes. Oxidisers find use to depolarise cathodes, and reducing agents with anodes.

■ derived unit

refers to a unit defined terms of base units, and not directly from a standard value of the quantity it measures. e.g., the newton is a unit of force defined as a kilogram metre second^{-2} (kg ms^{-2}).

■ desulphorisation

a process which involves the removal of sulphur compounds from petroleum fractions in the presence of a catalyst. (Also known as hydrotreating or hydrefining).

■ detonating gas

it is a mixture of H_2 and O_2 in a ratio of 2:1. It is produced by electrolysis of water. It explodgs violently to reform water, on ignition.

■ detonation

refers to an exothermic chemical reaction that propagates with such rapidity the rate of advance of the reaction zone into the unreacted material exceeds. The velocity of sound in the unreacted material, i.e., the advancing reaction zone is preceded by a shock wave.

■ deuterated compound

a compound in which one or more ^1H atoms have been replaced by deuterium (^2H) atoms.

■ deuterium

a naturally occurring isotope of hydrogen, it is a colourless gas

having twice the density of ordinary hydrogen. It is chemically less reactive than hydrogen.

■ **devitrification**

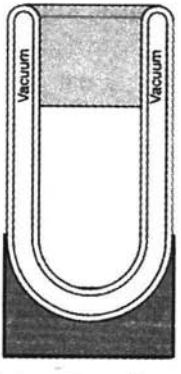
loss of the amorphous nature of glass as a result of crystallisation.

■ **dew point**

the temperature at which a mixture of air and water vapour is saturated with respect to water vapour.

■ **dewar flask (vacuum flask)**

refers to a double walled container of thin glass with the space between the walls evacuated and sealed to stop conduction and convection of energy



through it. The glass is often silvered to reduce radiation.

■ **dextran**

the temperature at which a mixture of air and water vapour is saturated with respect to water vapour.

■ **dextrin**

intermediate product formed during the hydrolysis of starch to sugars. Used as adhesives.

■ **dextrose (grape-sugar)**

refers to a naturally occurring glucose, belongs to the stereochemical series D and is dextrorotatory indicated by the symbol (+). Thus the term dextrose is used to indicate D- (+) glucose.

■ **diagonal relationship**

it refers to the similarities in properties shown by the first element of a group to the second element of second period. e.g., Li to Mg, Be to Al, B to Si etc.

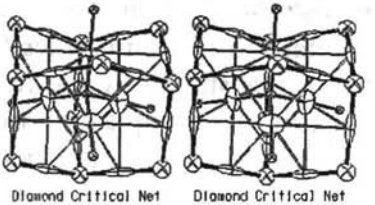
■ **diamagnetism**

the property of all substances that causes repulsion of the substance from a magnetic field. Originates in the inter-action of the electronic charge and the field and is an additive property

of the atoms and groups present. Order of magnitude 10^{-3} that of paramagnetism so that the effect is swamped by the presence of unpaired electrons.

■ **diamond**

an allotropic modification of carbon. It is the hardest substance known. In it, each carbon atoms is sp^3 hybridised. Each carbon atom is covalently bonded to four other carbon atoms resulting in a three dimensional network of covalent bonds. It is used in jewellery, for cutting glass, as a rock drill, as an abrasive etc.



■ **diaspore**

an important constituent of bauxite.

■ **diatomic**

describing a molecule that consists of two atoms. Hydrogen (H_2), oxygen (O_2), nitrogen (N_2), and the halogens are examples of diatomic elements.

■ **Diazonium compounds**

important type of compounds containing the RN=NX groups, where R is aromatic group and X a negative group.

■ **dibasic**

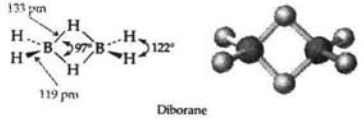
compounds containing two hydrogens that may be replaced by a monovalent metal or radical. An alcohol that has two hydroxyl groups, e.g., ethylene glycol.

■ **Dibereiner's triads**

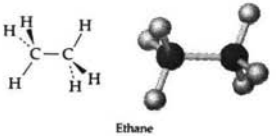
triads of chemically similar elements in which the central number, when placed in order of increasing atomic weight, has an atomic weight approximately equal to the average of the outer two. Other chemical and physical properties of the central number also lie between those of the first and last numbers of the triad. Dobereiner noted this relationship in 1817; the triads are now recognized as consecutive numbers of a group of the periodic table; *e.g.,* Ca, Sr, and Ba and Cl, Br, and I.

■ **diborane**

B_2H_6, a colourless, volatile compound that is soluble in ether; boiling point —92.5°C, melting point —165.5°C; can be used to produce pentaborane and decaborane, proposed for use as rocket fuels; also used to synthesize organic boron compounds. Also known as boroethane; diboron hexahydride.



Diborane



Ethane

■ **dichloramine**

1. NH_2Cl_2, an unstable molecule considered to be formed from ammonia by the action of chlorine. Also known as chlorimide.
2. any chloramine with two chlorine atoms jointed to the nitrogen atom.

■ **dichloride**

any inorganic salt or organic compound that has two chloride atoms in its molecule.

■ **dichroism**

the property of some crystals, such as tourmaline, of selectively absorbing light vibrations in one plane while allowing light vibrations at right angles to this plane to pass through. Polaroid is a synthetic dichroic material.

■ **dichromate (vi)**

a salt containing the ion $Cr_2O_7^-$. Dichromates are strong oxidising agents.

■ **dichromic acid**

$H_2Cr_2O_7$, an acid known only in solution, especially in the form of dichromates.

■ **dielectric**

a material which is an electrical insulator or in which an electric field can be sustained with a minimum dissipation of power.

■ **dielectric constant**

réciprocal of the force of attraction between two electric charges of unit value separated by a distance of 1 centimeter.

■ **dielectric properties**

a dielectric is a substance in which an electric field gives rise

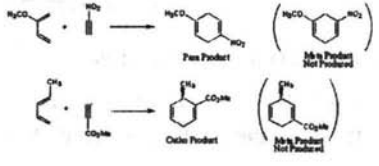
to no net flow of electric charge. The substance having dielectric properties shows piezoelectric effect.

■ **dielectric vapour detector**
refers to an apparatus to measure the change in the dielectric constant of gases ,of gas mixtures, used as a detector in gas chromatographs to sense changes in carrier gas.

■ **dielectronic recombination**
the combination of an electron with a positive-ion in a gas; thus the energy released is taken up by two electrons of the resulting atom.

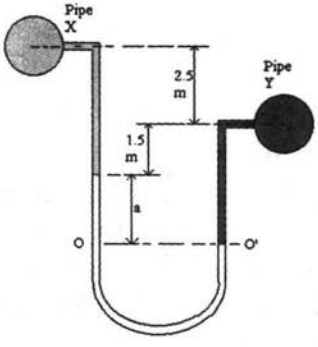
■ **dielectrophoresis**
refers to the ability of an unchanged material to move when subjected to an electric field.

■ **dienophile**
refers to an alkene compound in a reaction when an alkene reacts with a diene.

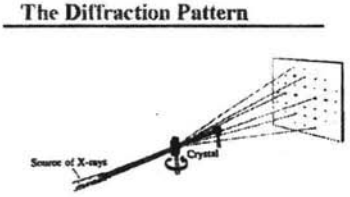


■ **differential extraction**
the process in which a component from a mixture can be taken out part by part by solvent or any other means. In order to extract another component, the solvent or other similar means correspondingly change.

■ **differential manometer**
a manometer that is used for the measurement of differences of pressure, e.g., between the vapour pressure of a solvent and its solution.



■ **diffraction pattern**
the pattern obtained on a photographic plate when a beam of X-rays or electrons is passed through a crystal. It is used for the study of crystal structures.



■ **dihydrate**

a crystalline compound which contains two molecules of water of crystallisation per molecule of compound.

■ **dihydrogen**

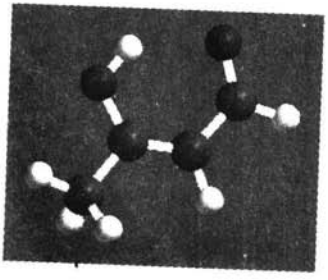
molecular hydrogen, H_2. It is a colourless, odourless gas and is used as a rocket fuel in liquid form. It is also used in hydrogenation of vegetable oils.

■ **di-iodide**

a molecule that contains two iodine atoms bonded to an element or radical.

■ **diketones**

organic compounds having two keto (>C = 0) groups. Show acidic properties and exist in keto and enol forms.

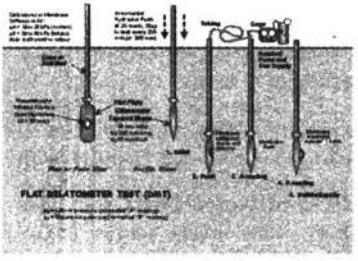


■ **dilatant**

a material with the ability to increase in volume when its shape is changed.

■ **dilatometer**

an apparatus for measuring small changes of volume of a liquid, solution or solid immersed in a liquid.



■ **dilute**

denoting a solution in which the amount of solute is low relative to that of the solvent. The term is always relative and includes dilution at trace level as well as the common term 'bench dilute acid', which usually means a 2M solution.

■ **dilution**

refers to the volume of solvent in which a given amount of solute is dissolved.

■ **dimethyl amine**

a colourless gas with an ammoniacal smell. It is used in dehairing hides and as a rubber accelerator.

■ **dinitrogen oxide**

(nitrous oxide, N_2O), a colourless gas with a faintly sweet odour and taste. It is prepared commercially and in the laboratory by the careful heating of ammonium nitrate:

■ **dinitrogen tetraoxide (N_2O_4)**

a colourless gas that changes to a pale yellow liquid below 21°C and solidifies below 11°C. It is used as a nitrating agent.

■ **diodine hexachloride**

refers to a powder made by reacting excess chlorine with iodine. It is a strong oxidising agent and at 70°C it dissociates into iodine monochloride and chlorine.

■ **diol (dihydric alcohol, glycol)**

refers to an alcohol that has two hydroxyl groups (-OH) per molecule of compound.

■ **dioxygen O_2**

formally the oxygen molecule but used for dioxygen complexes and dioxygenyl, $(O_2)^+$, salts.

■ **dioxygenyl compounds**

compounds containing the positive ion O_2^+ as in dioxygenyl hexafluoroplatinate O_2PtF_6—an organic solid that sublimes in vacuum at 100°C.

■ **dipole moment**

in a heteronuclear diatomic molecule, because of the difference in electronegativities of the two atoms, one atom acquires a small positive charge (q_+), the other a negative charge (q_-). The molecule is then said to have a dipole moment whose magnitude $?=qd$, where d is the distance of separation of the charges. With polyatomic molecules, the net dipole moment is the vector sum of the dipole moments of the individual bonds within the molecule. Thus symmetrical molecules, *e.g.*, CCl_4, may contain polar bonds but"possess no dipole moment. Measurements of dipole moments may be of

use to give information about the structure of complex molecules.

■ direct dyes

a group of dyes obtained from benzene or benzidene. These are used to dye cotton, viscous rayon and other cellulose fibres directly in the presence of NaCl or sodium sulphate as mordant.

■ direct effect

refers to a chemical effect caused by the direct transfer of energy from ionising radiation to an atom or molecule in a medium.

■ disinfectants

those chemical substances which can destroy or kill microorganism or stop their growth but are also harmful to human tissues. Such substances are used to disinfect floors, toilets etc. e.g., phenol (1%), SO_2(g) etc.

■ disperse dyes

water insoluble dyes, which, when held in fine suspension, can be applied to acetate rayon fabrics. The dye, together with a dispersing agent, is warmed to a temperature of 45-50°C and the fabric added. By modifying the method of application, it is possible to dye polyacrylic and polyester fibres. The yellow/orange shades are nitroarylamine derivatives and t
he green to bluish shades are derivatives of 1-amino anthraquinone. Certain azo compounds are disperse dyes and these give a range of colours.

■ dispersing agent

a substance used in the production of emulsions or dispersions of immiscible liquids or liquids and solids. The dispersing agent may lower the interfacial surface tension (surface tension depressant) or increase the viscosity of the continuous phase (protective colloid).
Dispersing agents, such as polyethylene polyamide succinimides or methacrylate type copolymers, are added to motor oils to disperse 'low-temperature sludge' formed in spark-ignition-engines.

■ **displacement series**

the elements in decreasing order of their negative potentials. Also known as constant series; electromotive series; Volta series.

■ **disproportionation**

a process in which a compound of one oxidation state changes to compounds of two or more oxidation states, *e.g.*, $2Cu^{+} ==> Cu + Cu_2^{+}$ in aqueous solution. Alternatively, redistribution of groups around a central atom, *e.g.*, $2PF_4Cl ==> PF_3Cl_2 + PF_5$

■ **dissociation pressure**

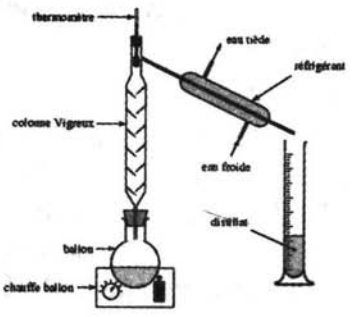
the pressure for a given temperature at which a chemical compound dissociates.

■ **distillate**

the material generally liquid, that is vapourised and condensed in the process of distillation.

■ **distillation**

refers to a process of boiling a liquid and condensing the vapour. Distillation is used to purify liquids or to separate components of a liquid mixture.



■ **dithionate**

a salt of dithionic acid, containing the ion $S_2O_6^{2-}$ usually formed by the oxidation of a sulphite using manganese reducing properties.

■ **dithionic acid**

$H_2S_2O_6$, a strong acid formed by the oxidation of sulphurous acid, and known only by its salts and in solution.

■ **ditungsten carbide**

W_2C, a grey powder having hardness approaching that of diamond; forms hexagonal crystals with specific gravity 17.2; melting point 2850°C.

■ **divalent (bivalent)**

having a valency of two.

■ d-lines

two close lines in the yellow region of the visible spectrum of sodium, having wavelengths 589.6 nm. As they are prominent and easily recognized, they are used as a standard in spectroscopy.

■ donor

an ion or molecule that provides a pair of electrons in forming a coordinate bond.

■ dopamine

a catecholamine that is a precursor in the synthesis of noradrenaline and adrenaline. It is also believed to function as neurotransmitter in the brain.

■ doping

the name given to the practice whereby electrical, magnetic and other properties of an ionic solid may be changed by incorporation of an intervalent ion in the host lattice. e.g. the incorporation of small amounts of Li^+ or Ga^{3+} into the nickel oxide lattice results in a respective decrease or increase in conductivity of the latter. When the dopant is not incorporated directly into the lattice, but rather forms discrete aggregations within it, the process is referred to as domain doping.

■ double refraction

refers to the property which is possessed by certain crystals (notably calcite), of forming two refracted rays from a single incident ray. The ordinary ray obeys the normal laws of refraction. The other refracted ray, called the extraordinary ray, follows different laws.

■ double salt

a salt formed by crystallisation from a solution of two or more components that has distinct properties in the solid but in solution behaves as a mixture of the components. e.g. iron (II) ammonium sulphate, $FeSO_4(NH_4)_2$, SO_46H_2O. Double salts are either weak, easily dissociated complexes or the solid lattice which have an extensive interaction, *e.g.* hydrogen bonding, not found in the components.

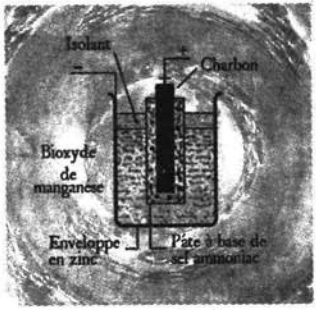
■ doublet

a pair of associated lines in certain spectra, *e.g.*, the two lines

that make up the sodium D-lines.

■ **dry cell**

refers to a voltaic cell in which the electrolytic is in the form of a jelly or paste. The Leclanche



dry cell is extensively used for flashlights and other portable applications.

■ **dry cleaning**

the process of cleaning fabrics using solvents which dissolve dirt at low temperatures but do not swell fibres. The most widely used cleaning fluids are the highly inflammable hydrocarbons and chlorinated hydrocarbons, particularly C_2CI_4.

■ **dry ice**

carbon dioxide in the solid form, usually made in blocks to be used as a coolant; changes directly to a gas at —78.5°C as heat is absorbed.

■ **ductility**

the ability of a material to be plastically deformed by elongation, without fracture. A property by which materials can be drawn into wires. Silver and gold are highly ductile.

■ **duplet**

a pair of electrons in a covalent chemical bond.

■ **duralumin**

(trademark), a strong lightweight aluminium alloy containing 3-4% copper, with small amounts of magnesium, manganese, and sometimes silicon. It is widely used in aircraft bodies.

■ **dutch metal**

a Cu-Zn alloy prepared in leaf form in imitation of gold-leaf.

■ **dyestuffs**

intensely coloured compounds applied to a substrate, e.g., fibre, paper, cosmetic, hair, to give colour. React by absorption, solution, bonding. Pigments retain their identity more closely on bonding to the

substrate. Colours generally originate in electronic transitions; most dyestuffs are organic in nature but are frequently applied together with inorganic species. Classified in the colour index by chemical nature; also classified by their method of application as acid, basic, direct, disperse, azo, sulphur, vat or fibre reactive.

■ **dynamite**

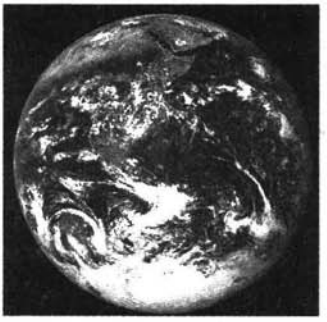
any of a class of high explosives based on nitroglycerin. The original form invented in 1867 by Alfred Nobel, consisted of nitroglycerin absorbed in kieselguhr. Modern dynamites, which are used for blasting contain sodium or ammonium nitrate sensitised with nitroglycerin and use other absorbers (*e.g.*, wood pulp).

■ **dynel or vinyon**

a copolymer of acrylonitrile and vinyl chloride containing about equimolar quantities of the two monomers and can be spun into fibre from acetone solution.

■ **earth**

planet Earth orbits the sun between the planets Venus and Mars, and has three distinct layers.



the gaseous atmosphere,
the liquid hydrosphere, and
the solid lithosphere, which has three distinct regions
the crust (EarthCrust),
the mantle (EarthMantle) and
the core (EarthCore).

■ **earth's atmosphere**

earth's atmosphere is the layer of gasses that surrounds the earth.

■ **earth's core**

earth's core, part of which is believe to be liquid, lies below the mantle.

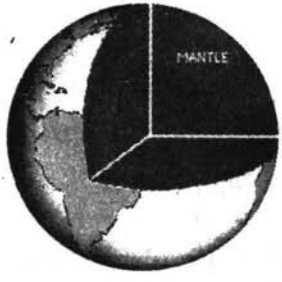
■ **earth's crust**

earth's Crust has a mean thickness of about 32 km under the land and 10 km under the sea, and has the approximate chemical composition :

Oxygen	47%
Silicon	28%
Aluminium	8%
Iron	4.5%
Calcium	3.5%
Sodium	2.5%
Potassium	2.5%
Magnesium	2.2%

■ earth's mantle

earth's mantle extends some 2900 km below the crust.



■ ebullioscopy

a process used for the determination of molecular weight from elevation of boiling point of solution.

■ edeleanu process

an extraction method utilizing liquid sulphur dioxide for the removal of aromatic hydrocarbons and polar molecules from petroleum fractions.

■ effective atomic number rule

applied to transition metal carbonyls and to many organometallic derivatives. It is frequently found that the total number of electrons available to the central atom from its own electrons, by donation (lone pairs, etc. of electrons from ?-bonding systems), by covalent bonding (each covalent bond to a substituent or another metal contributes 1 electron), and taking into account charge add up to the total number of electrons of the next noble gas. This does not apply to paramagnetic species and there are many other exceptions to the rule. e.g., $ClMn(CO)_5$.Mn7 valence electrons, 1 from covalent bond to Cl, 5×2 electrons from carbonyls. Total 18 electrons, krypton structure.

■ effective molecular diameter

the general extent of the electron cloud surrounding a gas molecule as calculated in any of several ways.

■ **effervescence**

effervescence is the formation of gas bubbles in a liquid by chemical reaction. An example of effervescence is the release of carbon dioxide which bubbles as a gas from the liquid when limestone chips, which are composed of calcium carbonate are added to dilute hydrochloric acid.

■ **efforescence**

efforescence is the process where a crystalline hydrate loses water, forming a powdery deposit on the crystals.

■ **effusion**

effusion is the flow of a gas through a small aperture. The relative rates at which gases effuse, under the same conditions, is approximately inversely proportional to the square roots of their densities.

■ **Einstein**

it is a unit of radiant energy named after a great scientist.

■ **Einsteinium compounds**

the element shows oxidation states of +2 and +3, the +3 state being that of a typical tripositive actinide, $EsCl_3$, EsOCl and Es_2O_3 are known. $EsBr_2$ is reduced to $EsBr_3$ by hydrogen.

■ **Elaidinisation**

refers to the process of changing the geometric form of an unsaturated fatty acid or a compound related to it into the transform, resulting in an acid that is more resistant to oxidation.

■ **electret**

refers to a permanently electrified substance or body that has opposite charges at its extremities.

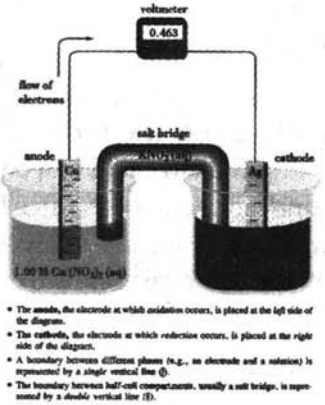
■ **electrical conductivity**

refers to the ability of substances to transmit electricity under the action of an external electrical field. If electrons are charge carriers as, e.g., in metals and most semiconductors, the phenomenon is termed as electronic conductivity.

■ **electrochemical cell**

an Electrochemical Cell consists of a pair of electrodes immersed in solutions of electrolytes and connected via an ex-

ternal metallic conductor such an arrangement is called an electrochemical cell.



- The anode, the electrode at which oxidation occurs, is placed at the left side of the diagram.
- The cathode, the electrode at which reduction occurs, is placed at the right side of the diagram.
- A boundary between different phases (e.g., an electrode and a solution) is represented by a single vertical line (|).
- The boundary between half-cell compartments, usually a salt bridge, is represented by a double vertical line (||).

If the cell is used as a source of electrical energy, (i.e. if it converts the free energy of a physical or chemical change into electrical free energy), it is called a Galvanic Cells.

If the cell is used to achieve a change in the physical or chemical composition of the constituents of the cell by the application of electrical energy from some external source, it is called an Electrolytic Cell.

■ **electrochemical corrosion**

it involves deterioration of metal due to flow of electric current from one point to another point.

■ **electrochemical equivalent**

the Electrochemical Equivalent of a substance is the mass of the substance, in grams, which is liberated by the passage of 1 coulomb of electricity.

■ **electrochemical series**

the electrochemical series consists of a list of metals have been arranged in order of their standard electrode potentials. The standard electrode potentials which has been measured for most elements that form ions in solution. Metals which are higher in the electrochemical series displace metals which are lower in the sequence from solutions of their salts. The electrochemical series The following is a list of the standard potentials:

Element	Electrode Potential (Volts)
Lithium	-3.04
Rubidium	-2.92
Potassium	-2.92
Calcium	-2.87
Barium	-2.80
Sodium	-2.71

Magnesium	-2.37
Aluminium	-1.67
Mangnesium	-2.34
Zinc	-0.76
Chromium	-0.74
Iron	-0.44
Nickel	-0.24
Tin	-0.14
Lead	-0.13
Hydrogen	+0.00
Copper	+0.34
Iodine	+0.54
Silver	+0.80
Gold	+0.80
Mercury	+0.80
Iodide	+0.54
Bromine	+1.07
Chlorine	+1.36
Fluorine	+2.87

A negative value for electrode potential means that the element loses electrons more readily than hydrogen (i.e. it is better reducing agent). A positive value for electrode potential means that the element is a poor reducing agent than hydrogen.

A strong oxidising agent has a large positive potential and a strong reducing agent a large negative potential.

The electrochemical series is extremely useful for predicting the chemical behaviour of an element. An electropositive element will displace a less electropositive element from a solution of its ions (e.g. zinc will displace copper from a copper solution).

However, aluminium which is more electropositive than copper does not displace copper from copper salt solutions, due to the presence of a very stable film of aluminium oxide on the surface of the aluminium which has a lower electrode potential. This oxide film can be destroyed by the presence of added chlorine ions. Thus, in the presence of added chloride ions in the solution, copper is deposited and the aluminium dissolves.

■ electrochemistry

electrochemistry is the study of the effects of electric current on the properties and reactions of chemical substances in solution, including electrolysis and electric cells.

■ **electrode**

an electrode is a conductor that emits or collects electrons in a cell. The anode is the positive electrode, where ions lose electrons and thus, oxidation occurs at the anode. The cathode is the negative electrode, where ions gain electrons, and thus, reduction occurs at the cathode.

■ **electrode potential**

the electrode potential (i.e. the Reduction Potential) of a half cell is a measure of the potential for an element to lose its electrons when in contact with a solution of its ions. It is not possible to measure the electrode potential of a single electrode, so two half-cells are joined and the difference between their electrode potentials is measured. If the electrode potential is known for one of the half cells, that of the other may be calculated. The standard half-cell chosen as a reference is the hydrogen half cell, which is assigned an electrode potential of zero. The hydrogen cell consists of a platinum electrode coated with platinum black containing absorbed hydrogen which catalyses the half-cell reaction.

$2H^+ + 2e^- \Longrightarrow H_2$

The ability of an element to be oxidised or reduced in a cell is used to obtain a value for the electrode potential. If an electrode is immersed in one molar hydrochloric acid and hydrogen gas at a pressure of 1 atmosphere is bubbled over the platinum black electrode to maintain equilibrium, it is possible to obtain a value for the electrode potential of any element.

For example, if a hydrogen half cell is connected to a copper half-cell, (i.e. a copper rod in a solution of copper ions) and the potential of the cell measured, it is found to be +0.34 volts, and assigned as the electrode potential of the copper half cell, using the following convention. If the metal electrode loses electrons more readily than the hydrogen electrode, the metal eventually acquires a negative potential due to the accumulation of electrons on the metal. If the metal electrode does not form ions as readily as the hy-

drogen electrode, the metal appears positive with respect to the hydrogen electrode.

Standard electrode potentials have been measured for most elements that form ions in solution.

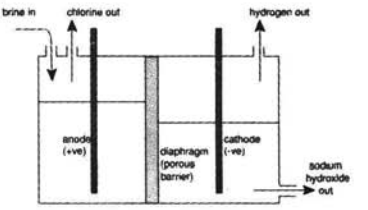
A negative value for electrode potential means that such an element loses electrons more readily than hydrogen (i.e. it is a better reducing agent). A positive value means the element is a poorer reducing agent than hydrogen. Thus, strong oxidising agent has a large positive potential and a strong reducing agent a large negative potential.

■ **electrodeposition**

refers to the process of depositing one metal on another by electrolysis, as in electroforming and electroplating.

■ **electrolysis**

electrolysis is the production of a chemical change by electrical energy. In electrolysis, positive ions migrate to the cathode and negative ions migrate to the anode. At the anode, the negative ions in solution may lose electrons to form neutral species. Alternatively, atoms of the electrode can lose electrons and go into solution as positive ions. In either case, anodic reactions are oxidation reactions. At the cathode, positive ions in solution can gain electrons to form neutral species. Thus, cathodic reactions are reduction reactions.



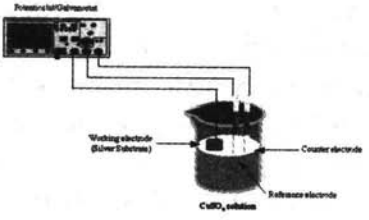
■ **electrolyte**

an electrolyte is a compound which conducts an electric current when in solution or in the molten state, and is simultaneously decomposed by the current. In contrast with metals where the current is carried by electrons, in electrolytes the current is carried by the ions migrating through the liquid.

■ **electrolytic cell**

an electrolytic cell is one in which a physical or chemical

change is caused by electrical energy applied from some external source.



■ **electrolytic corrosion**

electrolytic corrosion of a metal occurs through electrochemical reactions.

■ **electrolytic gas**

electrolytic gas is the highly explosive gas formed by the electrolysis of water. It consists of two parts hydrogen and one part oxygen by volume.

■ **electromagnetic spectrum**

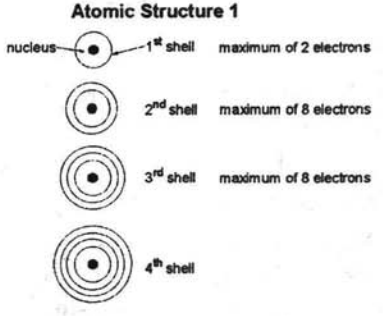
the electromagnetic spectrum is the range of wavelengths over which electromagnetic radiation extends. The spectrum includes
radio waves
(10^{5} to 10^{-3} meters), the longest waves,
infrared waves
(10^{-3}-10^{-6} meters), next longest,
visible radiation
(4×10^{-7} to 7×10^{-7} meters),
ultraviolet waves
(10^{-7}- to 10^{-9} meters) and
X-rays and gamma radiation
(10^{-9} to 10^{-14} meters).

■ **electrometallurgy**

the uses of electrical processes in the separation of metals from their ores, the refining of metals, or the forming or plating of metals.

■ **electron**

the electron is an atomic particle. It travels in the orbitals about the nucleus, which is the central core of the atom. It has a unit negative charge and its mass is only 1/1850 that of the proton. It is characterised in terms of its particle and wave-like properties.



■ **electron affinity**

the electron affinity of an element is the energy released when an electron is added to a neutral gaseous atom of that element. It is measured in electron volts. The values of the electron affinities are difficult to determine, but some have been obtained by a method involving the Born-Haber Cycle.

The fluorine and chlorine atoms can each readily acquire an electron to form the fluoride and chloride ions, respectively. These ions have the Electronic Configuration of the noble gases (i.e. a full outer valency shell), and are therefore stable ions. The reason for this is that the fluorine and chlorine atoms can accommodate an electron in their 2p and 3p orbitals respectively and that the attraction of the positively charged nucleus is great enough to overcome the repulsion from the other five electrons. A list of values for the electron affinities of fluorine, chlorine, bromine, iodine, hydrogen, oxygen and sulphur is given below.

Table of Electron Affinity (eV)

F + e(-)	F(-) - 3.62
Cl + e(-)	Cl(-) - 3.79
Br + e(-)	Br(-) - 3.56
I + e(-)	I(-) - 3.28
H + e(-)	H(-) - 0.77
O + 2 e(-)	O(2-)+ 7.28
S + 2 e(-)	S(2-)+ 3.44

The Electron Affinity for an element depends on the atomic radius, the nuclear charge, and the screening effect of inner layers of electrons.

The decrease in value of the Electron Affinity on going from chlorine to iodine is reasonable, because the electron added to the iodine goes into the fifth level and is less tightly bound to the nucleus. Hence the addition of this electron releases less energy.

For the elements oxygen and sulphur which form di-negative ions, the electron affinity values are negative. Although energy is released when one extra electron is added, much more energy is required to force the second electron into an ionised atom.

The electron affinity for the alkali elements of Group 1 are assumed to be zero.

Electron Deficient Compound

An electron deficient compound is one in which there are fewer electrons forming the chemical bonds than required in normal electron-pair bonds.

■ electron compounds

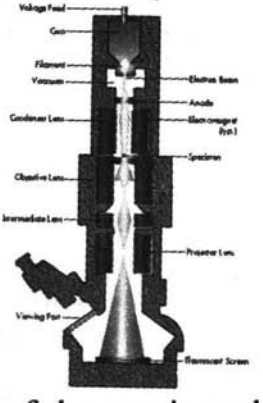
compounds which are formed by transition metals and one of the main group elements in which the structure of particular phases depends on the ratio of the total valency electrons available to the total number of atoms in the simrlest empirical formula (making assumptions such that Fe, Co, Ni group elements have 0, Cu group 1 valence electrons). The ratios are 3:2 , 21 ; 13 (y-phase complex), 7 : 4.

■ electron diffraction

when we allow beam of electrons to interact with atoms or molecules, because of the wave properties of the electrons, they get diffracted. The diffraction of a beam of electrons by the surface of a nickel single crystal was used by Davission and Germer to demonstrate that electrons have wave properties. Electron diffraction finds use to study molecular structure, especially in the gas phase and the investigation of surfaces.

■ electron microscope

the electron microscope is a form of microscope that uses a



beam of electrons instead of a beam of light (as in optical microscope) to form a large image of a very small object.

■ electron pair repulsion

electron pair repulsion is the divergent force between the electron pairs in the sub-orbitals of the valence shell about an atom. There are two types of electron pairs :

Bond Pairs :
where the electron pair are shared in a covalent bond,
Lone Pairs :
where the electron pair are not shared in any bond.
There are three types of interaction between these different types of electron pairs :
bond pair : bond pair repulsion (bp:bp)
where both electron pairs are shared in covalent bonds,
lone pair : lone pair repulsion (lp:lp)
where both electron pairs are not shared in any bond, and
lone pair : bonding pair repulsion (lp:bp)
where one electron pairs are shared in a covalent bond, and the other electron pair is not shared in any bond.
The magnitude of the repulsion force between electron pairs depend on the proximity of each pair to the central atom. Lone pairs lie closer to the central atom than bond pairs, since lone pairs have no other nearby positive nucleus to attract them away from the centre. Bond pairs are attracted by a second nucleus and so they are drawn further away from the central atom.
Repulsion between electron pairs is inversely proportional to the distance between them. The repulsion between electron pairs influence the shape of simple covalent molecules, because the presence of a lone pair in a molecule tends to cause bond pairs to come closer together. This will result in smaller bond angles in the molecule; since it is the angle between the bond pairs which dictates the bond angle.

■ electron pairs

electron pairs are the two electrons which have opposite spins that occupy the same sub-orbital in the valence shell of an atom, or in the single covalent bond between atoms.

# electron pairs (bonding or non-bonding)	Structure	Name
2		linear
3		Trigonal Planar
4		Tetrahedral
5		Trigonal Bipyramidal
6		Octahedral

■ **electron probe microanalysis**

electron probe microanalysis, EPM, is the method of analysing a very small quantity (i.e. as little as 10^{-13} gram) of a substance. The method consists of directing a very finely focused beam of electrons on to the sample to produce the characteristic X-ray spectrum of the elements present in the sample. It can be used quantitatively for elements with atomic numbers in excess of 11.

■ **electron spin resonance**

a similar technique to nuclear magnetic resonance, but applied to unpaired electrons in a molecule (rather than to the nuclei). It is a powerful technique for studying free radicals and transition-metal complexes.

■ **electron volt**

an electron volt (eV) is the energy acquired by an electron when it passes through a potential difference of one volt.
1 eV = 1.60 X10^{12} erg = 96 kJ/mole.

■ **electron-deficient compounds**

compounds in which the number of electrons available for bonding is insufficient for the bonds to consist of conventional two-electron covalent bonds. Diborane, B_2H_6, is an example in which each boron atom has two terminal hydrogen atoms bound by conventional electron-pair bonds and in addition the molecule has two hydrogen atoms bridging the boron atoms (B-H-B). In each bridge there are only two electrons for the bonding orbital.

■ **electronegativity**

electronegativity is the measure of the relative attraction that atoms in a molecule have for shared pairs of electrons.
Tables of the electronegativity values of the elements have been prepared by Millikan by correlating ionisation potential and electron affinity data :
EN = (IP + EA) / 2
Later, Pauling used bond energies to prepare a scale in which he assigned fluorine, the most electronegative element, a value 4.

The electronegativity values increase across each row of the periodic table because the nuclear positive charge is increasing and the atomic radius decreasing. Hence the closer the outer level of electrons is to the nucleus, the more difficult to attract electrons from the atom.

The values decrease down each group, because the increasing atomic radius means a looser hold on outer level electrons and the effect of the increasing nuclear positive charge is weakened by the screening effect of the extra inner shells.

The uses of electronegativity values are that they help to predict the type of bonding to be expected in a molecule, as well as the polarity of covalent molecules. The greater the difference in electronegativity values between the combining elements, the more likelihood of an ionic bond; the closer the values, the more likelihood of a covalent bond.

For simple bonds, if the difference of the electronegativities on the Pauling Scale of the elements between which the bond is formed is greater than 1.9, then the bond will likely be ionic. Similarly, if the difference of the electronegativities on the Pauling Scale of the elements between which the bond is formed is equal to or less than 1.9 the bond will be predominantly covalent.

■ **electronic band spectra**

molecular spectra occurring in ultraviolet or visible regions of spectrum, studied by absorption or emission.

■ **electronic configuration of an atom**

the electronic configuration of an atom is the arrangement of electrons in the atomic orbitals about the nucleus of the atom. The electrons of an atom travel in orbitals about the nucleus of the atom. Each orbitals is a volume in space in which the electrons located in that orbital travel, giving rise to an electron cloud. The orbitals about an atom have different energy levels. The electrons associated with a given atom fill these or-

bitals of that atom according to the following rules.

The Aufbau Principle

Electrons occupy the lowest energy levels (i.e. sub-orbital) available when the atom is in the ground state.

Hund's Rule of Maximum Multiplicity

Where more than one orbital of equal energy is available, the electrons will occupy each orbital singly, before filling any orbital in pairs.

Pauli's Exclusion Principle

A pair of electrons in any sub-orbital must have opposite spins. Hence, no two electrons in the same atom can have the same four Quantum Numbers.

To construct the electronic configuration of an atom from these rules it is necessary to know the energy levels of the different orbitals in an atom, or at least the sequence of increasing energy levels of the orbitals.

■ electronic publishing

electronic publishing is the method of preparing and delivering text material for access and display on a computer system. This hypertext document is an example of electronic publishing.

■ electronic structure of elements

the electrons of atoms are distributed over various levels in accordance with Pauli's exclusion principle, Hund's rule etc. It is represented in a simple form as e.g., for Na, $1S^2$, $2S^2$, $2p^6$, $3S^1$.

■ electrons in the outer shells

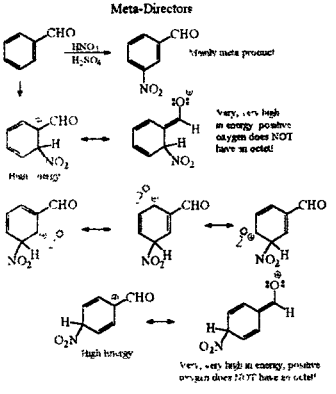
the electrons in the outer shells (i.e. in the outer atomic orbitals) of the atom determine to a great extent the chemical properties of the elements.

■ electrophiles

electrophiles are atoms or radicals which are attracted to the electron rich sites in a molecule. Frequently, when an electrophile attacks a carbon atom in a molecule, it results in the displacement of another atom, or group, from that carbon, giving rise to a substitution reaction.

■ electrophilic

any chemical process in which electron are acquired from or shared with other molecules or ions.



■ electrophilic addition reactions

electrophilic additions reactions occur when the electrophile, adds to the molecule without displacing any atom or group of atoms already present in the molecule.

■ electrophilic substitution reactions

electrophilic substitution reactions are substitution reactions at electron rich carbon sites, where the substituting reagent is an electrophile and it displaces another atom, or radicals, from an electron rich carbon atom during the course of the reaction.

Common electrophiles include the positively charged nitronium ion, NO_2^+, the positively charged chloronium ion, Cl^+), and the positively charged methyl ion, CH_3^+.

■ electrophoretic effect

under an applied voltage, an ionic atmosphere moves in the opposite direction to that of a particular ion. The ionic atmosphere tends to drag the ion with it. This is equivalent to an increase in viscosity of the solution which slows down the speed of an ion towards an elec trode.

■ electroplating

electroplating is the process of coating the surface of one metal object with a thin layer of another metal. The applied metal is usually more expensive than the base metal that is coated. Electroplating is used for the protection of the metal which is coated, or to give a shining surface.

■ **electrorefining**

electrorefining is process of using electrolysis for the purification of metals. For example, when copper rods are used as electrodes in the hydrolysis of a solution of copper sulphate, if impure copper is used as anode, it dissolves and pure copper is deposited on the cathode, leaving the impurities behind in solution.

■ **electrovalent bond**

(ionic bond) a binding force between the ions in compounds in which the ions are formed by complete transfer of electrons from one element to another element or radical. For example, Na + Cl becomes $Na^+ + Cl^-$. The electrovalent bond arises from the excess of the net attractive force between the ions of opposite charge over the net repulsive force between ions of like charge. The magnitude of electrovalent interactions is of the order 10^2-10^3 kJ mol^{-1} and electrovalent compounds are generally solids with rigid lattices of closely packed ions.

■ **element**

chemists once defined an element as a substance which could not be broken down chemically to give two or more simpler substances. Thus, the elements are the simplest chemical entities. However, with the discovery of Radioactivity, this definition was not strictly correct. For example, the element radium was found to be constantly decomposing into different substances.

Chemists once defined an element as a substance in which all the atoms were alike. However, the discovery of Isotopes showed that not all atoms of an element are alike. A new definition was thus proposed:

An element is defined as a substance in which all of the atoms have the same atomic number (i.e. they contain the same number of protons in their nuclei). Elements cannot be further subdivided by chemical means.

Each element is unique and is composed of atoms with a definite fixed atomic composition. There are 92 naturally occurring Elements on Earth. Further

elements have been synthesisef in nuclear reactions. All known matter on Earth is composed of different combination of these elements. The majority of elements are classified as metals, the remainder being non-metals.

Metals

Iron, Copper, Tin, Manganese, Potassium, Sodium

Non-Metals

Carbon, Hydrogen, Iodine, Phosphorus, Nitrogen, Sulphur

From the 18th Century, chemists began to discover new elements. This discovery of elements continued until 92 elements had been identified. Chemists have been successful in synthesising new elements so that the total has now risen to 103.

Every element has its own symbol, which represents one atom or sometimes one mole of that element. The symbols of the elements which were known in earlier days were derived from Latin names. Many of the initial letters of the elements; others have a second letter where there is more than one starting with the small letter (e.g. Hydrogen has the symbol H and Helium has the symbol He).

Some elements can exist in different physical forms, which differ in colour, hardness, melting point, etc.. These different forms are called allotropes. For example, carbon can exist in several different forms, including graphite and diamond (which are pure forms of carbon) and charcoal, coke and lampblack (which are impure forms of carbon). Sulphur has five different allotropes.

■ elevation of the boiling point

an elevation of the boiling point of a solvent is observed when substances are dissolved in it. The amount by which the boiling point is elevated is proportional to the number of molecules of solute and independent of their nature.

The molecular elevation of boiling point is the elevation of the boiling point produced when one gram-molecular weight of the solute is dissolved in 100 gm. of solvent.

■ **elutriation**

the method of separating a material into fractions of various sizes by permitting it to settle against upward moving stream of fluid, generally air or water.

■ **emanation**

an obsolete name for radon.

■ **emerald**

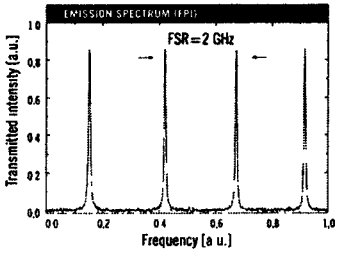
the green gem variety of beryl : containing some Cr^{3+}one of the most highly prized gemstones. The finest specimen occur in the Muzomines, Colombia. Other occurrences include the Ural Mountains, the Transvaal in South Africa, and Kallgunan in India. Emeralds can also be successfully synthesized.

■ **Emil Hermann Fischer**

a German chemist, Emil Hermann Fischer (1852-1919), produced synthetic sugars. His description of the chemistry of the carbohydrates and peptides laid the foundations for the science of biochemistry.
He received the Nobel prize 1902.

■ **emission spectrum**

a spectrum formed by a material which is heated, e.g., a white hot wire, or by excitation from an electric arc or electric discharge, e.g., as seen in gases in a discharge tube. A spectrum can be a continuous line or a band spectrum. It is formed in the visible region or in the infrared or ultra-violet region of e.m. waves. It is produced by extra-nuclear electrons first being excited by energy and being raised to a higher energy level, and then falling back to a lower energy level and emitting energy in the form of e.m. waves.



■ **empirical data**

empirical data are the results that are obtained by experiment or observation rather than from theory.

■ **empirical formula**

the empirical formula of a compound is the number of atoms of each element the are present in a molecule of the compound in their simplest ratio.

■ **emulsification**

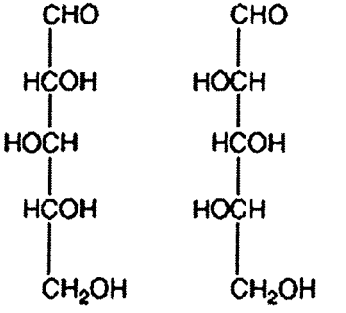
the process of dispersing one liquid in a second immiscible liquid; the largest group of emulsifying agents are soaps, detergents, and other compounds, whose basic structure is a paraffin chain terminating in a polar group.

■ **emulsion breaking**

in an emulsion, the combined sedimentation and coalescence of emulsified drops of the dispersed phase so that they will settle out of the carrier liquid; can be accomplished mechanically (in settlers, cyclones, or centrifuges) with or without the aid of the droplets.

■ **enantiomorph**

one of an isomeric pair of crystalline forms or compounds whose molecules are non-superimposable mirror images. Also known as enantiomer; optical antipode; optical isomer.



■ **enantiotropy**

refers to the existence of different stable allotropes of an element at different temperatures; sulphur, for example, exhibits enantiotropy. The phase diagram for an onantiotropic element is having a point at which all the allotropes can coexist in a stable equilibrium. At temperatures above or below this point, one of the allotropes will be more stable than the others(s).

■ **end point**

the end-point of a titration occurs when the reaction is complete, as shown by the change of colour of an indicator or by other means.

■ **endothermic reaction**

an endothermic reaction is a chemical reaction in which heat is absorbed.

■ **energy**

energy is the ability to do work, and it is measured in joules. Energy is conveniently classified into two forms.

Potential Energy

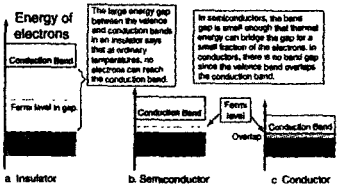
which is the energy stored in a body or system as a consequence of its position, shape or state (this includes gravitational energy, electrical energy, nuclear energy and chemical energy), and

Kinetic Energy

which is energy of motion and is usually defined as the work that will be done by the work that will be done by the body possessing the energy when it is brought to rest.

■ **energy bands**

refers to continuous bands of energy arising from a series of close energy levels occurring mainly in metals where the valency electrons form bonds with an increased number of quantised energy levels.



■ **energy change**

whenever a reaction occurs, it is generally accompanied by a release or absorption of energy. This gives the change in energy i.e. the difference in the energy of products and reactants.

■ **energy change in nuclear reaction**

it is given by the Einstein's energy mass equation. $E = mc^2$ where E is the energy equivalent of mass m and c is the velocity of light. 1 amu=931 Mev.

■ **energy changes in chemical reactions**

the energy changes in chemical reactions is manifested in the heat which is either absorbed or released during the course of the reaction.

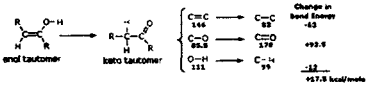
■ **energy level**

one of the discrete energies that an atom or molecule, for instance, can have according to

quantum theory. Hence, in an atom there have been certain definite orbits that the electrons can be in, corresponding to definite electronic energy levels of the atom. Similarly, a vibrating or rotating molecule can be having discrete vibrational and rotational energy levels.

■ **enol-keto tautomerism**

the tautomeric migration of a hydrogen atom from an adjacent carbon atom to a carbonyl group of a keto-compound to produce the end form of the compound, the reverse process of hydrogen atom migration also occurs.



■ **enthalpy**

enthalpy, H, is the thermodynamic property of a system defined by the relationship

$H = U + pV$

where H is the Enthalpy,
U is the Internal Energy of the system,
p its Pressure, and V its Volume.

■ **enthalpy of sublimation**

it is the enthalpy change that accompanies the conversion of one mole of solid directly into gaseous state at a temperature below its melting point.

■ **entropy**

the entropy, S, is a measure of the fraction of the energy in a system that is unavailable to do work.

In a closed system, an increase in entropy is accompanied by a decrease in energy available to do work.

■ **enzymes**

enzymes are proteins that acts as a catalyst in biochemical reactions. Each enzyme is specific to a particular reaction or group of similar reactions. The names of most enzymes end in "-ase", which is added to the names of the substrates on which they act.

■ **epoxy resins**

polyethers obtained by condensation of epichlorophydrin with polyols like bisphenol A, or by epoxidation of Diels-Alder adducts with peroxy compounds.

These are used as adhesives protective coatings, etc.

■ equation of state

the equation of state is an equation that relates the pressure, p, the volume, V, and the thermodynamic temperature, T, and the amount of substance, n. The simplest equation of state (which applies only to ideal gasses) is the ideal gas law

$pV = nRT$

where R is the universal gas constant.

A more accurate equation of state is :

$(p + k)(V - nb) = nRT$

where k is a factor that reflects the decreased pressure on the walls of the container as a result of the attractive forces between particles, and nb is the volume occupied by the particles themselves when the pressure is infinitely high.

In the Van der Waal's equation of state:

$k = n^2 a / V_2$,

where a is a constant. This equation more accurately reflects the behaviour of real gases.

■ equilibrium

equilibrium is a state in which a system has its energy distributed in the statistically most probable manner, in which the forces, influences, reactions, etc., balance each other out so that there is no net change over time. A system at equilibrium shows no tendency to alter over time. A body is said to be in thermal equilibrium with its surroundings if no net heat exchange is taking place within it or between it and its surroundings.

■ equilibrium constant

the equilibrium constant of a chemical reaction is the product of the molar concentrations of the products divided by the product of the molar concentrations of the reactants at a specific temperature.

■ equivalence point

the equivalence point in a titration is the point at which reaction is complete, as shown by the colour change of the indicator or by any other means.

■ **equivalent electrons**

electron in an atom which have the same principal and orbital quantum numbers, but not necessarily the same magnetic orbital and magnetic spin quantum numbers.

■ **equivalent weight**

the equivalent weight of an element or compound is the mass that combines with or displaces one gram of hydrogen (or eight grams of oxygen or 35.5 grams of chlorine) in a chemical reaction. The equivalent weight represents the combining power of the substance. For an element it is the relative atomic mass divided by the valency. For a compound it depends on the reaction considered.

■ **erbium**

symbol Er, a soft silvery metallic element belonging to the lanthanides; a. n. 68; r.a.m. 167.26; r.d. 9.066 (20°C); m.p. 1529°C; b.p. 2868°C. It occurs in apalite, gadolinite, and xenotine from certain sources. There are six natural isotopes, which are stable, and twelve artificial isotopes are known. It has been used in alloys for nuclear technology as it is a neutron absorber; it is being investigated for other potential uses.

■ **eriochrome black T indicator**

eriochrome Black T is the indicator used in titrations.

■ **essential amino acid**

refers to an amino acid that an organism is unable to synthesize in sufficient quantities. It must therefore be present in the diet. In man, the essential amino acids are arginine, histidine, lysine, threonine, methionine, isoleucine, leucine, valine, phenylanine, and tryptophan.

■ **esters**

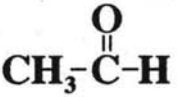
esters, RCOOR', are organic compounds of carbon, hydrogen and oxygen, that are the products formed by the condensation reaction between organic acids and alcohols. The ester functional group, -C=O.O-, is contained within the molecule.

■ **ethanal**

ethanal, $CH_3.CHO$, is the second member of the aldehyde series of compounds.

Aldehydes

Nomenclature:



ethanal
(acetaldehyde)

■ **ethane**

ethane, CH_3CH_3, is the second member of the alkane series of hydrocarbons.

■ **ethanolamines**

ethanolamines form soaps with higher fatty acids, which are excellent emulsifying agents and are used extensively in the manufacture of shaving creams and lotions, insecticide sprays, furniture polishes, and dry-cleaning preparation.

■ **ethylene oxide**

2-epoxyethane, oxirane $CH_2.CH_2O$. Colourless gas with a sweet odour which is somewhat lachrymatory; b.p. 10.5°C. Manufactured by heating ethylene chlorophydrin with $Ca(OH)_2$ or NaOH solution; or by the direct oxidation of ethene at 250-300°C using a silver catalyst. It forms an explosive mixture with air. Reacts with water in the presence of sulphuric acid to give ethylene glycol and polyethylene glycols; with alcohols and phenols to give ethers of glycol; and with hydrochloric acid to give ethylene chlorophydrin. It reacts with many primary and secondary amines to give ethanolamines; with organic acids to give monoesters of ethylene glycol, and with acid anhydrides to give diesters. It is reduced by hydrogen to ethanol, and is converted to ethanal by heating at 200-300°C in the presence of alumina. Its principal use is for Polymerisation to 1, 2-epoxide polymers. It is also used as an intermediate in the manufacture of ethylene glycol, polyethylene glycols, glycol ethers, ethano-lamines and similar compounds.

■ **eucalyptus oil**

oil distilled from the leaves of different species of Eucalyptus. It is used as an antiseptic and as a prophylactic for cold and influenza.

■ **europium oxide**

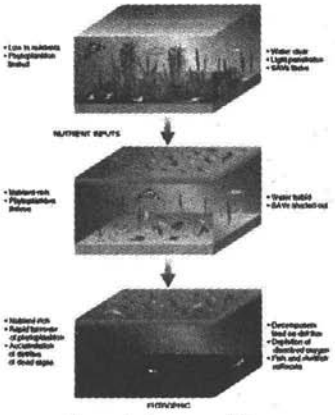
Eu_2O_3, a white powder, insoluble in water; used in red- and infrared-sensitive phosphorus.

■ **eutectic mixture**

a solid solution having two or more substances and having the lowest freezing point of any possible mixture of these components. The minimum freezing point for a set of components is termed as the eutectic point.

■ **eutrophication**

eutrophication is the enrichment of bodies of water by nutrients which lead to the enhanced growth of algae. High levels of algae in natural waters give rise to undesirable consequence, including increased turbidity due to the suspended solids, reduced levels of dissolved



oxygen by night, and increased synthesis of toxic compounds associated with algae. Further, the organic compounds synthesised by algae give rise to chloroorganics when these waters are extracted and disinfected with chlorine for use as drinking water.

■ **evaporation**

evaporation is the change of state of a liquid into a vapour at a temperature below the boiling point of the liquid. Evaporation occurs at the surface of a liquid, some of those molecules with the highest kinetic energies escaping into the gas phase. The result is a fall in the average kinetic energy of the molecules of the liquid and con-

sequently a fall in its temperature.

■ **even-even nucleus**

a nucleus having an even number of neutrons and an even number of protons.

■ **excitation**

refers to the process of producing an excited state of an atom, molecule, etc.

■ **excitation energy**

refers to the energy which is required to change an atom, molecule, etc. from one quantum state to a state with a higher energy. The excitation energy (sometimes called excitation potential) refers to the difference between two energy levels of the system.

■ **excitation**

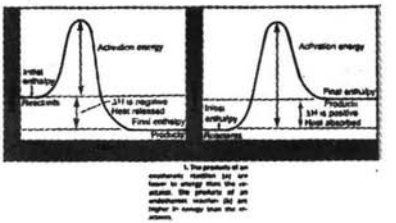
excitation is a process in which a nucleus, electrons, atom, ion, or molecule acquires energy that raises it to a higher quantum state (i.e. excited state) than that of its ground state. The difference between the energy in the ground state and that in the excited state is called the excitation energy.

■ **exclusion principle**

the principle, enunciated by Pauli in 1925, that no two electrons in an atom could have an identical set of four quantum numbers.

■ **exothermic reactions**

exothermic reactions are chemical reaction in which heat is evolved.



■ **experiment**

an experiment is a procedure used to check the validity of an assumption or hypothesis, or to measure some characteristic of a substance.

■ **explosion**

a chemical reaction or change of state which is effected in an exceedingly short space of time with the generation of a high temperature and generally a large quantity of gas.

■ **explosives**

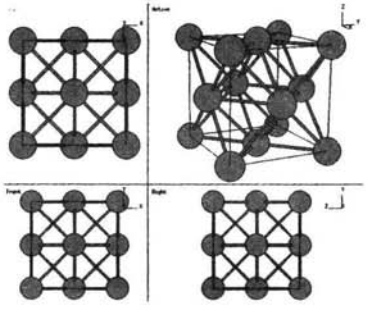
modern explosives are organic compounds of carbon, hydrogen, nitrogen and oxygen, whose the molecules contain sufficient oxygen to convert the carbon and hydrogen in the molecule to carbon dioxide and water and to liberate the nitrogen as a gas. The decomposition of explosives is extremely rapid and highly exothermic.

■ **extinction coefficient**

the reciprocal of the thickness of an absorber necessary to reduce the light intensity to 9/10 of its initial value.

■ **face-centred cubic crystal**

(f.c.c.), a crystal structure in which the unit cell has atoms, ions, or molecules at each corner and each face centre of a cube (also called cubic close-packed). It has a coordination number of 12. The structure is close-packed and made up of layers of atoms in which each atom is surrounded by six others arranged hexagonally. Copper and Aluminium have face-centred cubic structures.



■ **factors affecting the rates of chemical reactions**

the factors affecting the rates of chemical reactions include temperature, concentration of reactants, the presence of catalysts, etc..

■ **Fahrenheit scale of temperature**

the Fahrenheit scale of temperature, named after G.D. Fahrenheit (1686-1736) who invented it, has the temperature of boiling water as 212 degrees and the temperature of melting ice as 32 degrees. The Fahrenheit scale is no longer in scientific use.

To convert from the Fahrenheit scale to the Celsius scale the formula is

$$\text{deg C} = 5\,(\text{deg F} - 32)\,/\,9.$$

■ **Fajan's method**

the titration of Cl^- with Ag^+ using fluorescein as an adsorption indicator. At the end point, the colour of the precipitate is red.

■ **Fajan's rules**

the polarisation of anion takes place when two oppositely charged ions approach each other. The polarisation of anion is favoured by large size of the ions, small cation and large anion, nature of the solvent and nature of the cation.

■ **fall out**

1. radioactive particles deposited from the atmosphere either from a nuclear explosion or from a nuclear accident. Local fall-out, within 250 km of an explosion, falls within a few hours of the explosion. Tropospheric fall-out consists of fine particles deposited all round the earth in the approximate latitude of the explosion within about one week. Stratospheric fall-out may fall any where on earth over a period of years. The most dangerous radioactive isotopes in fall-out are the fission fragments iodine-131 and strontium-90. Both can be taken up by grazing animals and passed on to human populations in milk, milk products, and meat. Iodine 131 accumulates in the thyroid gland and stronium-90 accumulates in bones.

2. chemical fall-out. Hazardous chemicals discharged into and subsequently released from the atmosphere, especially by factory chimneys.

■ **family**

a group of elements whose chemical properties, such as valence, solubility of salts, and behaviour toward reagents, are similar.

■ **Faraday's constant**

the Faraday Constant, F, is the electric charge carried by one mole of electrons or singly ionised ions (i.e. the product of Avogadro constant and the charge on an electron or ion, disregarding sign).

It has the value 9.648670×10^4 coulombs per mole.

This number of coulombs is sometimes treated as a unit of

electric charge called the Faraday.

■ **Faraday's laws of electrolysis**

faraday's Laws of Electrolysis govern the electrolysis of aqueous solutions and state
Faraday's First Laws of Electrolysis
The mass of a substance liberated at each electrode is directly proportional to the quantity of electricity which passes (i.e. to the current strength and to the time), and
Faraday's Second Laws of Electrolysis
The masses of the elements liberated by the same quantity of electricity are directly proportional to their chemical equivalents.

■ **fast chemical reaction**

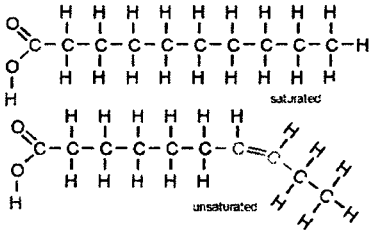
refers to a reaction with a half-life of millisecond or less; such reactions proceed so rapidly that special experimental techniques are required to observe their rate.

■ **fat**

a mixture of lipids, chiefly triglycerides, that is solid at normal body temperatures. Fats occur widely in plants and animals as a means of storing food energy, having twice the calorific value of carbohydrates. In mammals, fat is deposited in a layer beneath the skin (subcutaneous fat) and deep within the body as a specialised adipose tissue. Fats derived from plants and fish generally have a greater proportion of unsaturated fatty acids than those from mammals. Their melting points thus tend to be lower, causing a softer consistency at room temperatures. Highly unsaturated fats are liquid at room temperatures and are therefore more properly called oils.

■ **fatty acids**

fatty acids, RCOOH, are a homologous series of organic acids, where R is an alkyl radical. The higher members of this series of acids occur in nature in the combined form of esters of glycerol, and hence all of this family are called fatty acids.



■ **feedstock**

the Feedstock for the manufacture of petroleum products and petrochemicals is crude oil extracted from known reserves.

■ **feldspars**

a group of aluminosilicates with framework structures with Al or Si in tetrahedral co-ordination. The most common constituents of igneous rocks. Subdivided into two groups depending on the detailed structural types. Used in the ceramic and enamelling industries.

■ **fermentation of carbohydrates**

the fermentation of carbohydrates is a form of anaerobic respiration occurring in certain microorganism (e.g. yeasts), comprises a series of biochemical reactions by which sugars (i.e. saccharides), including glucose and sucrose, are converted to ethanol and carbon dioxide.

■ **fermi**

a unit of length equal to 10^{-15} metre. It was formerly used in atomic and nuclear physics.

■ **fermi level**

refers to the energy level in a solid at which the probability of finding an electron is 1/2. The Fermi level in conductors is situated in the conduction band, in insulators it is situated in the valence band, and in semiconductors it falls in the gap between the conduction band and the valence band.

■ **fermium**

symbol Fm, a radioactive metallic transuranic element belonging to the actinoids; a.n. 100; mass number of the most stable isotope 257 (half-life 10 days). Ten isotopes are known. The element was first identified by A. Ghiorso and associates in debris from the first hydrogen-bomb explosion in 1952.

■ **ferrate**

a multiple iron oxide with another oxide, for example, Na_2FeO_4.

■ **ferric**

the term for a compound of trivalent iron, for example, ferric bromide, $FeBr_3$.

■ **ferric compound**

ferric compound are compounds of iron in its +3 oxidation state. Examples include iron (III) chloride, $FeCl_3$, which was previously called ferric chloride.

■ **ferromolybdenum**

alloy of Fe and Mo (60-65%) used to introduce Mo into alloy steels and special cast irons. Obtained by reducing MoS_2 with Fe and C in an electric furnace.

■ **ferrosilicon**

iron silicide, FeSi, obtained by reducing a silicon-containing iron-ore in an electric furnace; used in the manufacture of steels and to reduce the amount of iron carbide in cast iron.

■ **ferrous ammonium sulphate**

$Fe(SO_4).(NH)_2SO_4.6H_2O$, light-green, water-soluble crystals; used in medicine, analytical chemistry, and metallurgy. Also known as iron ammonium sulphate; Mohr's salt.

■ **ferrous arsenate**

$Fe_3(AsO_4)_3.6H_2O$, water-insoluble, toxic green amorphous powder, soluble in acids; used in medicine and as an insecticide. Also known as iron arsenate.

■ **ferrous carbonate**

$FeCO_3$, green rhombohedral crystals that are soluble in carbonated water and decompose when heated; used in medicine.

■ **ferrous chloride**

$FeCl_2.4H_2O$, green, monoclinic crystals, soluble in water; used as a mordant in dyeing, for sewage treatment, in metallurgy, and in pharmaceutical preparations. Also known as iron chloride; iron dichloride.

■ **ferrous compounds**

ferrous compounds are compounds of iron in its +2 oxida-

tion state. Examples include iron (II) chloride, FeCl2, which was previously called ferrous chloride.

■ **ferrous hydroxide**

$Fe(OH)_2$, a white, water-insoluble, gelatinous solid that turns reddish-brown as it oxidises to ferric hydroxide.

■ **ferrous oxide**

FeO, a black powder, soluble in water, melting at 1419°C. Also known as black iron oxide; iron monoxide.

■ **ferrous sulphate**

$FeSO_4.7H_2O$, blue-green, water-soluble, monoclinic crystals; used as a mordant in dyeing wool, in the manufacture of ink, and as a disinfectant. Also known as ferricsulphates; green copper as; green vitriol; iron sulphate.

■ **ferrous sulphate**

ferrous sulphate, $Fe(II)SO_4$, is the salt formed when iron is dissolved in sulphuric acid.

■ **ferrous sulphide**

FeS, black crystals, insoluble in water, soluble in acids, melting point 1195°C; used to generate hydrogen sulphide in ceramics manufacture. Also known as iron sulphide.

■ **fertilisers**

although any substance which increases production when added to the soil could be called a fertiliser, usually in practice by fertilisers are meant compounds containing N, P or K. Ammonium sulphate is the most important nitrogenous fertiliser; sodium nitrate, ammonium nitrate, ammonia and urea are also used. A mixture of ammonium nitrate and calcium carbonate is sold under the name of Nitro-chalk. The most important fertilisers containing phosphorus are the superphosphates which are mineral tricalcium phosphates rendered more soluble by treatment with sulphuric acid and ammonium phosphate. Many mixed fertilisers are now sold, containing various proportions of nitrogen, phosphorus and potassium.

■ **filter**

a filter is a device for separating solids from liquids or an

insoluble substance from a soluble one.

The simplest laboratory filter for liquids is a fluted glass funnel in which a cone of special paper, known as filter paper, is placed. The liquid to be filtered is passed through the paper filter, whereupon the insoluble solids are retained on the filter. Grouch crucibles, which are special containers with a porous base of sintered glass, are also used as filters.

■ **filter pump**

a filter pump is a simple laboratory vacuum pump in which air is removed from a system by a jet of water forced through a narrow nozzle. The lowest pressure possible is the vapour pressure or water.

■ **filtration**

filtration is a method of separating a solid from a liquid or an insoluble substance from a soluble one. The mixture is poured through a filter; the liquid that goes through the filter and is called the filtrate, and the solid that remains on the filter is called the residue.

■ **first law of thermodynamics**

the First Law of Thermodynamics states that in a system of constant mass, energy can neither be created nor destroyed, but may be converted from one form to another.

■ **flocculation**

flocculation is a process of aggregating into larger clumps. Finely divided precipitates, where the particles are small enough to pass through the pores in a filter, need to undergo flocculation to form larger particles before filtration.

■ **fluorescence**

fluorescence is emission of light from compounds which have been illuminated, due to the return of the compound from an excited state to the ground state.

■ **fluorides**

fluorides are the salts of hydrofluoric acid.

■ **fluorination**

fluorination is a chemical reaction in which a fluorine atom is introduced into a molecule.

■ fluorocarbons

fluorocarbons are compounds obtained by replacing some or all the hydrogen atoms of hydrocarbons with fluorine atoms. Their high stability to temperature makes them suitable for a variety of uses, including aerosol propellants, oils, polymers, etc..
They are often known as freons. Their use in aerosols is one cause of the depletion of zone layer.

■ fluorspar

fluorite or fluorspar (i.e. calcium fluoride, CaF_2) is a mineral that occurs in Derbyshire, crystallised in cubes or octahedral or in compact masses like marble. It is also called Derbyshire spar, or Blue Jhon, when the crystals are coloured blue or purple. The colourless transparent crystals show a bluish tinge when light falls on them, and this property is called fluorescence.
Fluorspar was described by Agricola in 1530AD, as fluor (from the Latin fluo, I flow), since it melts at a red heat, approximately 1330 degC.

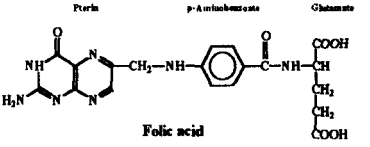
Fluorspar is used chiefly as a flux material in the smelting of iron and steel. It is also used as a source of fluorine and hydrofluoric acid and in the manufacture of ceramics and in the optical-glass industry.

■ foam

foam is a dispersion of bubbles of gas in a liquid.

■ folic acid

folic acid is a member of the vitamin B group of vitamins.



■ formula

a formula is a way of representing a chemical compound using symbols for the atoms present. Subscripts are used to denote the numbers of each type of atom.

■ fossil fuels

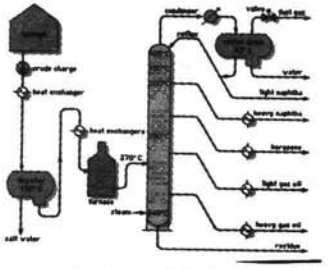
the fossil fuels (i.e. coal, oil, natural gas, etc.) derive from the decay of vegetable matter and are used by man as a source of energy.

■ fractional crystallisation

fractional crystallisation is a method of separating a mixture of soluble solids by dissolving them in a suitable hot solvent and then lowering the temperature slowly. The least soluble component will crystallise out first, leaving the other components in solution. By controlling the temperature, it is sometimes possible to remove each component in turn.

■ fractional distillation

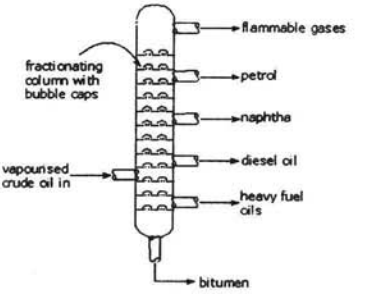
fractional distillation is similar to distillation, but uses an additional piece of apparatus called a fractionating column. A fractionating column contains glass



rings or balls which provide a large surface area for condensation and re-evaporation. The vapour of the liquid with the lowest boiling point reaches the top of the column first. Fractional distillation is used to separate liquids with close boiling points.

■ fractionating column

a fractionating column is added before the condenser in fractional distillation and contains glass rings or balls which provide a large surface area for condensation and re-evaporation.



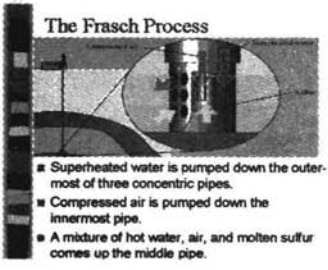
■ Francois Auguste-Victor Grignard

a French chemist, Francois Auguste-Victor Grignard (1871-1935) discovered in 1900 a series of organic compounds now known as the Grignard Reagents. These reagents have found applications as some of the most versatile reagents in organic chemistry. Members of this class contain a hydrocarbon radical, magne-

sium, and a halogen such as chlorine.
He received the Nobel Prize for chemistry in 1912.

■ **Frasch process**

the Frasch Process is a method of obtaining sulphur from underground deposits using a tube consisting of three concentric



pipes. Superheated steam is passed down the outer pipe to melt the sulphur, which is then forced up through the intermediate pipe by compressed air from the inner tube. The steam in the outer casing keeps the sulphur molten in the pipe.

■ **free radical**

a free radical is an atom, or group of atoms, which normally exist only in combination with other atoms, but which may exist independently for short periods during the course of a chemical reaction or for longer periods under special conditions.
Examples of free radical formation include the case where a chlorine molecule is dissociated by a photon of light into two chlorine radicals (i.e. unpaired chlorine atoms), which are highly reactive

Cl_2 (light) ==> 2 Cl*

These radicals are then available to initiate and propagate other chemical reactions.

■ **free radical chain reaction**

the free radical chain reaction is the mechanism of many self-sustaining chemical reactions. Chain reactions are exothermic (i.e. they release large amounts of heat), but they may require a high temperature, or other special conditions, to start them. In the case of combustion, the initial heat is required for the bond breaking which is required to produce the free radicals, and initiate the chain reaction. However, when this initiation has been achieved, the chain reaction can proceed with the release of energy in suffi-

cient quantity to continue to propagate the reaction.

■ freeze drying

freeze drying is the process used in dehydrating food, blood plasma and other heat sensitive substances. The product is deep frozen and the ice trapped in it removed by reducing the pressure and causing it to sublime. The water vapour is then removed, leaving an undamaged dry product.

■ freezing

freezing is the process by which a liquid changes from liquid to solid. It is the opposite of melting.

■ freezing point

the freezing point of a substance is the temperature at which it changes state from a liquid to a solid. The melting point and the freezing point are identical.

■ Friedel-Crafts reaction

the Friedel-Crafts Reaction, named after the French chemist Charles Friedel (1832-99) and the US chemist James M Craft (1839-1917), consists essentially in the elimination of a molecule of halogen hydracid, usually hydrogen chloride or hydrogen bromide from the complex formed between the molecule of an aromatic compound and another halo-compound which may or may not be aromatic in character. This reaction is effected with the aid of anhydrous aluminum chloride as a catalyst.

The mechanism is an electrophilic substitution. The hydrogen atom which is eliminated must come from the nucleus of an aromatic body, and the halogen atom may be provided either by an aliphatic halogen compound or by an aromatic compound in which the halogen atom is present in a side chain (i.e. not in the nucleus).

For example, when benzene is heated with methyl chloride or bromide in the presence of the catalyst anhydrous aluminum chloride, toluene, $CH_3.C_6H_5$ (i.e. methyl benzene) is obtained. The catalyst acts as an electron acceptor for a lone pair on the chlorine atom. This polarises the haloalkane or acyl group.

It is worth noting that the Friedel-Crafts reaction has no parallel in aliphatic chemistry.

■ **Fritz Haber**

a German chemist, Fritz Haber (1868-1934) was the inventor of the Haber Process. He was awarded the Nobel Prize in Chemistry in 1918AD for this work which led to the Synthesis of Ammonia from hydrogen, and nitrogen.

His study of the combustion of hydrocarbons led to the combustion of hydrocarbon led to the commercial Cracking or Fractional distillation of natural oil (petroleum) into its components.

In Electrochemistry, he was the first to demonstrate that oxidation and reduction take place at the electrodes, from this he developed a general electrochemical theory.

■ **fuel cells**

fuel cells are electrochemical cells in which the chemical energy of a fuel is converted directly into electrical energy.

■ **fuel oil**

fuel oil is a higher boiling fraction from the distillation of crude oil.

■ **functional group**

a functional group is an atom or a group of atoms that defines the characteristic properties of a particular family of compounds. Organic compounds are classified into a number of distinct homologous series of compounds, according to the functional groups which they contain.

For example, any compound containing the carboxyl functional group, -COOH, belongs to the carboxylic acid homologous series and acidic properties are always associated with the carboxylic acids due to the presence of an ionisable hydrogen atom..

■ **fundamental particles**

the fundamental particles are the subatomic particles in the atomic particles, from which the atoms of all elements are made. The protons and neutrons exists in the nucleus, which is the central core of the

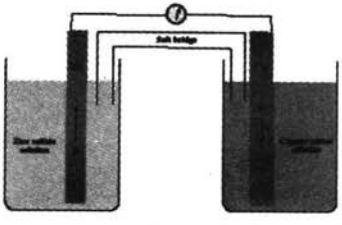
atom, and the electrons travels in the orbitals about the nucleus of the atom. These atomic particles (i.e. protons, and neutrons) are themselves composed of the sub-atomic particles (i.e. the Quarks and Leptons), which are also called the fundamental particles.

■ **furan**

furan, C_4H_4O, is a colourless liquid.
It has a five membered ring consisting of four methylene groups, CH_2, groups and one oxygen atom.

■ **galvanic cells**

galvanic cells are electrochemical cells in which the chemical energy of the constituents of the cell are converted into electrical energy. Electrochemical cells



are the assembly of electrodes and solutions of electrolytes that result in the production of electric energy. When the electrochemical cell is used as a source of electrical energy, (i.e. if it converts the free energy of a physical or chemical change into electrical free energy), it is called a Galvanic Cell.

■ **gamma-ray**

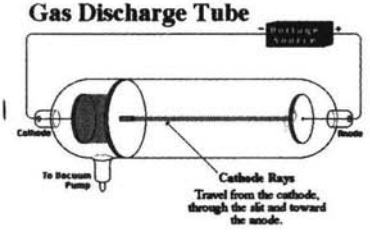
a gamma-Ray is a photon of electromagnetic radiation emitted from the excited (i.e. high energy state) nucleus, so that the latter goes to a more stable lower energy state.

■ **gas**

a gas is one of the states in which matter can exist. A gas has neither a fixed volume, or a definite shape.

■ **gas discharge tubes**

gas discharge tubes were used about 1750AD by William Watson in England, who showed that the flow of charge



through a gas in sealed container increases as the pressure is lowered. As the pressure in the container is reduced below that of the atmosphere, conductivity increases until, at a pressure of about 0.001 atmosphere, gases become fairly good conductors.

Two things can be observed about electric conduction in a gas at low pressure.

A considerable potential difference (i.e. voltage) must be applied to the gas before any current can be detected. The exact value of the minimum voltage depends on the gas used and on the design of the apparatus.

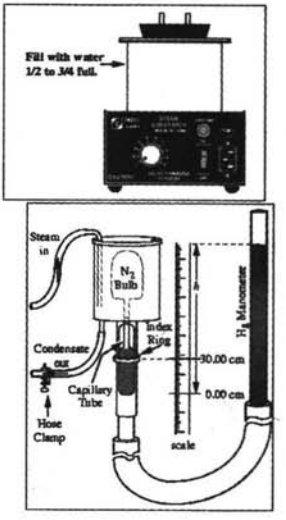
As charge flows through the gas, the gas glows with a colour which depends on the gas used. This process is often called gas discharge, and the apparatus used is called a gas discharge tube.

■ gas mixtures

gas mixtures result from the property that all gases expand to fill the volume into which they are introduced (i.e. they do not have a fixed shape). Provided that the individual gases introduced into a given volume do not react with each other, that volume becomes a homogeneous mixture of the gases. The physical properties of a mixture of gases, which do not react with each other, are described by Dalton's Law of Partial Pressures and by Graham's Law.

■ gas thermometer

a gas thermometer is a device for measuring temperature in which the working fluid is a gas.



■ gasahol

gasahol is the mixture of petroleum spirits with ethanol derived from the fermentation of

agricultural products (e.g. grains, molasses, etc.). Gasahol is used extensively in Brazil to reduce the quantity of oils imported into the country. It is also used to increase the oxygen content of the fuels, to reduce polluting exhausts. The use of alcohol from renewable sources is considered to be environmentally friendly.

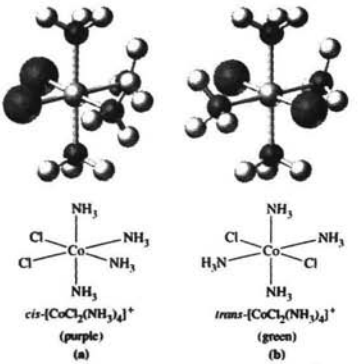
■ Gay-lussac's law

Gay-Lussac's 's Law states that when gases combine in chemical reactions to give gaseous products, the ratio of the volumes of the reacting gases to that of the product is a simple integral one.

■ geometric isomerism

geometric isomerism is an important consequence of lack of free rotation about the carbon to carbon axis in the case of double bonds, which is prevented by the pi bond (i.e. the second bond of the double bond). The geometry of the molecule is determined by the nature of the s bonds (sigma bonds) between the two carbon atoms and the four attached groups (i.e. sp2 hybrid bonds). Thus, the two carbons linked by the double bond and the first atom of each of the four groups attached to these atoms are planar.

Thus, different compounds which contain the same number of each constituent atoms but differing only in the way that these atoms are arranged in space can exist. Such compounds are called steroisomers and those which owe their existence to hindered rotation about a carbon to carbon double bond in open-chain compounds are known as geometric isomers. There is hindered rotation about every carbon to carbon double bond, but geometric isomers are possible only if a certain order exists among the



atom or groups of atoms attached to that bond. If either carbon carries two identical atom or groups of atoms, geometric isomerism cannot exist.

Geometric isomers are possible only if a certain order exists among the atom or groups of atoms attached to that bond. If either carbon carries two identical atom or groups of atoms, geometric isomerism cannot exist.

■ Gerhard Domagk

a German pathologist Gerhard Domagk (1895-1964), the antibacterial sulphonamide drugs. He found in 1932 that coal-tar dye called Prontosil red contains chemicals with powerful antibacterial properties. Sulphanamide drugs, used before antibiotics were discovered to treat a wide range of conditions, including pneumonia and septic wounds. Domagk was awarded the 1939 Nobel Prize for Physiology and medicine (because of the war had to wait until 1947 to claim his prize).

■ Germain Henri Hess

a Swiss chemist and doctor, Germain Henri Hess (1892-1850), was born in Geneva and was brought to Russia in 1805AD. He is remembered for his work in Thermochemistry and his Law of Heat of Summation.

■ Gooch crucible

a Gooch crucible is a porcelain dish with a perforated base over which a layer of asbestos is placed, used for filtration in gravimetric analysis.

■ Graham's law of gaseous diffusion

Graham's Law of Gaseous Diffusion states that the diffusion rate of a gas is inversely pro-

portional to the square root of its density.
The principal described in this law is used in the diffusion method of separating isotopes.

■ **gravimetric analysis**

gravimetric analysis is the quantitative analysis of materials that depends on weighing. For example, the amount of silver in a solution of silver salts could be measured by adding excess hydrochloric acid to precipitate silver chloride, filtering the precipitate, washing, drying and weighing.

■ **greenhouse effect**

the greenhouse effect is the increase in the temperature of the earth's atmosphere caused by the presence of certain gases. Carbon dioxide plays an important role in warming the earth by trapping the sun's heat. For millions of years the carbon cycle maintained a balance between the process that add and those that take away carbon from the air.
In modern times, people have upset this balance by burning vast amounts of fossil fuels, and so releasing excess carbon dioxide into the atmosphere. A lot of tropical rainforest has been destroyed, which in turn has reduced the amount of carbon dioxide used up by green plants during photosynthesis. This has resulted in an increase in the concentration of carbon dioxide in the atmosphere.
As the concentration of carbon dioxide in the air increases, more heat energy is trapped, and less is radiated out of the atmosphere. Thus, the average temperature of the earth's surface gradually increases.

■ **Grignard reagents**

the Grignard Reagents, named after their French discoverer, are very reactive compounds and are used in the synthesis of hydrocarbons, alcohols, carboxylic acids and aldehydes. For example, when a solution of a suitable alkyl halide in dry diethyl ether is added to magnesium turnings heat is evolved and the magnesium gradually dissolves in the boiling ether. The resulting solution is the Grignard Reagent, which con-

tains a highly reactive polar covalent carbon to magnesium bond.

■ **group I elements**

the elements in this group have one electron in their outer electronic shell. Thus, each element in this group has a tendency to lose a single electron, to form a singly charged positive ion, which has the stable electronic configuration of its neighbouring Nobel Gas element in the periodic table.
The elements in the group are chemically reactive.
The group is divided into two sub-groups.
Sub-Group I A : The Alkali Metals
Lithium, Sodium, Potassium, Rubidium, Caesium, Francium
Sub-Group I B : Transition Metal Elements
Copper, Silver, Gold
Hydrogen is included in this group because it has a single electron in its outer electronic shell. However, hydrogen has none of the metallic properties of the alkali metals.

■ **group II elements**

the elements in this group have two electrons in their outer electronic shell. Thus, each element in this group has a tendency to lose two electron, to form a doubly charged positive ion, which has the stable electronic configuration of its neighbouring Nobel Gas element in the periodic table.
The elements in the group are chemically reactive.
Sub-Group II A : The Alkaline Earth Metals
Beryllium, Magnesium, Calcium, Strontium, Barium, Radium
Sub-Group IIB : Transition Metal Elements
Zinc, Cadmium, Mercury

■ **group III elements**

the elements in this group have three electrons in their outermost electronic shell. The electronic configurations of the n th orbitals (i.e. outer-most orbitals) are ns^2 np1. Thus, each element in this group has a tendency to lose three electron, to form a triply charged positive ion, which has the stable electronic configuration of its near-

est neighbouring Nobel Gas element in the periodic table.
The elements in the group are chemically reactive.
Sub-Group IIIa : Transition Metal Elements
Scandium, Yttrium, Lanthanum , The following elements also have the same electronic configuration as lanthanum (i.e. $4s^2$ 4p1) in their outer-most electronic orbitals, while the inner 3d orbitals are being filled, from going from element to element.
Cerium, Praeseodymium, Neodymium, Promethium, Samarium, Europium, Gadolinium, Terbium, Dysprosium, Holmium, Erbium, Thulium, Ytterbium, Lutecium, These are the transition elements, and are also called the Lanthanides.
Actinium
The following elements also have the same electronic configuration as actinium (i.e. $5s^2$ 5p1) in their outer-most electronic orbitals, while the inner 4d orbitals are being filled, on going from element to element.
Neptunium, Plutonium, Americium, Curium, Berkelium
These are the inner transition elements, and are also called the Actinides.
Sub-Group IIIb : Main Group Elements
Boron, Aluminium, Gallium, Indium, Thallium

■ group IV elements

the elements in this group have four electrons in their outer electronic shell. Thus, each element in this group has a tendency to share these four electrons, to form covalent compounds, thereby gaining the stable electronic configuration of its neighbouring Nobel Gas element in the periodic table.
The elements in the group are chemically reactive.
Sub-Group IVA : Transition Metal Elements
Titanium, Zirconium, Hafnium, Thorium ,
Sub-Group IV sB : Main Group Elements
Carbon, Silicon, Germanium, Tin, Lead

■ group number

the group number is the number assigned to the vertical columns of the structured list of

all known elements in the periodic table. Elements within the same group have the same number of electrons in their outer electron shells. Thus, all elements in the same group have similar chemical properties.

■ **group V elements**

the elements in this group have five electrons in their outer electronic shell. Thus, each element in this group has a tendency to gain three two electron, to form a triple charged negative ion, which has the stable electronic configuration of its nearest neighbouring Nobel Gas element in the periodic table.

The elements in the group are chemically reactive.

Sub-Group VA : Transition Metal Elements

Vanadium, Niobium, Tantalum, Protactinium

Sub-Group V B : Main Growp Elements

Nitrogen, Phosphorus, Arsenic, Antimony, Bismuth

■ **group VI elements**

the elements in this group have six electrons in their outer electronic shell. Thus, each element in this group has a tendency to gain two electron, to form a doubly charged negative ion, which has the stable electronic configuration of its nearest neighbouring Nobel Gas element in the periodic table.

The elements in the group are chemically reactive.

Sub-Group VI A : Transition Metal Elements

Chromium, Molybdenum, Tungsten, Uranium ,

Sub-Group VI B : Main Group Elements

Oxygen, Sulphur, Selenium, Tellurium, Polonium

■ **group VII elements**

the elements in this group have seven electrons in their outer electronic shell. Thus, each element in this group has a tendency to lose an electron, to form a singly charged negative ion, which has the stable electronic configuration of its nearest neighbouring Nobel Gas element in the periodic table.

The elements in the group are chemically reactive.

Sub-Group VIIa : Transition Metal Elements
Manganese, Technetium, Rhenium
Sub-Group VIIb : Main Group Elements
Fluorine, Chlorine, Bromine, Iodine, Astatine

■ **group VIII elements**

this group contains three triads of elements, in the centre of the periodictable. Iron, Cobalt, Nickel, Ruthenium, Rhodium, Palladium, Osmium, Iridium, Platinum, These elements have the typical properties of metals, metallic luster, tensile strength, and rightly.

■ **groups in the periodic table**

the elements are arranged in the sequence of their increasing atomic numbers into the periodic table, which is arranged in rows and columns, so that elements with similar chemical properties are in the same vertical column.
The elements which are in the same columns are said to be in the same group, and they have similar chemical properties.

■ **gun metal**

a type of bronze usually having 88-90% copper, 8—10% tin, and 2—4% zinc. Formerly used for cannons, it is still used for bearings and other parts that require high resistance to wear and corrosion.

■ **gunpowder**

a powdered mixture of sulphur, charcoal, and potassium nitrate, used as an explosive.

■ **Gurney-Mott theory**

a theory of the photographic process that proposes a two-stage mechanism; in the first stage, a light quantum is absorbed at a point within the silver halide gelatin, releasing a mobile electron and a positive hole; these mobile defects diffuse to trapping sites within the volume or on the surface of the grain; in the second stage, trapped electron is neutralised by an interstitial silver ion, which combines with the electron to form a silver atom; the silver atom is capable of trapping a second electron, after which the process repeats itself, causing the silver speck to grow.

■ **Gutzeits test**

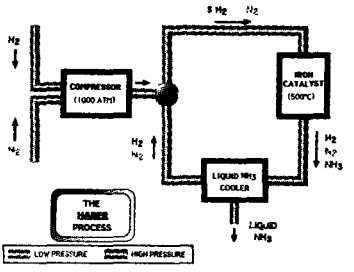
the test is used to detect arsenic in samples. The sample is heated to release arsenic, which reduces silver nitrate to yellow deposit Ag_3 As. $AgNO_3$, which rapidly changes to silver.

■ **gypsum**

mineral $CaSO_4$, $2H_2O$. Used in the production of plaster of paris, to control the rate of setting of Portland cement and as a filler. It occurs in five varieties: rock gypsum, which is often red stained and granular; gypsite, an impure earthy form occurring as a surface deposit: alabaster, a pure fine-grained translucent form; stain spar, which is fibrous and silky; and selenite, which occurs as transparent crystals in muds and clays. It is used in the building industry and in the manufacture of cement, rubber, paper, and plaster of Paris.

■ **Haber process**

the Haber Process is the industrial method for the production of ammonia by reacting nitrogen with hydrogen.



$N_2 + 3H_2 ==> 2NH_3$

The process is reversible and exothermic. The process operates at high temperatures because at low temperature the rate of reaction would be too slow for equilibrium to be reached in a reasonable time. Thus, high temperature, 450 degC, and high pressure, 250 atmospheres, is used to increase the yield. An iron catalyst is used. The process was invented by the German chemist, Fritz Haber in 1909AD.

However, Carl Bosch developed it for industrial use, leading to the alternative name Haber-Bosch Process.

■ **half cell**

a half-cell is an electrode in contact with a solution of ions, and it forms one half of a cell. Gas half cells have a gold or plati-

num plate in a solution with gas bubbled over the metal plate. The hydrogen half-cell is used as a reference half cell and is assigned the electrode potential of zero. Common half cells include the zinc and copper half cells.

■ halides

halides are compounds which contain one of the halogen elements in chemical combination with another element. The halides of typical metals are ionic. Metals form halides in which the chemical bonding is largely covalent. The halide salts are the fluorides, chlorides, bromides or iodides.

■ halogens

the halogens (from the Greek hals, salt) are the non-metallic elements in group VII of the periodic table (i.e. fluorine, chlorine, bromine, iodine and astatine). They are highly reactive and are not found in the elemental state in nature. The halogens are used as oxidising agents in many chemical reactions. The electronic configuration of the halogens has one electron short of the stable configuration of its neighbouring Nobel Gases in the periodic table. The halogen atoms can acquire a Nobel Gas structure in either of two ways.

by accepting an electron from a donor atom to form an ionic bond. Example of this behaviour includes sodium chloride, potassium bromide and sodium iodide, or

by forming a covalent bond by either

overlap of p orbitals of the atoms. Example of this behaviour includes chlorine and bromine, or

by overlap of a p of the halogen and the s orbital of another atom. Example of this behaviour includes hydrogen chloride and hydrogen bromide.

Thus, the halogens exhibit an electrovalence and a covalence of 1. Positive oxidation states of III, V, VII are also known for all the halogens, with the exception of fluorine.

The melting points and boiling points of the halogens increase with atomic number.

The electron affinity is at a maximum in chlorine. The halogens are oxidising agents, (i.e. they readily gain electrons to form negatively charged ions).

Fluorine has the highest electrode potential and is therefore the strongest oxidising agent. The high electrode potentials illustrate high activity in solution. Fluorine with its high electronegativity, is the most reactive non-metal in the Periodic Table.

■ **hard water**

water which does not form leather with soap due, to the presence of Ca, Mg and Fe compounds. Removal of these compounds renders the water soft.

■ **hardness of water**

the hardness of water results from dissolved salts of calcium and magnesium, which are introduced into the water in the environment when it passes through limestone areas. The nature of the materials dissolved will depend on the geology of the region. However, calcium and magnesium salts are the source of the hardness of water. Total hardness and calcium hardness can be distinguished chemically.

The hardness may be classified as temporary hardness which is removed on boiling, or permanent hardness which is due to dissolved salts.

■ **heat capacity of constant pressure**

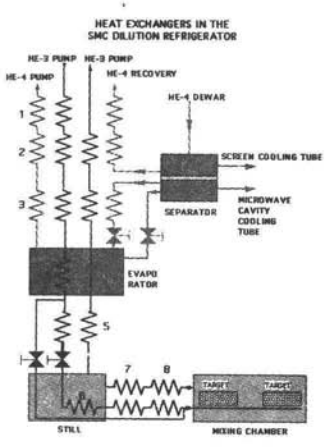
the quantity of heat required to raise the temperature of a gaseous system at constant volume by one degree Kelvin.

■ **heat energy**

all the substances possess heat energy. More the temperature more is the heat energy associated with it. This type of energy is absorbed during endothermic reaction and given our during exothermic reaction.

■ **heat exchangers**

devices that enables the heat from a hot fluid to be transferred to a cool fluid without allowing them to come into contact. The normal arrangement



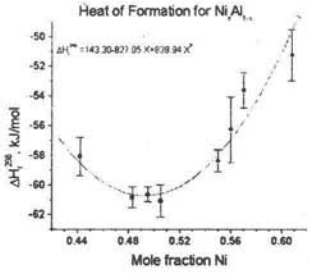
is for one of the fluids to flow in a coiled tube through a jacket containing the second fluid. Both the cooling and heating effect may be of benefit in conserving the energy used in a chemical plant and in controlling the process.

■ heat of combustion

the heat of combustion of a substance is the heat evolved when one gram-molecule of the substance combines with oxygen. When a substance burns in air, combustion is the process of reacting a substance with oxygen. In everyday life, we make use of the combustion of coal or gas in air as a source of heat. Chemical reactions accompanied by an evolution of heat are called exothermic reactions.

■ heat of formation

the heat of formation of a substance is the heat evolved when



one gram-molecule of the substance is produced from its elements.

■ heat of neutralisation

the heat of neutralisation is the quantity of heat liberated when one mole of a strong acid is neutralised by one mole of strong base.

The heat Of neutralisation is independent of the nature of the acid or base. For this reason, it is assumed to be the heat released due to the recombination of the hydrogen ion from the acid and hydroxide ion from the base to form water.

$H^+ + OH^- ==> H_2O$

The heat of neutralisation is the amount of heat evolved when one gram equivalent of an acid is neutralised by one gram equivalent of a base to give one gram equivalent of a neutral salt. Thus, in dilute solution, an acid or base is considered to be completely ionised, and the neutralisarion reaction is

$Na(+) + OH(-) + H(+) + Cl(-) \Longrightarrow Na(+) + Cl(-) + H_2O$

The value of H should always be - 57.26 kJ per mole for neutralisation of any strong acid and strong base.

■ **heat of reaction**

the heat of reaction is a difference between the intrinsic energy in the products of a chemical reaction and the intrinsic energy in the reactants, and it is either adsorbed or released during the course of the chemical reaction.

■ **heat of solution**

the amount of energy change when one mole of a substance is dissolved in a given solvent to infinite-dilution (in practice to form a dilute solution).

■ **heat of vaporisation**

the quantity of heat required to vaporise a unit mass of a given liquid at constant temperature.

■ **heavy hydrogen**

it is deuterium.

■ **heavy water (deuterium oxide)**

water in which hydrogen atoms, ^1H, are replaced by the heavier isotope deuterium, ^2H. It is a colourless liquid, which forms hexagonal crystals on freezing. Its physical properties differ from those of 'normal' water; r.d. 1.105; m.p. 38°C; b p 101.4°C. Deuterium oxide occurs to a small extent (about 0.003% by weight) in natural water, from which it can be separated by fractional distillation or by electrolysis. It is particularly useful in the nuclear industry because of its ability to reduce the energies of fast neutrons to thermal energies and because its quenching cross-section is lower than that of hydrogen and consequently it does not appreciably reduce

the neutron flux. In the laboratory it is used, for labelling other molecules for studies of reaction mechanisms.

■ **Heisenberg uncertainty principle**

the Heisenberg Uncertainty Principle describes the uncertainty with which the velocity and position of an electron in an orbital can be known. Only the wave function for the electron is known with certainty, and the electron density at any point is the square of the wave function at that point. Thus, the probability of finding an electron at any point is proportional to the electron density at that point.

■ **Henry's law**

Henry's Law states that the mass of gas which is dissolved by a given volume of liquid at a fixed temperature, is proportional to the pressure of the gas. In the case of water, the law only applies to those gases which are slightly soluble in it, as the more soluble gases react with water to form ionic species in solution.

■ **heptane**

heptane, C_7H_{26}, is the seventh member of the alkane series of hydrocarbons. It is a liquid which is obtained from petroleum. Its relative density is 0.684, its melting point is -90.6 °C, and its boiling point is 98.4 °C.

■ **Hertz**

Hz, is the unit of frequency, and is the number of cycle per second. It is called after a German physicist, Heinrich Hertz.

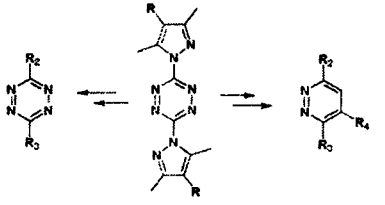
■ **Hess's law of heat summation**

Hess's Law of Heat Summation states that the internal energy of a substance is independent of the process by which it was made. Thus, if a chemical reaction takes place in stages, the algebraic sum of the amount of heat evolved in each separate stage is equal to the total amount of heat that would be evolved if the reaction took place in one stage.

■ **heterocyclic compounds**

heterocyclic compounds are ring compounds in which the

ring contains carbon and other elements, the commonest being oxygen, nitrogen and sulphur.



■ **high density polyethylene**

high density polyethylene, HDPE, is an important plastic which is manufactured industrially by the polymerisation of ethylene.

■ **Hofmann voltmeter**

a Hofmann Voltmeter is an apparatus for the volumetric analysis of gases produced during electrolysis. For example, the hydrogen and oxygen produced during electrolysis can be collected in separate graduated tubes, and volumes produced compared.

■ **homologous series**

a Homologous Series is a family of organic compounds which have
a common general formula,
similar methods of preparation,
similar chemical properties,
a regular trend in physical properties, and
a molecular weight difference of 14 between adjacent members of the series, due to each member of the series containing an extra -CH2- group (i.e. a methylene group).

■ **Hund's rule of maximum multiplicity**

the Hund's Rule of Maximum Multiplicity states that when electrons occupy the orbitals about a nucleus, and two or more orbitals are at the same energy level, each orbital is filled singly, before any is filled doubly.

■ **hybridisation**

when bonds are formed between atoms in the formation of molecules, there is a change in the nature of the Atomic Orbitals in each atom. Effectively, new molecular orbitals are formed, and the electrons in these orbitals are those of the molecule as a whole. The alteration of the structure of the atomic orbitals is called hydridisation, as it involves

combining a number of orbitals to create an equal number of new orbitals, where each of the new hybrid orbitals have properties which are an average of those of the orbitals from which they were created.

A number of different types of hybrid orbitals are known for carbon in the organic compounds.

Hybridisation sp

Hybridisation sp^2

Hybridisation sp^3

The different hybrid orbitals, which have different orientations in space, account for the geometry of the organic compounds of carbon in which they appear.

■ **hybridisation sp**

the simplest alkyne, Ethyne (i.e. Acetylene), has a linear structure, where the two carbon atoms and the two hydrogens atoms that are attached to these carbon atom lie along a straight line. The carbon to carbon and carbon to hydrogen bonds are arranged as far apart in space as possible. Thus, these bonds are at 1800 to each other. The geometry of this structure cannot be explained using the shape of the Atomic Orbitals on the carbon atom.

The Electronic Configuration of carbon in the ground state (i.e. the lowest energy state) is 1s(2) 2s(2) 2p(2). If energy is supplied to raise one of the 2s electrons to a higher energy level to fill the vacant 2p orbital, the electronic configuration of carbon in the excited state, is 1s(2) 2s(1) 2p(3). More specifically, the electronic configuration of the excited carbon atom is 1s(2) 2s(1) 2px(1) 2py(1) 2pz(1). If we leave two of the 2p sub-orbitals (e.g. the 2py(1) and 2pz(1) sub-orbitals) to form the second and third bonds of the carbon to carbon triple bond, we can rearrange the other two sub-orbitals (i.e. 2s(1) and 2px(1)) to form two equivalent hybrid orbitals. When these new orbitals are arranged as far apart in space as possible, the new orbitals are arranged in a plane and are 180 degrees apart.

The particular hybridisation of the orbitals of carbon atoms in ethene, are called sp1 hybrids

orbitals, (i.e. they arises from the hybridising of one sigma orbital and one pi orbitals). The bonds between the hydrogen atoms and carbons, and the first bond (of the double bond) between the carbon atoms of ethene are formed by the end-on overlap of these sp1 hybrids orbitals to form sigma bonds, and accounts for the 180 degree bond angles observed in this compound. The second and third bonds (of the triple bond) between the carbon atoms in ethyne is formed by the side-on overlap of the original atomic unhybridised orbitals (i.e. the 2py(1) and 2pz(1) orbitals) and these are pi bonds.

■ **hybridisation sp^2**

the simplest alkene, Ethene, has a planar structure, where the two carbon atoms and four hydrogens atoms that are attached to these carbon atom lie in a plane. The carbon to carbon and carbon to hydrogen bonds are arranged as far apart in space as possible. Thus, these bonds are at 120 degrees to each other. The geometry of this structure cannot be explained using the shape of the Atomic Orbitals on the carbon atom.

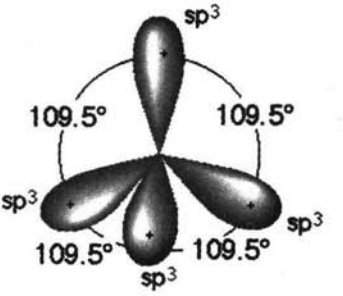
The Electronic Configuration of carbon in the ground state (i.e. the lowest energy state) is 1s(2) 2s(2) 2p(2). If energy is supplied to raise one of the 2s electrons to a higher energy level to fill the vacant 2p orbital, the electronic configuration of carbon in the excited state, is 1s(2) 2s(1) 2p(3). More specifically, the electronic configuration of the excited carbon atom is 1s(2) 2s(1) 2px(1) 2py(1) 2pz(1). If we leave one of the 2p sub-orbitals (e.g. the 2pz(1) sub-orbital) to form the second bond of the carbon to carbon double bond, we can rearrange the other three sub-orbitals (i.e. 2s(1) 2px(1) 2py(1)) to form three equivalent hybrid orbitals. When these new orbitals are arranged as far apart in space as possible, the new orbitals are arranged in a plane and are 120 degrees apart.

The particular hybridisation of the orbitals of carbon atoms in ethene, are called sp2 hybrids orbitals, (i.e. they arises from

the hybridising of one sigma orbital and two pi orbitals). The bonds between the hydrogen atoms and carbons, and the first bond (of the double bond) between the carbon atoms of ethene are formed by the end-on overlap of these sp^2 hybrids orbitals to form s bonds (sigma bonds), and accounts for the 120 bond angles observed in this compound. The second bond (of the double bond) between the carbon atoms in ethene is formed by the side-on overlap of the original atomic unhybridised orbitals (i.e. the 2pz(1) orbital) and this pi bond prevents free rotation in the carbon to carbon axis.

■ hybridisation sp^3

the simplest alkane, Methane, CH_4, has a tetrahedral structure, where the four hydrogens that are attached to the central carbon atom are arranged symmetrically about the carbon atom, and arranged as far apart in space as possible. The geometry of this structure cannot be explained using the shape of the Atomic Orbitals on the carbon atom.



■ ignition temperature

ignition temperature is the temperature to which a substance must be heated before it will burn in air.

■ implosion

implosion is the inward collapse of a vessel, usually when the pressure of the gas in the container is less than atmospheric pressure.

■ indicators

indicators are substances which change colour at the end point of titration's. Indicators are compounds which change colour in different concentrations of the specific analyte for which they are used, so as to give visual indication of the concentration.

For example, a number of compounds have a different colour

in acid solutions than they have in basic solutions. These compounds are used in acid-base titration's as indicators, because they change colour during the course of the titration, to give a visual indication of the end-point of the titration.

■ **industrial nitrogen fixation**

industrial nitrogen fixation is the conversion of atmospheric nitrogen into ammonia which is carried out using the Haber Process.

■ **inert electrodes**

inert electrodes are electrodes which do not undergo chemical change during the course of an electrolysis experiment.

■ **influence of temperature on the rates of chemical reactions**

the influence of temperature on the rates of chemical reactions depends on the Boltzman distribution of energies in the reactant molecules. Thus, the higher the temperature, the greater the fraction of molecules that is present in an excited (i.e. reactive) state.

■ **initiation**

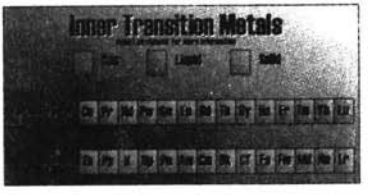
initiation is the first step in a free radical mechanism that creates the initial free radicals necessary to start the sequence of reactions.

■ **inner transition metals**

the Inner Transition Metals are the series of elements from Cerium (Atomic Number 58) to Lutetium (Atomic Number 71), which are called the Lanthanoids, and from Thorium (Atomic Number 90) to Lawrencium (Atomic Number 103), which are called the Actinoids.

The inner transition elements are found between group 2 and the transition elements in the fifth row of the periodic table. The transition elements are also known as the f-block elements. These two series make up the f-block elements in the periodic table, and their chemical properties of the elements derive from the filling of the f atomic sub-orbitals. The electronic configuration of these elements are characterised as having full outer orbitals and full second outermost orbitals, while the

second outermost orbitals are incompletely filled. Thus, in the case of the first inner transition metals series, the electronic configuration of the outermost and second outermost orbitals is $4s^2$ $3d^{10}$, while the third outermost orbitals (i.e. the 4f level) are incompletely filled.



■ **inoraganic ion exchanges**

these are hydrated aluminium silicates $Na_2 Al_2 Si_2 O_8 . xH_2O$. It can be prepared by mixing soda ash (Na_2CO_3), sand (SiO_2)and alumina (Al_2O_3). It is also known as permutit. The portion $Al_2 Si_2 O_8 . xH_2O$ is Zeolte (Z) and inorganic exhanger is represented by Na_2Z.

■ **inorganic**

pertaining to or composed of chemical compounds that do not contain carbon as the principal element i.e., matter other than plant or animal.

■ **inorganic chemistry**

inorganic chemistry is the chemistry of all other substances other than organic compounds, although it is convenient to include in it such common carbon compounds as are frequently encountered e.g. carbon dioxide, carbonates or are essential to placing the element carbon in its correct relationship in the periodic system of classification.

■ **insoluble**

a solid is said to be Insoluble in a liquid if it does not dissolve in the liquid.

■ **instability constant**

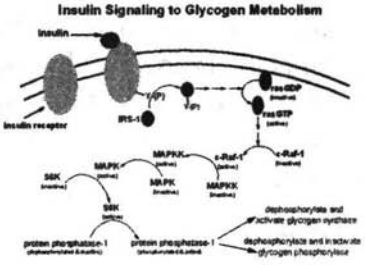
the reverse of a stability constant; the measure of dissociation.

■ **insulator**

a substance with a very low electrical conductivity. In insulators, there is a wide separation between completely filled and completely empty electronic energy levels. Most pure solid ionic substances are insulators although impurities or imperfections may introduce semiconductivity.

■ **insulin**

$(C_6H_{10}O_5)_x$, a fructose polysaccharide of approximately 30 fructofuranose units. It is present in the underground tubers and rhizomes of the Compositae.



■ **interatomic distances**

it is the distance between the nuclei of atoms (bonded or non-bonded) in a molecule or crystal. It can be determined by spectroscopy, electron diffraction method etc.

■ **intercalation compounds**

derivatives, particularly of graphite, in which molecules are accommodated in holes or between layers in the lattice. The resulting compounds are easily handled and stored (*e.g.,* graphite-SbF_5, used as a fluorinating agent; graphite-$FeCl_3$ stable to water.

■ **International Union Of Pure And Applied Chemistry**

the International Union of Pure and Applied Chemistry, IUPAC, is the organisation which regulates the nomenclature of chemical substances. In particular, it prescribes the formal rules for naming organic compounds.

■ **interstitial compound**

a crystalline compound in which atoms of a nonmetal (e.g., carbon hydrogen or boron) occupy interstitial positions in the crystal lattice of a metal.

$N_1V_1 = N_2V_2$

N_1V_1 = unknown normally (titre) and volume of the solution to be titrated.

N_2V_2 = normality and volume of the titrating solution.

In acid-base titrations, close to the equivalence point, there is a rapid change in pH which may be assessed by adding a suitable indicator. The acid-base indicator must change its colour over a range of pH which is as near as possible to that of equivalence point.

$NH_4NO_3(s) ==> N_2O(g) + 2H_2O(g)$

The gas is used as a mild aesthetic in medicine and dentistry, being marketed in small steel cylinders. It is sometimes called laughing gas because it induces a feeling of elation.

Zeolite removes Mg^{2+} and Ca^{2+} ions from hard water by exchanging it with Na^+ ions.

$Na_2Z + CaCl_2 ==> CaZ + 2NaCl$

■ intrinsic energy

the intrinsic energy, U, (i.e. its internal energy) of a substance is the chemical energy of a substance (i.e. the amount of energy stored within the substance).

■ ion

an ion is

an atom, or a group of atom, which has gained one or more electrons to form a negatively charged ion, or

an atom or group of atoms which has lost one or more electrons to form a positively charged ion.

For example,

in sodium chloride, the sodium ion, Na^+, is formed when a sodium atom loses an electron to form a positively charged sodium ion, Na^+,

the chloride ion, Cl^-, is formed when a chlorine atom gains that electron.

■ ion exchange resins

ion exchange resins are the polymers to which ionic groups have been attached. An ionic resin has negative ions built into its structure and therefore exchanges positive ions. A cationic resin has positive ions built in and exchanges negative ions.

■ ionic bond

an ionic bond, (which is also called an electrostatic bond), is the attractive force between oppositely charged ions.

An ionic bond results from the transfer of one or more electrons from the outer shell of one atom to the outer shell of another atom. This type of bond is usually formed between elements whose positions in the periodic table lie just before or just after the Nobel Gases.

■ ionisation potential

the ionisation potential (i.e. the first ionisation potential) is the energy required to remove the outermost electron from a neutral gaseous atom.

The second, and third ionisation potentials, etc. relate to the removal of the second, and third electrons respectively, and are higher than the first ionisation potential, as each successive electron is removed against increasing positive charge. The ionisation potential is usually expressed in electron volts and is determined from spectra.

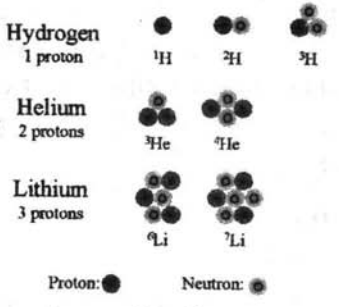
■ isomers

isomers are substances which have the same molecular formula but which have different structural formulae. Isomers are distinct chemical compounds, which have different physical and chemical properties. Structural isomerism are very common in organic chemistry.

■ isotopes

the isotopes of an element are the atom of different atomic mass for that element. All atoms of an element must have the same atomic number (i.e. the same number of protons in its nucleus) However, they may have different atomic mass (i.e. due to numbers of neutrons in the nucleus). The isotopes of an element have different physical properties. However, because they all have the same number of electrons, their chemical properties are identical.

Isotopes are separated by the principal described in Graham's Law which uses diffusion as the method of separation.



By using a simple mass spectrometer, F.W.Aston discovered that all atoms of a particular element do not have the same mass. In the Mass Spectrometer, atoms are given a charge and accelerated in an electric field so that they move at high

speeds. When this beam of charged atoms passes through an electric field and a magnetic field, all particles of the same mass are focused on a line. The particles strike a photographic plate or detector so that their positions are recorded. These atoms of different mass number but having the same atomic number are called Isotopes.

Hydrogen has three isotopes.

The first isotope (called Hydrogen) has a mass number of 1 and has a single proton in the nucleus.

The second isotope (called Deuterium) has a mass number of 2, and has one proton and one neutron in the nucleus.

The third isotope (called Tritium) has a mass number of 3, and has one proton and two neutrons in its nucleus.

Chlorine consists of two isotopes :

The first isotope has a mass number of 35 which has 18 neutrons and

The second isotope has a mass number of 37 which has 20 neutrons in the nucleus.

The observed atomic weight of chlorine is 35.46, which indicates that chlorine is a mixture of these two isotopes, and that the isotope with mass number 35 is the more abundant atom present. Indeed, the isotope of mass number 35 is approximately three times more abundant than the isotope of mass number 37.

■ **John Dalton**

an English teacher and scientist, John Dalton (1766-1844) is the originator of the modern chemical Atomic Theory of the Structure of Matter.

He produced the first list of relative atomic masses in *Absorption of Gasses* 1805.

He discovered the Law of Partial Pressures of Gases (Dalton's Law) in 1801AD, which states that the pressure exerted by a mixture of gases equals the sum of the partial pressures of the components of the mixture.

His Law of Multiple Proportions states that if two elements, A and B, form more than one compound, the various weights of B which combine

with A are in small whole number ratios.

■ **John Daniell**

a British chemist, John Daniell (1790-1845) discovered the Daniell Cell in 1836AD.

■ **Joseph Louis Gay-Lussac**

a French chemist and physicist, Joseph Louis Gay-Lussac (1778-1850), is known for the Gay-Lussac's Law Law, which he stated in 1808AD, which states that when gases combine in chemical reactions to give gaseous products, the ratio of the volumes of the reacting gases to that of the product is a simple integral one. Avagadro's Hypothesis is based on Gay-Lussac's Law and on Dalton's Law of Multiple Proportions.

■ **Josiah Gibbs**

J Willard Gibbs (1839 to 1903) was an American mathematician best-known for the *Gibbs effect* seen when Fourier-analysing a discontinuous function.

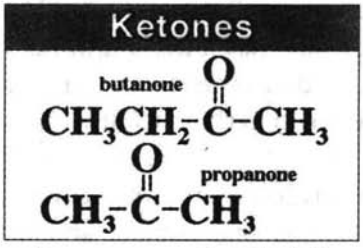
He developed a mathematical approach to thermodynamics. His book. *Vector Analysis* . 1881 established vector methods in physics.

■ **joule**

the joule is the unit of energy in the SI system of units. It is the energy dissipated when a current of one ampere flows through a resistance of one ohm.

■ **ketones**

ketones are organic compounds of carbon, hydrogen and oxygen, where the ketone functional group, >C=O is contained within the molecule. The



are the compounds which form a homologous series which can be represented by the general formula R.CO.R', where R and R' are alkyl groups, and may be the same or different groups. Ketones are formed by the oxidation of secondary alcohols.

$R_2CHOH\ [O] \Longrightarrow R.CO.R' + H_2$

Secondary Alcohol à Ketone

The chemistry of the ketones is governed largely by the presence of the Carbonyl Group, >C=O. The polarity of this group means that the electron-deficient carbon atom of the carbonyl group is susceptible to attack by reagents which are rich in electrons.

The first member of the homologous series of ketones is acetone, $CH_3.CO.CH_3$. Other aliphatic ketones are named by naming the groups attached to the carbonyl group and adding the word ketone. Using systematic nomenclature, the longest chain carrying the carbonyl group, >C=O, is made the parent structure and compounds named by replacing the "e" of the parent alkane by the suffix "-one". The positions of substituents are indicated by numbers, where the carbonyl carbon atom is allocated the lowest possible number.

■ **kinetic energy**

kinetic energy is the energy possessed by a body due to its motion.

■ **knocking**

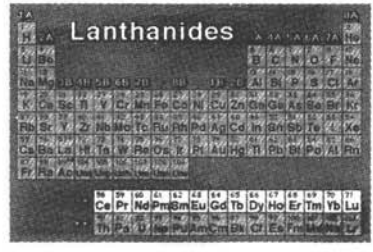
knocking is the premature spontaneous explosion of the petrol mixture during the compression stroke in a petrol engine before the mixture is ignited by a spark. Knocking causes significant loss of power and may result in damage to the engine.

■ **Kohlrausch's law**

Kohlrausch's Law states that the equivalent conductivity of an electrolyte at infinite dilution is equal to the sum of the ionic motilities of the ions produced by the electrolyte.

■ **lanthanides**

the lanthanoids (also called lanthanides, lanthanons or rare earth elements) are the series

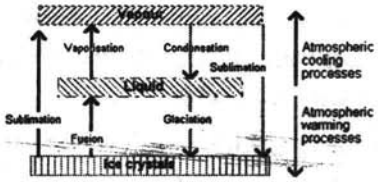


of elements from Cerium, Atomic Number 58, to Lutetium, atomic number 71.

The lanthanoids all have two outer s-electrons (i.e. having a 6s(2) electronic configuration). The lanthanoids and actinoids make up the f-block. The lanthanides are silvery very reactive metals.

■ **latent heat of evaporation of water**

the latent heat of evaporation of water is the amount of heat required to convert 1 gm. of water at 100 degreeC into steam at 1000C.



■ **latent heat of fusion of water**

the latent heat of fusion of water is the amount of heat required to convert 1 gm. of ice at 0 °C into water at the same temperature.

■ **lattice energy**

the lattice energy of an ionic solid is the energy released when the requisite number of moles of each of the component ions is brought together from infinity to form 1 mole of the ionic crystalline solid. This is also the energy required to remove the ions from their equilibrium positions in the crystal to infinity. A negative value for the heat change due to the lattice energy indicates that the process is exothermic (i.e. heat is being released by the system). A positive value for the heat change due to the lattice energy indicates that the process is endothermic (i.e. heat is being absorbed by the system).

■ **law of chemical equilibrium**

the law of chemical equilibrium (also called the law of mass action)

states that the rate at which a substance reacts is proportional to its active mass (i.e. to its molar concentration).

Thus, the velocity of a chemical reaction is proportional to the product of the concentration of the reactants.

■ **law of conservation of energy**

the law of conservation of energy states that in any chemical transformation, energy is conserved (i.e. it is neither created or destroyed). Although that energy cannot be destroyed or created during the course of a chemical reaction, it may be altered from one form of energy to another form.

■ **law of conservation of matter or mass**

the law of conservation of matter or mass states that in any chemical transformation, matter is conserved (i.e. it is neither created or destroyed). This means that although substances change into other substances in a chemical reaction, the actual number of atoms remains the same.

■ **law of constant composition**

the law of constant composition states that a pure compound has a fixed and invariable composition (i.e. the compound always contains the same elements, united together in the same fixed proportions by mass).

■ **law of definite composition**

states a pure compound has a fixed and invariable composition. It was discovered by a French chemist, Joseph Louis Prout (1754-1826).

■ **law of mass action**

the law of mass action states that the rate at which a chemical reaction proceeds is directly proportional to the product of the active masses of the reacting substances. The active mass is defined as the concentration measured in terms of gram-molecular weights per unit volume, usually 1 liter. This law was formulated by Guldberg and Waage in 1864 AD.

■ **law of multiple proportions**

the law of multiple proportions states that if two elements combine in more than one proportion to form more than one compound, then the weights of one of them which combine with a fixed weight of the other bear a simple, whole number ratio to each other. This law was first proposed by John Dalton

in 1803AD. For example, carbon forms two different oxides. In carbon monoxide, 12 grams of carbon is combined with 16 grams of oxygen. However, in carbon dioxide, 12g of carbon combine with 32 grams of oxygen. Thus, the oxygen masses combining with a fixed mass of carbon are in the ratio 16:32 or 1:2.

■ **law of octaves**

the law of octaves states that each eight element had similar chemical properties. The law of octaves was an early attempt to summarise the regularly repeating chemical properties of the elements with increasing atomic number.

■ **alcohols**

alcohols are the homologous series of organic compounds of general formula, ROH, where R is any alkyl group or substituted alkyl group. An alcohol may be a primary alcohol, secondary alcohol, or tertiary alcohol, depending on whether the carbon atom attached to the hydroxyl group, -OH, is combined with an alkyl group attached to one, two or three carbon atoms, respectively.

■ **Le Chatelier principle**

states that a chemical system will respond so as to minimise the applied external forces.

■ **lead compounds as pollutants**

there is anxiety that lead compounds are significant pollutants in the environment. The use of lead compounds as additives to fuels is being phased out.

■ **lepton**

the lepton is a fundamental subatomic particle.

■ **Lewis theory of acids**

Lewis introduced the idea that acids and bases had a reciprocal relationship and he introduced the concept of Lewis conjugate acid-base pairs.

A Lewis acid is an electron pair acceptor.

A Lewis base is an electron pair donor.

Using this definition, ammonia is easily classified as a base.

$NH_3 + H_3O^+ ==> NH_4^+ + H_2O$

Lewis Base+Lewis AcidàLewis Acid+Lewis Base
In particular, water and the hydrated proton, H_3O_+), are a Lewis conjugate acid-base pair. Thus, the hydrated proton is able to donate a proton, (i.e. it is a Lewis Acid) and water is able to receive a proton by donating its lone pair of electrons (i.e. it is a Lewis base).
$H^+ + H_2O ==> H_3O^+$
It should be noted that the hydrogen ion exist in aqueous solution as hydrated proton.

■ **lime**

lime, also called quicklime or calcium oxide, is a white solid compound formed by heating calcium in oxygen or by the thermal decomposition of calcium carbonate.

■ **limestone**

limestone is a rock composed of calcium carbonate.

■ **limiting reagents**

the limiting reagents in a chemical reaction is that reactant which are those that determines the maximum quantity of the product that may be formed.

■ **line spectra**

the line spectra of an element are the specific wavelengths of light which are emitted when the element is excited in an electric arc. The spectra are the discontinuous lines produced by excited atoms and ions as they fall back to a lower energy level.

■ **liquefaction of air**

in this process of the liquefaction of air, air from the atmosphere is drawn through purifiers to remove carbon dioxide and the resulting gas mixture is compressed. The heat of compression is removed by a cooler and the compressed air is passed through a chilled condenser to remove moisture. The dry compressed air is then allowed to expand through a jet and is cooled by adiabatic expansion. This adiabatic process is repeated a number of times, where the temperature drops at each stage. Finally, the air becomes so cold that it liquefies on leaving the jet. The liquid air obtained from the liquefier is richer in oxygen than gaseous air.

■ **liquid**

a liquid is one of the states in which matter can exist. A liquid has a fixed volume, but has no definite shape.

■ **lone pair of electrons**

a lone pair of electrons are the pair of electrons in a single sub-orbital of an atom, which do not involved in a bond to another atom.

■ **magnetic quantum number**

the magnetic quantum number, ml is used to indicate the direction of the sub-orbital in space. The allowed values for the magnetic quantum numbers depends on the subsidiary quantum number of the sub-orbital. For each sub-orbital, l, the magnetic quantum number, ml, must lie in the range ml = + l or ml = - l. Within an orbital, the sub-orbitals designated by the subsidiary quantum number, l , have the same energy level, but have different orientations in space.

■ **main group elements**

the main group elements in the periodic table can be classified as either being metals or non-metals. The vertical columns in the table are called groups. Elements within the same group all have the same number of electrons in their outer shell. Group I Elements are known as alkali metals. Group II Elements are known as the alkaline earth metals and the group of elements between group II and III are known as the Transition Element.

■ **manufacture of ammonia**

the manufacture of ammonia involves the fixation of atmospheric nitrogen, there by making it available for incorporation into a variety of other compounds. The Haber Process is used industrially for this fixation.

■ **manufacture of steel**

the manufacture of steel, which is an alloy of iron and carbon uses the basic-oxygen process, ld process, by blowing oxygen onto molten scrap and pig iron at high pressure. This process

removes impurities from the metal in the form of slag and gases. The gases are burned off at high temperature. Various other materials are then added to the iron in order to make different types of steel. Steels containing over 11 per cent of chromium are known as stainless steel.

■ **Markownikoff rule**

the Markownikoff Rule specifies the orientation with which a small asymmetric molecule adds across the double bond of an alkene in an addition reaction.

The Markownikoff Rule states that in the ionic addition of an acid to the carbon carbon double bond of an alkene, the hydrogen of the acid attaches itself to the carbon atom that already holds the greater number of hydrogens.

For example, when hydrogen bromide adds across the double bond of propene, the hydrogen initially adds to that carbon atom which already has the greater number of hydrogen atoms directly attached to it (i.e. the terminal carbon atom) and then the bromine then attaches to the other carbon of the double bond (i.e. the central carbon atom) to yield 2-bromopropane.

■ **Martin Heinrich Klaproth**

a German chemist, Martin Heinrich Klaproth (1743-1817) is known for his work on chemical analysis. In 1789AD, he discovered Zirconium, Uranium and Titanium in 1795 A.D.

The elements in this group have a full outer electronic shell and thus, the elements in this group have no tendency to lose, gain or share electrons. Thus, the elements in the group are chemically inert.

All the elements in this group are gaseous. Because of their

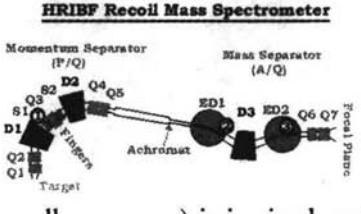
chemical inertness, the elements in this group are called the Nobel Gases :
Helium Neon Argon Krypton Xenon Radon

■ **mass**

mass is the intrinsic characteristic of matter and all matter has mass. Mass is the amount of matter in a substance, and it is measured in grams and kilograms.

■ **mass spectrometer**

the mass spectrometer is an instrument for the separation and analysis of ions and atoms. In the mass spectrometer a sample



(usually gaseous) is ionised and the positive ions produced are accelerated into a high vacuum which is exposed to electric and magnetic fields. Ions of different types can be sorted via a detector into a mass spectrum. The mass spectrum consists of peaks of varying intensity to which mass/charge"values can be assigned, and from which molecular structure can be deduced.
Francis William Aston (1877-1945) invented the Mass Spectrometer.

■ **matter**

matter is defined as anything that occupies space and that has mass.
These three forms are called the States of Matter:
Solid,
Liquid, and
Gas.
Examples of matter are a book, pen, ruler, the sun, the moon, air, water, milk, etc., since each has mass and occupies space.
Radio waves, heat and light are not matter since they have no mass.

■ **maximum-boiling mixtures**

a maximum-boiling mixture is an azeotrope having a boiling point higher than those of its components.

■ **melting**

melting is the process by which a solid changes state from a solid to a liquid.

■ **melting point**

melting point is the temperature at which a substance change state from being solid to being liquid.

■ **metal**

a metal is an element which has the physical properties of having
a lustrous appearance, being malleable, being tenacity, having high densities, and being good conductors of heat and being good conductors of electricity. Metals react with oxygen to form basic oxides. Metals react with halogens to form halogen compounds which are stable in presence of water. Metals are electro-positive elements and form complex salts.

■ **metallic bond**

the atoms in a metal are arranged in an orderly manner. Because metals have low ionisation potential, they can easily lose their outermost electrons, which are then free to travel in a cloud between all the atoms of the metal. The electrostatic attractive force between the positively charged ionised atoms of the metal and the negatively charged electronic cloud is responsible for the bonding in the metal. The metallic bond is very strong and accounts for the mechanical strength of metals.
The metallic bond accounts for the physical and chemical properties of metals. The following structure is proposed for the metallic bond.
Metals consist of positive ions of the metal packed closely. The packing structure varies with the metal.
When forming this arrangement each atom of the metal releases its valancy electrons, which are now free to roam through the intervening spaces between the positive ions. This space of moving electrons is often referred to as the electron gas or electron atmosphere.
The positive ions are not free to move, but they are able to vibrate.
The mutual sharing of this electron atmosphere by all the positive ions of the metal establishes a kind of diffuse bonding,

which is non-directional, and is called the metallic bond.

■ **metallic chlorides**

those metals which are high on the electrochemical series form chlorides which are non-volatile ionic solids and have cubic ionic lattices (e.g. sodium chloride). These ionic crystal lattices, which are composed of metal ions and chloride ions, dissociate in water but the ions themselves are not hydrolysed (they do not react with water).
Many metallic chlorides liberate chlorine when treated with sulphuric acid and manganese dioxide.
Many metallic chlorides liberate hydrogen chloride gas when warmed with concentrated sulphuric acid.

■ **methane**

methane, CH_4, is the simplest hydrocarbon and first member of the alkane series. The methane molecule has a tetrahedral shape, and there are single covalent bonds between the carbon atom to each hydrogen atom in the molecule.

■ **Michael Faraday**

an English chemist and physicist, Michael Faraday (1791-1867), in 1821 began experimenting with electromagnetism, and ten years later discovered the induction of electric currents and made the first dynamo. He subsequently found that magnetic field will rotate the plane of polarisation of light. Faraday also investigated Electrolysis.

■ **migration**

migration is the movement of ions through the solution towards the electrodes during electrolysis.

■ **minimum boiling mixture**

a minimum boiling mixture is an azeotrope have a boiling point lower than those of its components.
For example, 95% alcohol, boils at a lower temperature than either pure ethanol or water.

■ **miscible**

when two liquids mix readily to form a solution, they are said to be miscible.

■ **mixture**

a mixture is composed of two or more constituent substances which are not bound together by a chemical bond. Mixtures can occur in each of the states of matter.

For example, air is a mixture of gases, consisting of approximately 78% nitrogen, 20% oxygen, and smaller quantities of carbon dioxide, argon and water vapour. The composition of the atmosphere is changing gradually over time, due to the burning of fossil fuels and emissions from industry.

Mixtures can be found everywhere, as well as air. Mixtures can be found in practically all foods, the soil in the ground, oil and petrol and many other everyday substances.

Alloys are a very important kind of mixture in modern life. Alloys are made by mixing two or more molten metals uniformly together, and allowing the metal in metal solution to solidify on cooling.

■ **molal concentration (molarity)**

molal concentration is the amount of substance dissolved per unit volume and has units of mol per dm cubed or mol per liter cubed. It has the symbol c.

■ **molar mass**

molar Mass is the amount of substance per unit mass of solvent and has units of mol per kg. It has the symbol m.

■ **molar solution**

a molar solution, M, is one which contains one gram molecular weight (i.e. one mole) of the solute in a liter of solution.

For example, 0.5M HCl means a hydrochloric acid solution containing 0.5 moles of hydrochloric acid per liter of solution.

■ **mole**

a mole is the amount of substance which contains as many molecules as are present in 12 grams of Carbon 12. One mole of a compound is its molecular weight in grams.

■ **molecular formula**

every compound has a molecular formula, which shows the elements that are present in the compound and the number of

atoms of each element in the compound.

■ molecular weight

molecular weight, M_r, (also called relative molecular mass) is the ratio of the average mass per molecule of naturally occurring form of an element or compound to one twelfth (i.e. 1 / 12) of the mass of a Carbon-12 atom. The molecular weight is equal to the sum of the relative atomic masses of all the atoms that comprise the molecule.

■ molecule

a molecule is the smallest particle of a substance (i.e. of a chemical compound) which can maintain an independent existence and consists two or more atoms bonded together. In general, atoms do not exist individually, but occur in groups called molecules. For example, a molecule of hydrogen consists of two hydrogen atoms bonded together. A molecule of oxygen consists of two oxygen atoms bonded together. Similarly, a molecule of nitrogen consists of two nitrogen atoms bonded together. A molecule that consists of two atoms is known as a Diatomic Molecule.

A molecule of helium consists of a single atom of helium, as it has a valency of zero.

A molecule of sulphuric acid consists of two atoms of hydrogen, one atom of sulphur and four atoms of oxygen. Chemists give each type of molecule a chemical formula, showing what atoms are contained in the molecule and in what proportions.

■ monobasic acids

monobasic Acids are acids that contain one ionisable hydrogen atom in each molecule.

■ monohydric alcohol

a monohydric alcohol contain one hydroxyl group in the molecule. The general formula of saturated aliphatic alcohols is $C_nH_{2n+1}OH$, where n=1,2,3, etc.

■ monomer

monomers are the low molecular weight materials from which high molecular weight polymers are formed in a polymerisation process.

■ **mortar**

mortar is a hydraulic cement, the best known of which is known as Portland Cement.

■ **multiple bonds**

multiple bonds are formed between atoms in a molecule where more than one pair of electrons are shared between the atoms. Examples of molecules containing multiple bonds include, the alkenes, the alkynes, and the arenes.

■ **naphtha**

naphtha is a hydrocarbon, which is used as a fuel.

■ **natural abundance of an isotope**

the natural abundance of an Isotopes is the ratio of the number of atoms of a particular isotope of an element to the total number of atoms of all the isotopes present. It is often expressed as a percentage.

■ **natural gas**

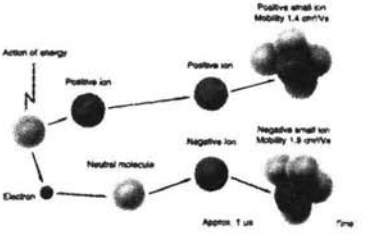
natural gas is a naturally occurring mixture of gaseous hydrocarbons. The approximate composition of natural gas is 85% methane, 10% ethane, 3% propane, with lesser amounts of butane, and other higher alkanes. Natural gas is used as a fuel and for the manufacture of chemicals.

■ **nature of reactants**

the nature of reactants determine the course of a chemical reaction.

■ **negative ions**

negative ions are atoms or groups of atoms that have acquired one or more electrons.



■ **neutral oxides**

neutral oxides are those oxides, which show neither basic nor acidic properties when they react with water. Examples include carbon monoxide and nitrous oxide which are only slightly soluble in water and nitric oxide which is appreciably soluble in cold water.

■ **neutron**

the neutron is a sub-atomic particle, which resides in the nucleus, which is the central core of the atom, and it has unit atomic mass and no charge.

■ **nitrates**

nitrates are the salts of nitric acid, and are strong oxidising agents.

■ **nitrogen cycle**

the nitrogen cycle involves the fixation of atmospheric nitrogen and the transport of thg ammonia and nitrates so formed to the soil as nutrients for the growth of plants.

■ **nitro-glycerine**

nitro-glycerine is an oil which crystallises on cooling. The liquid is highly explosive, and detonates violently when subjected to slight shock.

■ **nobel gas**

the noble gas elements, whose atoms have full outer orbitals tend to be stable, inert and not chemically active, are found in Group 0 Elements of the periodic table. The elements in this group are Helium Neon Argon Krypton Xenon Radon .Helium is an inert gas, because it has two electrons in its outer orbital. Only two electrons may reside in an s-orbital of helium and therefore the outer orbital is full.

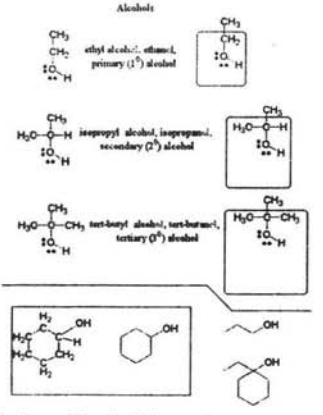
The noble gases are characterised by their stable electronic configurations. The small atomic radii and high ionisation potential values suggest the presence of strongly bound electrons. There are no molecules and the inert gases are all monatomic. Low values for the boiling points indicate the presence of weak Van der Waal's Forces. Melting points and boiling points increase with atomic size.

They were called the inert gases, because it was thought that they would not react with other elements. Helium and Neon are not known to combine with other elements. However, compounds of the higher members of the noble gas group have been found, this is due to the presence of d orbitals (e.g. xenon tetrafluoride and krypton difluoride).

Helium is used along with oxygen by divers. Neon is used in neon sign electrical discharge tubes. Argon, krypton and xenon, are used in incandescent lamps. Radon a radioactive noble gas is used in the treatment of malignant growths.

■ nomenclature of alcohols

alcohols are named by three different naming systems. The International Union of Pure



and Applied Chemistry system is analogous to the ones used for alkanes and alkenes.

Systematic names for alcohols in the series are derived by applying the following rules : Select the longest continuous carbon chain carrying the hydroxyl group as the parent structure. Consider a particular alcohol to be derived from this structure by replacement of one or more hydrogen atoms by different atoms or groups of atoms. Indicate the position of the hydroxyl group in the parent structure by the lowest possible number. Indicate the position of any substituents in the parent structure by a number. Replace the terminal "e" of the appropriate alkane by the suffix "-ol". Most of the simpler alcohols are known by their common names. These names consist of the name of the alkyl group, followed by the word alcohol. For example :

CH_3CH_2OH (Ethyl Alcohol)

CH_3CHCH_3OH (Isopropyl Alcohol)

It should be noted that similar names do not always mean the same classification. For example, isopropyl alcohol is a secondary alcohol, whereas isobutyl alcohol is a primary alcohol. Compounds which are too complicated for common names may be given derived names. According to this system, alcohols are considered to

be derived from methyl alcohol, CH_3OH by the replacement of one or more hydrogen atoms by other groups. The group attached to the carbon bearing the OH is named and then add the suffix carbinol to include the COH portion.

■ **nomenclature of alkanes**

the nomenclature rules for alkanes requires that the names of all alkanes end in "-ane". The nomenclature system agreed by International Union of Pure and Applied Chemistry, is now widely used for naming these and other classes of organic compounds and is likely to be adopted universally in due course. This system enables us to describe structures of the alkanes systematically by observing certain rules.

The longest continuous chain of saturated carbon is selected as the parent hydrocarbon and name compounds as variants of this hydrocarbon by replacing hydrogen atoms by alkyl groups.

$CH_3CHCHCHCH_3$ H_3C
CH_3

2, 3 -dimethyl pentane

The compound is therefore called a pentane, and since there are two methyl substituents on the linear chain, it is a dimethylpentane.

Give each carbon atom a number so that the lowest possible numbers are used. In numbering the carbon atoms always start at that end of the chain which will result in the lowest numbers for the side chain groups. Thus, the above compound is therefore called 2, 3 -dimethyl pentane, and not 3, 4 -dimethylpentane.

Use the prefix di, tri, tetra, etc. to indicate that a substituent occurs more than once in the side chain of a compound.

When there are two identical substituents at the same carbon atom, numbers are supplied for each,

CH_3
$H_3CCCH_2CH_3$
CH_3

2-2-dimethylbutane.

3-ethyl-4-methylhexane

Derivatives of the alkanes such as RBr and RNO_2, where R is an alkyl group, are named as

haloalkanes and nitroalkanes, respectively

$CH_3CH_2CH_2CHCH_3$
Cl

2-chloropentane

$CH_3H_2CH_2CH_2NO_2$ (1-nitrobutane)

Alkanes with halogen and alkyl substituents are named as haloalkylalkanes (not alkylhaloalkanes).

CH_3
$CH_3H_2CHCHCH_3$
Br

3-bromo-2-methylpentane

The longest chain in the above example consists of five carbon atoms.

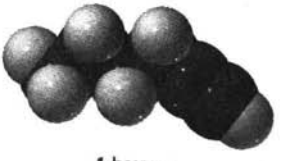
■ **nomenclature of alkenes**

but-1-ene, but-2-ene the nomenclature rules for alkenes requires that the names of all alkanes end in "-ene". The nomenclature system agreed by the International Union of Pure and Applied Chemistry, for the naming of the alkenes can be summarised as follows:

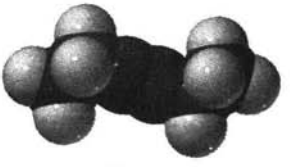
Select the longest continuous chain containing the carbon to carbon double bond as the parent hydrocarbon and name the compound as a derivative of this structure when hydrogen atoms have been replaced by alkyl groups. The names of alkenes all end in "-ene", (e.g. ethene, propene, butene, pentene, etc.).

■ **nomenclature of alkynes**

the nomenclature rules for alkynes requires that the names of all alkanes end in "-yne". The nomenclature system agreed by the International Union of Pure and Applied Chemistry (IUPAC) for the naming of the alkynes can be summarised as follows:



1-hexyne
a terminal alkyne



3-hexyne
an internal alkyne

Select the longest continuous chain containing the carbon to carbon double bond as the parent hydrocarbon and name the compound as a derivative of this structure when hydrogen atoms

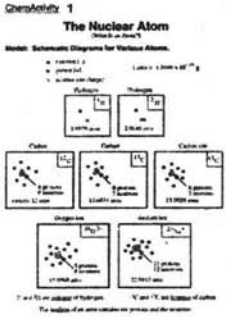
have been replaced by alkyl groups. The names of alkenes all end in "-yne", (e.g. ethyne, propyne, butyne, pentyne, etc.). Give the position of the first carbon atom attached to a C C triple bond the lowest possible number.

■ non-metal

non-metal are the elements which has the physical properties of having a dull appearance, having low densities, and are poor conductors of heat and electricity. In general. non-metals react with oxygen to form acidic oxides.

■ nuclear atom

the nuclear atom was proposed by Rutherford to explain the scattering of alpha particles by gold foil, and the theory now forms the basis of our understanding of the chemical properties of the elements.



■ nucleon

nucleons are the constituents of the nucleus in an atom, and include neutrons and protons.

■ nucleophile

nucleophiles are atoms, or radicals, which are attracted to electron deficient sites in a molecule.

■ nucleophilic aromatic substitution

nucleophilic aromatic substitution occurs when an atom or group which is attached to an aromatic ring is replaced by another atom or group. Benzene, C6H6, is the simplest aromatic compound and is often presented as a six-member ring with alternating single and double bonds. However, these bonds exist as resonance hybrids, leading to significant stabilisation of the ring structure. Because of this stability of the aromatic ring, arenes tend to undergo substitution reactions to preserve the aromatic character of the ring, and the attacking nucleophile displaces a hydrogen atom from the ring. Therefore, the double bonds in

an aromatic systems do not undergo the type of addition reactions observed for the Alkenes Alkynes.

■ **nucleus**

the nucleus is the central core of an atom, in which the neutrons and protons reside. The nucleus contains most of the mass of an atom.

■ **octane number**

the octane number of a fuel is an experimentally determined value for the fuel, which describes its combustion properties (i.e. knocking characteristics) relative to octane.

■ **octet rule**

the octet rule states that the chemical properties of the elements repeat on a regular basis with increasing atomic mass, and that the chemical properties of each eight element is similar. Since the inert gases, with the exception of helium have eight electrons in their outer shells, this stable electronic configuration is called the octet rule. In chemical reactions atoms of elements tend to react in such a way as to achieve the electronic configuration of the inert gas nearest them in the periodic table. There are a number of exceptions to the octet rule. The noble gases are known to be very inert chemically. In chemical reactions, the atoms of elements tend to react in such a way as to achieve the electronic configuration of the inert gas nearest them in the periodic table. Since all the inert gases, except helium, have eight electrons in the outer level, this concept is often referred to as the Octet Rule, to which there are exceptions. This rule is a guide to understanding bonding. In order to become stable, atoms with incomplete outer shells will attempt to join chemically with another atom, and to share the electrons of that atom in its own outer shell, so as to fill it. This is called chemical bonding.

■ **oil pollution**

oil pollution is the degradation of the quality of the water, when crude oil, lubricants, fuel oil, etc. contaminate the aquatic environment.

■ order of filling the atomic orbitals

the sequence in which the atomic orbitals in an atom are filled is as follows :

1s 2s 2p 3s 3p 4s 3d 4p 5s 4d 5p 6s 4f 5d 6p 7s 5f 6d 7p

■ organic chemistry

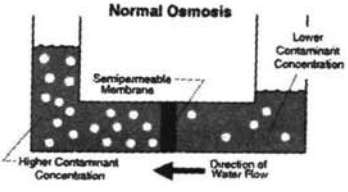
organic chemistry is the study of the chemistry of carbon compounds.

Organic compounds form the chemical basis for life and are more abundant than inorganic compounds. Carbon compounds are made up of carbon atoms which form covalent bonds with each of its neighbouring carbon atoms in either a chain or a ring and also form bonds with other atoms mainly hydrogen, oxygen, nitrogen or sulphur.

Compounds containing only carbon and hydrogen are known as Hydrocarbons.

■ osmosis

osmosis is the passage of a solvent through a semipermeable membrane which acts as a barrier to the passage of the solute dissolved in the solution. The passage of water through the walls of living cells, which consist of very thin membranes that act as a barrier to substances dissolved in the water, is an essential process in living cells and is an example of osmosis. In general, the molecules of the solute are too large to pass through such semi-permeable membranes.



■ osmotic pressure

the osmotic pressure of a solution is the pressure which must be applied to the solution to stop osmosis. Osmotic pressure is similar to gas pressure and is caused by the dissolved substances (i.e. the solutes) behaving as if they were gases occupying the space volume of the solvent. Under osmosis, a solvent always diffuses from the less concentrated solution to the more concentrated solution.

■ Oswald process

the Oswald Process is the three stage process by which nitric acid is manufactured. Firstly, ammonia is oxidised, at high temperature (900 °C.) over a platinum-rhodium catalyst, to form nitrogen monoxide.

$4\,NH_3\,(g) + 5O_2\,(g) \Longrightarrow 4\,NO\,(g) + 6H_2O$

The nitrogen monoxide cools and reacts with oxygen to produce nitrogen dioxide.

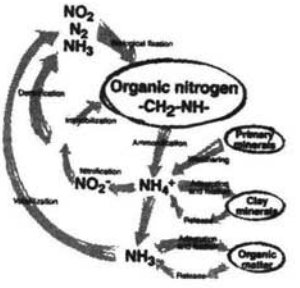
$2\,NO\,(g) + O_2 \Longrightarrow 2\,NO_2\,(g)$

Finally, the nitrogen dioxide reacts with water and oxygen to produce nitric acid.

$NO_2\,(g) + 2\,H_2O\,(l) + O_2 \Longrightarrow 4\,HNO_3\,(l)$

■ oxidation

oxidation is the process in which there is a loss of electrons from an atom or ion. This definition applies only to reactions in which electron transfer occurs. Originally, oxidation was simply regarded as a chemical reaction with oxygen.



■ oxidation number

the oxidation number describes the oxidation state of an atom or ion, and is the positive or negative charge which each atom in a molecule would possess if the bonds were purely ionic. The oxidation number is the same as the valency of an element. The oxidation number of an element in its neutral state, such as fluorine gas or solid copper, is zero. The sum of the oxidation states of all the atoms in a compound will be equal to zero. When balancing redox equations an increase in oxidation number means oxidation; decrease in oxidation number means reduction.

■ oxidising agent

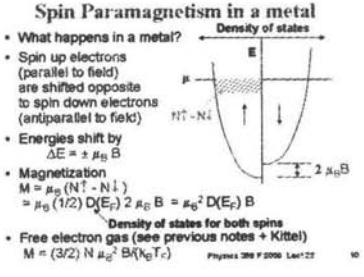
an oxidising agent is a substance which oxidises another substance.

■ ozone

ozone, O_3, is the triatomic isomer of oxygen, O_2, and it is a powerful oxidising agent. The presence of ozone in the stratosphere is responsible for the absorption of ultra-violet wavelengths from the sunlight.

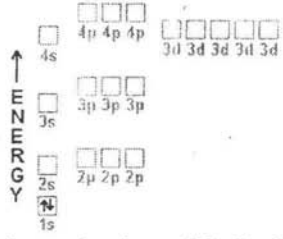
■ paramagnetism

paramagnetism in the transition elements is caused by the presence of unpaired electrons in the d sub-orbital, and results in these elements being attracted by a magnetic field.



■ Pauli's exclusion principle

the Pauli's exclusion principle specifies that no two electrons



which are in the orbitals about a nucleus of an atom may have identical Quantum Numbers.

■ periodic law

states that there are regularly repeating properties on going from element to element with increasing atomic number of the elements. These properties are best summarised in the modern version of the periodic table. The first attempt at defining a periodic law was the octet rule.

■ periodic table

the periodic table is the structured arrangement of the elements in a chart that accentuates the relationships between the chemical properties of the different elements. The structure of the modern version of

the periodic table is explained by the electronic configuration of the elements.

■ **permanent hardness**

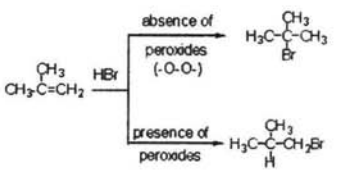
permanent hardness in water is caused by high levels of calcium salts (e.g. calcium carbonate) and magnesium salts (e.g. magnesium carbonate) being dissolved in the water.

■ **peroxide effect**

the peroxide effect results in the formation of a different product from that predicted by the Markownikoff Rule when an addition reaction takes place in the presence of a peroxide. Peroxides give rise to free radicals, and a free radical mechanism for a chain reaction is believed to be responsible for the products observed.

HBr - the peroxide effect

1933, Kharasch and Mayo



In the presence of a peroxides (which give rise to free radicals), the Anti-Markownikoff Rule specifies the orientation with which a small asymmetric molecule adds across the double bond of an alkene, because under these conditions the reactants add across a double bond in the opposite orientation to that specifies in the Markownikoff's Rule.

■ **peroxides**

peroxides, R-O-O-R, are organic molecules which contain the peroxide linkage, -O-O-, within the molecule. Peroxides readily give rise to free radicals, because the oxygen to oxygen bond is easily broken in these organic molecules.

R-O-O-R ==> 2 R-O*

Peroxide Peroxide Free Radical

The most important organic peroxide is benzoyl peroxide, $(C_6H_5COO)_2$, which is the initiator used in the polymerisation of many industrially important pol{mers (e.g. fillers, etc) and adhesives (e.g. superglue, etc.).

Peroxide are also the group of inorganic compounds that contain the peroxide ion, O_2^{2-}.

■ **perspex**

perspex is a trade name for plastics made from polymethylmethacrylate.

■ **petrochemicals**

petrochemicals are the industrially important organic chemicals which are derived from petroleum or natural gas.

■ **petrol**

petrol (i.e. Gasoline) is a complex mixture of hydrocarbons containing 5 to 10 carbon atoms in each molecule.

■ **pH**

the pH of an aqueous solution is the reciprocal of the logarithm of the concentration of hydrogen ions in the solution (i.e. the negative of the logarithm of the hydrogen ion concentration).

$pH = -\log_{10}[H^+]$

A neutral solution has a pH of 7.0. A pH less than 7.0 indicates an acid solution, while a pH above 7.0 indicates an alkaline solution. The scale was introduced by S.P. Sorensen.

■ **physical change**

a physical change is a change of state of a substance, where only the physical properties of the substance are changes and the chemical composition of the substance is unaltered.

■ **physical properties**

the physical properties of a substance are those permanent properties which describe the physical characteristics of the material.

■ **pi bonds**

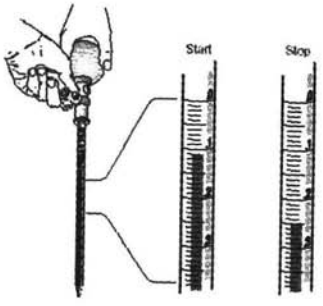
pi Bonds between atoms are formed by the side-on overlap of the atomic orbitals on the different atoms.

■ **pig iron**

pig iron is the impure form of iron produced in a blast furnace, which is then cast into pigs (i.e. blocks) for converting at a later date into cast iron, steel, etc.

■ **pipette**

a pipette is a graduated glass volumetric apparatus used to deliver a stated quantity of liquid in volumetric analysis by titration.



■ **Planck's constant**

Planck's constant, h, is the proportionality constant defining the relationship between the energy, E, associated with a photon and the frequency, u, of that photon.

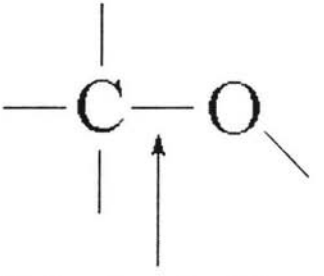
$E = h X u$

In 1900 AD, Plank made the assumption that the energy of light, and of radiation in general, may be absorbed and emitted in only in quanta (i.e. discrete packets of energy).

$h = 6.6X10^{-27}$ erg seconds

■ **polar covalent bond**

when the atoms that are linked by a covalent bond have significantly different electronegativities, the electron is likely to spend a greater time near theatom of higher negativity, giving to an unequal distribution of charge between the atoms.



Polar Covalent Bond

Thus, a dipole (i.e. a separation of charge along the length of the bond) is formed and the resulting bond is a polar covalent bond between the atoms. In general, the polar bond is stronger than the covalent bond from which it derives. Polar compounds (i.e. compounds containing polar bonds) tend to have hydrogen bonding between different molecules, and to have higher boiling points and higher melting points than would be the case in the absence of such hydrogen bonding.

■ **polar molecule**

a polar molecule is one that has a dipole moment (i.e. one in which there is some separation of charge in the chemi-

cal bonds), so that one end of the molecule has a positive charge and the other a negative charge.

■ **pollution**

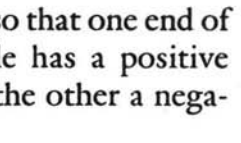
pollution is an undesirable change in the physical, chemical, or biological characteristics of the natural environment, brought about by man's activities. There are two main classes of pollutants

those that are biodegradable and which can be rendered harmless by natural processes and need therefore cause no permanent harm if adequately dispersed or treated; and

those that are non-biodegradable, which eventually accumulate in the environment and may be concentrated in food chains. Pollution can occur in the air or in water.

■ **polyhydric alcohol**

polyhydric alcohols contain several hydroxyl groups in the molecule and are normally obtained by the reduction of sugars. For example, sorbital is obtained by the reduction of glucose.



■ **polymer**

polymers are the long chain molecules obtained when a large number of small molecules combine together to form a smaller number of large molecules. Polymers are long chain molecules which have physical properties which are significantly different from the monomers (i.e. the short chain molecules) from which they are made. Polymers are the basis for a wide range of materials which have become indispensable in modern society, including synthetic fibers (rayon, nylon, terelene, etc), rubbers and plastics (polystyrene, polythene, PVC, etc.), and the structural polymers (carbon fiber, etc).

Polymerisation is the process by which many small molecules join together to form large molecules. The reactants (i.e. the small molecules) are called monomers and long chain products of the polymerisation process are called polymers. Many of useful materials are natural

polymers (e.g. wool, cotton, linen, etc) or synthetic polymers (e.g. nylon, terelyene, rayon, etc).

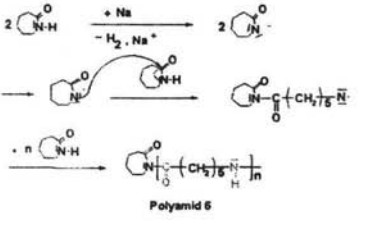
There are two general methods for preparing polymers, which involves the linking of small molecules together to form long chain molecules. The term "addition polymerisation" is used where small molecules are added directly to each other and the term "condensation polymerisation" is used where a molecule of water (or other small molecule) is released during the assembly process.

In general, addition polymerisations tend to proceed by a Free Radical Mechanism, while condensation polymerisation tends to proceed by an ionic mechanism.

The high pressure gas phase polymerisation of ethene to form Polythene involves a free radical mechanism. Thus, when ethylene is heated under great pressure in the presence of a suitable catalyst a large number of molecules of ethene combine together to form a much smaller number of molecules of Polythene, $(C_2H_4)n$, (i.e. Polyethylene).

■ polymerisation

polymerisation is the process of joining together a large number of small molecules to make a smaller number of very large molecules. The reactants (i.e. the small molecules from which the polymer is constructed) are called Monomers and products of the polymerisation process are called Polymers. There are significant differences between the chemical and physical properties of polymers and those of the monomers from which they are made. This polymerisation process can occur by two different mechanisms : by addition polymerisation and condensation polymerisation



Polyamid 6

■ polymers

polymers are giant molecules, built up from small units called Monomers which combined to-

gether to form a repeating structure. Polymers are classified into :
natural polymers
which include proteins starch, cellulose and rubber.
synthetic polymers,
include bakelite, perspex, terylene (a polyester) and nylon (a polyamide). These are man-made polymers, which are also called plastics.

■ **positive ion**

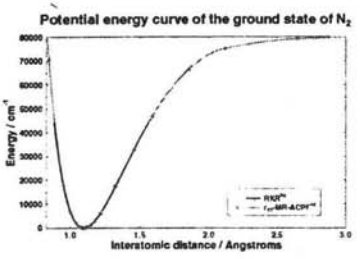
positive ions (i.e. cations) are atoms or group of atoms that has either lost one or more electrons, making them positively charged.

■ **kinetic theory of gases**

the kinetic theory of Gases is a model that accounts for many of the physical properties of gases. The main concepts of the theory are :
(a). that a gas consists of small identical particles which exert no forces on each other except at the instant of collision.
(b). that these particles move about at random and travel in straight lines between collisions.
(c). that the collisions of particles with each other and with the walls of the containing vessel are perfectly elastic.
(d). that the pressure of a gas is created by the particles striking the walls of the container.
(e). that the size of a particle is negligible compared with the volume of the container.
(f). that the particles are elastic, no energy is gained or lost on collision. In an elastic collision the only change in energy is the kinetic energy of the colliding particle will gain kinetic energy and the other will lose an equal amount.
The kinetic theory of gases is largely the result of the work of Count Rumford, James Joule, and James Clark Maxwell.

■ **potential energy**

the potential energy is the energy possessed by a body due to its position. The potential energy varies when a body moves from one position to another.



■ **preparation of acyl halides**

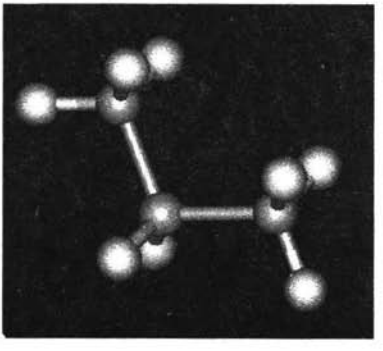
the —OH group in Carboxlyic acid is replaced by a halogen using a halogenating agent such as PCl_5.

■ **propagation**

propagation is the step in a free radical reaction, where new monomer molecules are added to the growing polymer chain in the free radical process.

■ **propane**

propane is the third member of the alkane series of hydrocarbons.



■ **proton**

a proton is an atomic particle. It resides in the nucleus, which is the central core of the atom. It has unit positive charge and unit atomic mass.

■ **purification**

purification is the physical or chemical process of removing contaminants from a compound. The physical processes may include sublimination, distillation, filtration, crystallisation, or extraction. The chemical processes may involve formation of a derivative, purification of the derivative and recovery of the original material in a pure form of the derivative.

■ **purification of ores**

the purification of ores are important industrial processes and are the first steps to the extraction of the metals. Normally, the ore is concentrated by separating it from the clay body in which it occurs either by gravity, sedimentation, or by a floatation process, before the extraction of the metal from the ore is started. This allows op-

erations with less inert materials during the extraction process.

■ **quantum mechanics**

quantum mechanics is the mathematical description of the behaviour of particles and energy at the atomic scale.

■ **quantum numbers**

quantum numbers are used to describe the different aspect of the electronic shell, they are required to describe the properties of each atomic orbital.

There are four quantum numbers :

Principal Quantum Number, n

This quantum number describes the general overall energy level and size of the orbital (i.e. shell).

Azimuthal (or Subsidiary) Quantum Number, l

This quantum number describes the shape of the sub-orbital. Each principal level is divided into sub-shells, which are designated by this number.

Magnetic Quantum Number, m

This quantum number is used to indicate the direction of the sub-orbital in space.

Spin Quantum Number, s

This quantum number indicates the spin of an electron in the sub-orbital.

Thus, for any atom, each electron in the orbitals about the nucleus in the atom has a unique set of quantum numbers, and no two electrons in the atom can have an identical set of quantum numbers.

■ **quark**

a Quark is a fundamental particle.

■ **quicklime**

quicklime, CaO, (i.e. calcium oxide) is manufactured by burning limestone (i.e. calcium carbonate, $CaCO_3$) in a furnace. It reacts vigorously with water to produce slaked lime (i.e. calcium hydroxide).

■ **Ra**

Radium Group 2 element, symbol Ra, an alkaline earth metal, Z = 88, Ar = [226].

■ **racemate**

a mixture of equal amounts of two enantiomers. A solution of a racemate (or racemic mix-

ture) will not rotate the plane of polarisation of plane polarised light because the effects of each enantiomer exactly cancels out that of the other.

■ **radiant energy**

energy which is transmitted away from its source. eg, energy that is emitted when electrons transition down from one level to another.

■ **radiant power**

total amount of energy emitted by a light source per second.

■ **radiation**

energy in the form of photons.

■ **radicals**

1.molecules or ions with one or more unpaired electrons and which consequently are generally very reactive. Also known as free radicals.

2. an old fashioned term for a group one used to talk about a "methyl radical" in the same way that one would use the phrase "methyl group"

■ **radioactive**

substance containing an element which decays.

■ **radioactivity**

radioactivity is the spontaneous disintegration of an unstable nucleus, by the emission of a small particle (i.e. an alpha-particle or a beta-particle) or by the change of the energy level of the nucleus by the emission of a gamma-ray.

■ **radiochemistry**

the branch of chemistry which studies radioactivity and the effects of the products of redioactive decay on matter.

■ **radon**

Group 18 element, symbol Rn, Z = 86, Ar = (222).

■ **Raman spectroscopy**

a spectroscopic technique in which information is obtained about molecular energy levels by analysing the intensity of electromagnetic radiation scattered inelastically from a molecule as a function of the energy of the scattered radiation. The technique is named after the discoverer of Raman scattering, Chandrasekhar Vankataswaran Raman, who in 1926 recorded Raman scattering from on pho-

tographic plates. The effect is so weak, however, that it was not until the advent of the laser that Raman spectroscopy became a viable proposition as a useful technique.

Raman spectroscopy is complementary to the corresponding absorption process because different selection rules are involved. For an absorption of a photon to take place there must be a change in the dipole moment of the molecule in the course of the transition (a non zero transition electric dipole moment). In Raman spectroscopy, however, the requirement for scatering to occur is that there is a change in the molecular polarizability (a second rank tensor) in the course of the transition.

For example, the infrared absorptions of carbon carbon double and triple bond stretching modes are weak due to the small electric dipole moment changes involved, but the corresponding polarizability changes are large resulting in strong bands in the vibrational Raman spectrum.

■ **Raoult's law**

Raoult's Law states that the vapour pressure of a solvent is reduced in the presence of dissolved solute. The law applies only to dilute solutions. The reduction of the vapour pressure of a solvent containing dissolved solute is proportional to the number of molecules of solute and is independent of their nature.

■ **rate of migration**

the rate of migration is the speed at which the ions travel through a solution during electrolysis.

■ **rates of reactions**

rates of reactions are the velocities with which chemical reactions proceed.

■ **ratio**

the relative size of two quantities expressed as the quotient of one divided by the other; the ratio of a to b is written as a b or a/b.

■ **Rayleigh scattering**

when light is scattered by particles much smaller than the wavelength. The shorter the

wavelength, the more intense the scattering.

■ **reactants**

reactants are the starting materials in a chemical reaction, and during the course of the reaction, these are replaced by a new set of materials called products.

■ **reaction mechanisms**

reaction mechanisms are the detailed step-by-step descriptions of the progress of a chemical reactions. The exact sequence for the breaking and making of bonds, and the electron transfers which give rise to this process are described.

■ **reaction rate**

the time rate of change in the concentration or amount of a reactant or product.

■ **reaction with phosphorus pentachloride**

reaction with phosphorus pentachloride is a characteristic of organic compounds containing a hydroxyl group and this reaction is used to identify these compounds in organic analysis.

■ **reactions of acyl chlorides**

acyl chlorides react readily with alcohols, RCOCl + R'OH ===> RCOOR' + HCl water, phenols and amines they are used in acylaction reaction.

■ **reactive plasma deposition**

similar to CVD, except that an rf plasma helps the decomposition/recombination process of the reactants.

■ **reactivity of a metal**

the reactivity of a metal is determined to a large extent by its reduction potential.

■ **receptor site, or receptor**

a membrane bound protein at which there is some interaction with a molecule or ion with biochemical consequences.

■ **reclaimed rubber**

rubber reclaimed from used or waste rubber goods. The method consists of heating the material with a dilute solution of sodium hydroxide for 12-20 hours at around 180°C.

■ **recrystallisation**

method of removing soluble impurities from a crystalline sample or for improving quality of crystals. Consists of dissolving the sample in the minimum amount of hot solvent. As the system is allowed to cool gradually, the solubility decreases and the sample crystallizes out leaving soluble impurities in solution. The slower the cooling process the greater the quality of the crystals.

■ **rectifier**

a device that turns ac power into dc power.

■ **red litmus**

a water soluble dye extracted from lichens. It is red under acid conditions and blue under alkaline conditions. Often used impregnated on paper (litmus paper) as a rough indicator of acidity or alkalinity.

■ **redox reaction**

redox reaction occur when Oxidation and Reduction takes place in the one reaction. If one substance loses electrons, or atoms of oxygen or hydrogen, then another substance must gain them. Redox reactions always involve the swapping of electrons.

■ **redox titration**

redox titration's are volumetric determinations titration's in which electrons are transferred from a Reducing Agent to an Oxidising Agent. The same principle holds as in acid-base and Argentometric Titration's.

■ **reduced mass**

$=m1m2(m1+m2)$

■ **reducing agent**

a substance that can donate electrons to another substance or decrease the oxidation numbers in another substance.

■ **reduction**

reduction is the process in which an atom or ion gains electrons. This definition applies only to reactions in which electron transfer occurs. Originally, reduction was simply regarded as a chemical reaction with the loss of oxygen.

■ **reduction by carbon**

reduction by carbon is an important method for the extraction of metals from their ores.

■ **reduction reaction**

a reaction in which a substance gains at least one electron.

■ **reforming**

reforming is the conversion of straight chain alkanes into branched chain alkanes by cracking or by catalytic reaction.

■ **refractory metals**

include tungsten, tantalum and molybdenum; used for electrode materials because they have a low, uniform surface potential, do not oxidize, and are bakeable.

■ **relative atomic mass, Ar**

the mass of an atom relative to the carbon 12 nucleus which has a value of 12 exactly. The relative mass is a pure number. Relative atomic mass used to be known as "atomic weight", and unless specified normally refers to a weighted mean over the naturally occurring isotopes of an element. For example, the relative atomic mass of carbon is 12.011 due to a small amount of naturally occurring carbon.

■ **relative density**

the relative density, r_d, of a substance is the ratio of the density of the substance to the density of some reference substance. For liquids or solids, the reference substance is water. This quantity was formerly called Specific Gravity.

■ **relative molecular mass**

relative molecular mass (i.e. molecular weight) is the ratio of the average mass per molecule of the naturally occurring form of an element or compound to the 1 / 12 part of the mass of the carbon-12 atom. It is equal to the sum of the relative atomic masses of all the atoms that comprise a molecule.

■ **relativity principle**

the basic laws of physics are the same in all inertial reference frames.

■ **relaxation times**

consist of T1 (longitudinal relaxation time) and T2 (transverse relaxation time). Basically, the relaxation times correspond to the time it takes after the pulse in NMR or other spectroscopic tecniques for the molecules to go back to their Boltzmann distribution of states.

■ **rempi**

resonance enhanced multi-photon ionisation.

■ **resistance thermometer**

uses the dependance of electrical resistance on temperature to measure the temperature.

■ **resolution (of a lens)**

the ability of a lens to produce distinct images of two point objects very close together.

■ **resonance**

resonance is the different arrangements of the bonds within a molecule that explain the chemical properties of the molecule, that cannot be accurately represented by a single structural formula. The compounds have properties consistent with a formula which is intermediate between all possible formulae. For example in the structure of the cyclic hydrocarbon Benzene, C_6H_6, there two arrangements of the alternating single and double bonds within the ring structure which are equally probable and give rise to identical chemical properties for benzene.

■ **resonance Raman spectroscopy**

when the energy of the excitation laser line in a Raman experiment coincides with an electronic transition in a molecule, intensity enhancements of many orders of magnitude can be observed for vibrational Raman bands associated with the chromophore. This effect is known as resonance enhancement of the vibrational bands and the technique is known as resonance Raman spectroscopy. It is of special value for studying large biomolecules. The problem here is that the extremely large molecules have a large number of vibrational degrees of freedom resulting in hopelessly cluttered conven-

tional Raman spectra. However, at the heart of many important biomolecules such as haemoglobin and cytochrome there is a complexed transition metal ion i.e. chromophore. Resonance Raman spectroscopy, therefore, can study the active sites of these important molecules.

The development of tuneable dye or solid state lasers over a wide range of frequencies has obviously increased the scope of this technique.

■ **resonant two-photon ionisation**

a process in which two photons strike a sample and ionise the molecules. One good thing about this process is that the product ions generally have known structure.

■ **rest mass**

the mass of an object as measured in a reference frame where it is at rest.

■ **reststrahlen filter**

utilises the phenomena that reflections of white light from crystal surfaces will contain only one region of the spectrum.

■ **resultant**

the sum of two or more vectors.

■ **retroreflector**

see corner-cube prism

■ **retrosynthesis (or retrosynthetic analysis)**

when practicing organic synthetic chemistry it is only natural to study a target molecule with a view to disassembling (or "disconnecting") it to see how it may be constructed from simpler molecules. However, this process was given a firm procedural foundation by E.J. Corey (who received the Nobel Prize for his efforts) and is now known as retrosynthesis.

■ **reverse osmosis**

reverse osmosis is a process of obtaining pure water from saline water, as in a descalination unit. Pure water and the salt are separated by a semi-permeable membrane, by raising the pressure of the salt water above the osmotic pressure. Then, the solvent, water, is able to pass through the membrane, leaving the solute (i.e. the dissolved salts) behind.

■ **reversible process**

for a system at equilibrium, a reversible process takes place when at any stage in the process an infinitesimal change in the reaction conditions (pressure,temperature, concentration) can reverse the direction of the chemical change.

■ **reversio**

right-to-left reversion of an image.

■ **Reynold's number**

characterises the onset of turbulence in a tube. R_c = 2vr(rho)/n, where n=viscosity, r=radius of tube, rho=density of the fluid, v=velocity of the fluid; If R_c<2000, there is laminar flow; if R_c>2000, there is turbulent flow.

■ **R_f value**

an R_f value of a substance is the ratio of the distance that the substance moves in a chromatographic separation, to the distance that the solvent moves.

■ **rhenium**

Group 7 transition metal of the third series, symbol Re, Z = 75, Ar = 186.207.

■ **rhme**

rotating hanging meniscus electrode.

■ **rhodium**

Group 9 transition metal of the second series, symbol Rh, Z = 45, Ar = 102.905.

■ **rhomboid prism**

used for lateral deviation of a light ray.

■ **ribonucleotide reductase**

the enzyme in all organisms that catalyses the conversion of nucleosides to deoxynucleosides.

■ **rideal**

eley mechanism for heterogeneous catalysis reaction occurs due to a collision between a reactant in the gas phase and one chemisorbed on a surface.

■ **ring**

a ring is an arrangement of atoms in a molecule to form a closed chain. Ring compounds may consist of an alicyclic ring structure (e.g. cyclohexane), an aromatic ring structure (e.g. benzene), or a fused ring structure (e.g. naphthalene).

■ ring closure

ring closures are chemical reactions in which one part of a molecule reacts with another part of the same molecule to form a ring structure. Examples of ring closures include the formation of lactams and lactones.

■ RNA

ribonucleic acid; a chemical found in cells that serves as an intermediate in the synthesis of proteins; the three major types are called messenger RNA (mRNA), ribosomal RNA (rRNA), and transfer RNA (tRNA).

■ Rochelle's salt

Rochelle's Salt, (i.e. Sodium Potassium Tartate), $KNaC_4H_4O_6.4H_2O$, is a colourless crystalline salt.

■ rolling friction

the friction from when one body rolls across a surface; generally much smaller than the sliding friction.

■ root-mean-square speed (rms)

the square root of the average of the squared speeds of gas molecules in a sample.

■ roots blower

a type of vacuum pump capable of pressures down to .01 torr.

■ rosaniline

triamino diphenyl tolyl hydroxy methane, component of fuchsine dyes, made by oxidizing an equimolar mixture of aniline, o toluidine and p toluidine.

■ rotating disk electrode

method to determine kinetics of electrodes. If you have the electrode be a rotating disk, the current of the sample can be related to the speed of rotation.

■ Rowland ghosts

spurious intensity maximum spurred from periodic errors in the spacing of the ruled grooves in a diffraction grating.

■ rpm

radical pair mechanism

■ rubidium

group 1 element, an alkali metal, symbol Rb, Z = 37, Ar = 85.4678.

■ ruby

aluminum oxide, Al_2O_3.

■ **rust**

rust is a hydrated ferric oxide which has the approximate chemical composition shown.

■ **ruthenium**

group 8 transition metal of the second series, symbol Ru, Z = 44, Ar = 101.07.

■ **s block elements**

elements in which s orbitals are being filled.

■ **s orbital**

an atomic orbital with a quantum number l=1.

■ **sacrifical anodes**

are metals that are used to protect valuable metals i.e., iron from corrosion by supplying an excessive amount of electrons and thus not allow any chemical reaction involving oxidation to take place on its surface.

■ **salt**

a salt is the product of the neutralisation of an acid by a base. Salts are usually ionic solids.

■ **salt bridge**

a salt bridge is the linking structure, consisting of a viscous gel of saturated sodium chloride in a glass tube, used to connect two half cells.

■ **saltpetre**

name given to natural deposits of potassium nitrate. Also known as nitre. An important compound in the manufacture of explosives. Chile was the major source of saltpetre and the naval blockade of Germany in WW1 ought to have meant that they would run out of explosives in 1916. However, after the invention of the Haber process in about 1908 and its development into a viable industrial process by Bosch during the war.

■ **salts**

ionic or electrovalent compounds in which one or more acidic protons of an acid have been replaced by cations, usually metal or ammonium cations. The word "salt" in daily use is taken to mean sodium chloride, NaCl, which is the sodium salt of hydrochloric acid.

■ **SAM**

self-assembled monolayer.

■ **samarium**

a lanthanide or rare earth element, symbol Sm, Z = 62, Ar = 150.36.

■ **saponification**

reaction (hydrolysis) of an ester with an alkali to give an alcohol and the salt of a carboxylic acid. When the ester is that of a fatty acid the product is a fatty acid salt which is a soap molecule (long hydrophobic chain with a hydrophilic head). Hence the name from "sapo", Latin for soap.

■ **sapphire**

Al_2O_3, aluminum oxide.

■ **SATP**

standard ambient temperature and pressure; corresponds to 25 C, 1 bar.

■ **saturated compound**

a saturated compound is one in which all the atoms are linked by single bonds. Saturated compounds react with other compounds by undergoing substitution reactions. If a saturated compound undergoes an elimination reaction, an unsaturated compound is formed.

■ **saturated solution**

a saturated solution is a solution contains as much solute as the solvent can hold (i.e. dissolve) at a that particular temperature.

■ **Sb**

antimony Group 15 element, symbol Sb (from Latin "stibnum"), Z = 51, Ar = 121.75.

■ **Sc**

Scandium Group 3 element, symbol Sc, Z = 21, Ar = 44.9559. Technically, Scandium is a member of the first row transition metal series, but its chemistry is principally that of the Sc^{3+} ion which has no d electrons.

■ **scalar**

a quantity which has magnitude but no direction associated with it. Familiar examples of scalars are temperature, volume and pressure.

■ **SCE**

standard calomel electrode.

■ **Schiff's reagent**

(not to be confused with a shift reagent) a solution of fuchsine (the hydrochloride of rosaniline) decolourised with sulphurous acid. A test for aliphatic aldehydes and aldose sugars which immediately restore the red violet colour. Aromatic aldehydes and aliphatic ketones restore the colour slowly, while aromatic ketones are unaffected.

■ **Schiff's test**

a test for cholesterol. When $FeCl_3$ and concentrated sulphuric acid are heated with cholesterol a violet residue is obtained on evaporation to dryness.

■ **Schott irg 11**

calcium aluminate; transmits light between .3-5.5 microns.

■ **Schott irg 2**

germanate; transmits light between .3-4.6 microns.

■ **Schott irg n6**

calcium aluminosilicate; transmits light between .3-4.75 microns.

■ **Schrödinger equation**

the equation at the heart of Schrödinger's formulation of quantum mechanics.

The most general form of the equation is time dependent, but for problems of atomic and molecular structure the time dependent equation reduces to the time independent Schrödinger equation which has the form

$$H\psi = E\psi$$

where H is the Hamiltonian, the operator corresponding to the total energy of the system, psi is the wavefunction of the system and E is the energy of the system.

This equation is an eigenfunction/eigenvalue problem. Once one has the Hamiltonian of a system, the mathematical problem is to find functions which, when operated on by the Hamiltonian, yield the same function multiplied by a number (which equals the energy of the system).

Boundary conditions generally result in quantisation a range (often of infinite size) of "stationary states" is found. Each

state has a discrete energy and is described by one or more quantum numbers.

■ **scientific method**

the fundamental way in which science progresses and in which our knowledge and understanding increase. Essentially it is based on experiment and observation.

■ **SCRF**

self-consistent reaction field method. A method for calculating the energies of molecules in a reaction.

■ **second law of thermodynamics**

the entropy of an isolated system increases in the course of a spontaneous change.

■ **secondary alcohol**

a secondary alcohol is one in which the hydroxyl group [-OH] is attached to a secondary carbon atom (i.e. a carbon atom which has one hydrogen atoms attached to it).

■ **secondary amine**

compound in which two hydrogens of ammonia have been replaced by organic groups.

■ **secondary cell**

a secondary cell is an electrochemical cell for the production of electricity. After use the secondary cell can be recharged by passing an electric current through the cell in the opposite direction to that delivered during use. Examples of a secondary cell include the lead-acid battery used in cars, and the nickel-cadmium cells used in portable electrical devices.

■ **secondary standard**

a secondary standard is a working standard material which is used in the laboratory as a working standard, and which has been calibrated against a primary standard material of known composition.

■ **secondary treatment**

secondary treatment involves the biochemical oxidation of a sewage or trade effluent to meet the standards before its discharge to the aquatic environment.

■ **Seeback effect**

when a metal has a temperature gradient, it has a volt-

age. The difference in thermally induced voltages of two metals will cause a net voltage in a junction.

■ **selenium**

Group 16 element, symbol Se, Z = 34, Ar = 78.96.

■ **semiconductor**

semiconductors are materials whose electrical conductivity is intermediate between that of conductors and that of insulators. The electronics industry is based on the beneficial uses of the electrical properties of semiconductors.

■ **sensitisation**

development of an allergic reaction when exposed to a chemical, especially involving the skin or lungs.

■ **separation**

separation is required to isolate pure compounds from mixtures and is a prerequisite to the analysis of mixtures. In chemical manufacturing plants, separation is normally achieved by distillation, sublimination, crystallisation, or by filtration. In analytical chemistry, separation is normally achieved by chromatographic methods.

■ **serine**

abbreviated to ser, 2 amino 3 hydroxypropanoic acid, pK_a values = 2.21, 9.15, an amino acid occurring in proteins. [Chime structure up shortly.]

■ **SERR spectroscopy**

surface-enhanced resonance Raman spectroscopy; a Raman method used because it has excellent selectivity to the microscopic environment and orientation of things adsorbed on surfaces.

■ **SERS**

surface-enhanced Raman scattering

■ **shape of ionic compound**

ionic compounds exist in a crystalline form in the solid state. For example, the electrostatic attractive force which exist between the positively charged sodium ion and the negatively charged chloride ion cause these oppositely charged ions to arrange themselves as close as possible in a crystal lattice. The exact structure of the unit cell

of the crystal structure will depend on the size and charge on each of the ions.

■ **SHE**

standard hydrogen electrode; defined as having 0V.

■ **shear modulus**

the modulus of rigidity; concerned with the elastic deformation of a body in which an applied force results in the shape of a body.

■ **shells and subshells**

each set of orbitals with the same value of n, the principal quantum number, forms what is known as an energy shell.
As a legacy from some early work on atomic spectroscopy, the n = 1,2,3 . . shells are also known as the K, L, M . . shells, respectively.
Each subset of each shell with the same value of l, the azimuthal quantum number, is known as a subshell.
There are (2l + 1) orbitals in a subshell with azimuthal quantum number l, and a total of n^2 orbitals in total in a shell with principal quantum number n.
Each s orbital in a shell forms the s subshell; each three degenerate p orbitals in each shell forms the p subshell and so on. One can label the subshell with the principal quantum number the s orbital in the n= 2 shell is the 2s subshell.

■ **shg**

second harmonic generation.

■ **shielded**

when the sigma value in NMR is greater than zero. Deshielding is when the value is less than zero.

■ **SI unit**

stands for Systeme International d'Unites, a international system which established a uniform set of measurement units.

■ **sigma bond**

sigma Bonds (s Bonds) are the single covalent bonds formed between two atoms by the end-on overlap of the atomic orbitals on the different atoms.

■ **silicon**

Group 14 element, symbol Si, Z = 14, Ar = 28.0855.

■ **silicon carbide (or carborundum)**

SiC, M_r 40.11, relative density 3.217, black solid crystallizing in both hexagonal and cubic forms, sublimes at 2700°C, soluble in molten potassium hydroxide.

A hard material used as an abrasive and refractory. SiC is made in an Acheson furnace carbon and silicon are packed round a core of carbon through which a large current is passed, raising the temperature to around 2000°C. (For less pure samples, coke and silica are used.)

■ **silicon controlled rectifier**

a switching device; in the on state it has low resistance and in the off state it has very high resistance.

■ **silver**

Group 11 transition metal of the second series, symbol Ag (from the Latin "argentum"), Z = 47, Ar = 107.868.

■ **single bond**

the single bond is the covalent or coordinate bond between two atoms that involves the sharing of a single pair of electrons between the atoms.

■ **Sir Humphrey Davy**

an English chemist, Sir Humphrey Davy (1778-1829) pioneered the study of Electrochemistry and isolated the elements sodium, potassium, magnesium, calcium, strontium and barium by Electrolysis 1807AD-1808AD.

He recognised that Chlorine was an element in 1810AD.

His most practical invention was the Davy Lamp, a safety lamp used by miners in the pits.

■ **size exclusion chromatography**

where you separate mixtures based on the sizes of the molecules.

■ **slaked lime**

Calcium hydroxide (or slaked lime) $Ca(OH)_2$, M_r 74.09, colourless hexagonal crystal, relative density 2.24, mp 580°C, decomposes before boiling.

Dissolves sparingly in water to form limewater. When carbon dioxide is bubbled through

limewater, a white precipitate of calcium carbonate is produced this is used a diagnostic test for the gas.

■ **slaked lime**

slaked lime (i.e. calcium hydroxide), is prepared by adding water to freshly prepared quicklime.

■ **SLAR**

single layer antireflection coating

■ **smectic**

a smectic phase is when the molecules align themselves into a pseudo-crystalline lattice. Liquid crystals are one example.

■ **smectic crystal**

Liquid crystal most crystalline substances melt to give clear, isotropic liquids in which all the order of the crystalline state has been replaced by random motion of the molecules in the liquid state.

However, some crystals on heating achieve a turbid state in which the substance exhibits the properties of a liquid such as surface tension and viscosity, but also displays a high degree of order in the arrangement of the molecules. Such substances are known as liquid crystals and they are characterised by optical anisotropy.

Typical molecules which give rise to liquid crystals have a high degree of asymmetry (long and skinny or planar).

In nematic liquid crystals, the molecular axes are ligned up in the same direction without any 2 dimensional ordering.

Cholesteric and smectic liquid crystals are composed of layers of molecules with long molecular axes parallel and perpendicular to the planes, respectively.

Cholesteric and nematic liquid crystals can exhibit very large optical activities; cholesteric types often exhibit iridescent colours due to dichroism.

■ **smokeless powder**

Cellulose nitrate (or nitrocellulose) a highly flammable material formed by treating cellulose (cotton or wood pulp, for example) with concentrated nitric acid or concentrated nitric acid plus either sulphuric or phosphoric acid.

If the nitrogen content is over 13%, then the material is known as guncotton or smokeless powder.
Used as a propellant or an explosive, in lacquers and formerly for movie film.

■ **Sn**

tin Group 14 element, symbol Sn (from the Latin "stannum"), Z = 50, Ar = 118.69.

■ **Snell's law**

$n_1 \sin\theta_1 = n_2 \sin\theta_2$, describes refraction.

■ **soap**

soap is a mixture of the sodium salt of the fatty acids, which is obtained on hydrolysis of fats with sodium hydroxide. Glycerol is also obtained in this reaction.

■ **sodium hydroxide**

(or caustic soda or sodium hydrate) NaOH, M_r 40.00, white deliquescent solid, relative density 2.130, mp 318.4°C, bp 1390 °C.
A strong base. It can be manufactured by adding quicklime to sodium carbonate or using the Castner.

■ **sodium sulphate**

Na_2SO_4, white orthorhombic crystals , relative density 2.67, mp 888°C.
Can be produced industrially by reacting magnesium sulphate with sodium chloride in solution followed by crystallization, or by the action of concentrated sulphuric acid on sodium chloride.
The decahydrate, $Na_2SO_4.10H_2O$ is known as Glauber's salt and is used as a laxative. This is named after J.R. Glauber (1604 1668).

■ **sodium thiosulphate**

sodium thiosulphate, $Na_2S_2O_3$, is a salt used in photography for the fixing of photographic plates.

■ **soft water**

water with relatively little dissolved calcium and magnesium ions (the ions which cause scum and prevent a good lather being got up).

■ **softening point**

the point at which a glass can be molded or worked.

■ **sol**

a stable dispersion of either solids in liquids or solids in solids.

■ **solenoid**

a long coil of wire consisting of may loops; when current flows through it, the magnetic field resembles that of a bar magnet.

■ **solid**

the state of matter in which the atoms or molecules are held together by forces which are so strong that the resulting structure is rigid.

■ **solubility**

solubility is the quantity of solute that dissolves a given quantity of solvent to form a saturated solution, and is expressed in kilograms per meter cubed, moles per kilogram of solvent, etc. The solubility of a substance in a given solvent depends on temperature. No simple general relation exists between solubility and temperature, so each case must be investigated separately. Polar solutes are more soluble in polar solvents.

■ **solubility of gases**

a general property of gases is that they diffuse to fill the volume in which they are contained (i.e. they have neither fixed shape or fixed volume). Thus, gases which do not react with each other, are infinitely soluble in each other in all proportions, due to this power of diffusion. This behaviour is described by Graham's Law and by Dalton's Law of Partial Pressures.

■ **soluble**

a substance is soluble in a liquid, if it dissolves in that liquid. A liquid can also dissolve in another liquid is it is miscible with the liquid.

■ **solute**

in a solution of two substances, that which is present in the smaller amount. See **solution**.

■ **solutions**

a solution is a mixture of a liquid, called as the solvent, with a gas, liquid or solid known as the solute. Solutions are homogeneous mixtures, and usually consist of a mixture of a

solid (i.e. the solute) and a liquid (i.e. the solvent). When a solution if formed, the molecules of the solute are evenly distributed amongst the molecules of the solvent. In a solution, there are interactions between the molecules of the solute and the molecules solvent, and this interaction is known as solvation.

■ solutions of electrolytes

solutions of electrolytes are the electrically conducting solutions formed when salts are dissolved in water. The high electrical conductivity of the solution is due to the presence of ions from the dissociation of the salt.

■ solvation

solvation is the interaction of ions of a solute with the molecules of the solvent. It occurs only with polar solvents. Solvation is the process that causes ionic solids to dissolve in polar solvents. The energy released during solvation is sufficient to compensate for the lattice energy of the ionic crystal, in which the ions are arranged in the solid state.

■ solvent

a solvent is a liquid that has the ability to dissolve, suspend or extract other materials, without chemical change to the material or solvent. Solvents make it possible to process, apply, clean or separate materials. Water is an inorganic solvent. Organic solvents include hydrocarbon solvents, oxygenated solvents and chlorinated solvents.

■ space quantisation

the restriction in the directions that an an angular momentum vector can take, given by the rule that the z component of the angular momentum (in units of h bar) must have maximum and minimum values equal to the value of the relevant angular momentum quantum number, respectively. Other allowed values are obtained by stepping from the larger value to the smaller in unit intervals. In the absence of a magnetic field, these states, differing only in the direction in which the angular momentum vector points, are degenerate.

A magnetic field lifts this degeneracy since the energy of

interaction with the magnetic dipole moment associated with the angular momentum is dependent on the angle between the two vectors.

■ **space-charge effect**

used to describe particle beam aberrations, it arises from the natural repulsion of particles of like charge; a focused beam will disperse, giving a diffuse image.

■ **spatial coherence**

how much the waves are in step as they leave a laser cavity.

■ **special theory of relativity**

1) The basic laws of physics are the same in all inertial reference frames.

2) Light propagates through empty space with a definite speed c independant of the speed of the source or observer.

■ **specific gravity**

the ratio of the density of a substance at 4 C to that of water at 4 C.

■ **specific heat**

the amount of heat it takes for a substance to be raised one degree C.

■ **spectrum**

the presentation of a wave phenomenon as a function of the frequency (or wavelength or wavenumber or energy) of the wave.

■ **spectrum of hydrogen**

the spectrum of hydrogen is obtained by an electrical discharge in a Geissler Tube. The spectrum contains four bright lines, due to atomic hydrogen and is used in calibrating spectroscopes and refractomeres. The principal lines in the spectrum of hydrogen are: a red line, H, at 656.2 nm (i.e. Fraunhofer's C), a blue line, H, at 434.0 nm, a greenish-blue line, H, at 486.1 nm, (i.e. Fraunhofer's F) and an indigo line, H, at 410.2 nm.

■ **speed of sound**

equal to the square root of the bulk modulus/density of the medium. As temperature rises, so does the speed of sound.

■ **sphere**

radius $=4\pi(r^2)$, volume $=4/3\pi(r^3)$.

■ **spherical aberration**

the variation of focus with aperture in which a ray through the edge of the lens intersects the axis at a point other than the paraxial focus.

■ **spin**

a source of angular momentum for atomic particles. Early quantum theory predicted that an electron in an orbital had angular momentum due to its orbital motion and that this angular momentum was quantised and governed by the orbital angular momentum quantum number (or azimuthal quantum number) l. Due to space quantisation each orbital would be (2l+1) fold degenerate. However, on detailed analysis of atomic emission spectra, Pauli concluded that there must be a second source of electronic angular momentum. By analogy with classical physics, it was reasonable to attribute this to the "spin" of the electron.

Experimental evidence for electron spin was provided by the experiment of Stern and Gerlach. They showed that the electron's spin angular momentum had to have spin orbital angular momentum quantum number, s , equal to 1/2.

Dirac eventually showed that spin emerges naturally from a solution of the relativistic Schrodinger equation.

Nuclei can also possess spin. Whereas every electron has a spin of half, nuclei can have nuclear spin angular momentum quantum number, I , equal to zero or other integer factors of 1/2.

The spin of the nuclei gives rise to nuclear magnetic resonance spectroscopy and there is a corresponding technique, electron spin resonance spectroscopy, arising from electron spin.

Photons have a spin angular momentum quantum number of 1. This is the origin of many spectroscopic selection rules. If a photon had no spin, there would be no optical activity.

■ **spin quantum number**

this spin quantum number, s relates to the spin on an electron. The spin may have one of two values, s = + 0.5. or s = - 0.5. Each sub-orbital can accommodate two electrons, and

the two electrons in each sub-orbital must have opposite spins. Allowing two electrons in each sub-orbital and the magnetic quantum, ml explains the number of electrons which can be accommodated in each sub-orbital.

■ **spinel**

magnesium aluminate, $MgAl_2O_4$.

■ **spin-spin coupling constant**

defines how much of an interaction you have between nuclei in a molecule. Gives rise to the fine structure in NMR.

■ **spontaneous reaction**

a reaction that will proceed without any outside energy.

■ **sputtering**

allow a material into the vapor phase to condense into a thin film

■ **sputtering**

see SPT

■ **square planer**

this involves the splitting of the d orbitals into more than two energy levels, this is due to the crystal field splitting. The relative placement of the d orbitals is difficult to determine, so it must be calculated.

■ **standard heat of combustion**

the standard heat of combustion is the heat evolved when one gram mole of a substance is burned in oxygen.

■ **standard reference electrode**

a standard reference electrode is required in all electrochemical measurements.

In the case of the determination of standard reduction potentials, the standard reference electrode is the hydrogen half-cell.

In the case of pH measurement, the standard reference electrode is the calomel electrode.

■ **standard solution**

a standard solution is one which contains a known weight of reagent in a definite volume of solution.

■ **standard state**

the pure form of a substance at 1 bar pressure for any given temperature.

■ **starch (or amylum)**

a polymeric carbohydrate made of a mixture of varying amounts of two glucose polymers amylose and amylopectin. (An approximate formula for starch is often given as $(C_6H_{10}O_5)_x$ where x is around 100.)

It is found in many green plants as an energy storage medium, in tubers such as potatoes, in the roots of vegetables like carrots, and in the seeds of grains like rice, wheat and barley.

Because it has no precise molecular formula, its molar enthalpies of combustion and formation are not defined, but its standard enthalpy of combustion for 1 kilogram of material is 17 480 kJ.

From a knowledge of the enthalpy of formation of carbon dioxide and water and the enthalpy of combustion of starch, a figure for the kilogram enthalpy of formation of starch may be obtained using Hess's Law.

When starch and iodine come into contact, a deep blue pigment is formed. Starch is often used as an iodine indicator in the form of starch solution which is prepared by boiling a little starch with water in a boiling tube and pouring some of the product into boiling water in a beaker (starch is sparingly soluble in water). The solution must be cooled before use as an indicator because the blue colour disappears on heating (and reappears on cooling).

■ **state function**

a function whose change in magnitude solely depends on the initial and final states of a process and not on the route taken.

■ **state property**

a state property is a quantity that is independent of how the substance was prepared. Examples of state properties are altitude, pressure, volume, temperature and internal energy.

■ **states of matter**

the states of matter are the three forms (i.e. solid, liquid and gas) in which matter is observed to exist. A fourth state of matter (i.e. the plasma state) exists at very high temperatures, when all materials are decomposed into their elements and the electrons are stripped from these atoms to form the plasma.

■ **stationary phase**

applies to chromatography and is the solvent which does not move the 'bound surface water' on the paper on paper chromatography.

■ **steady**

state approximation (or stationary state approximation) used in kinetics to simplify the mathematical treatment of complex reactions (especially chain reactions) and consists of considering the concentrations of intermediates as constant. The approximation is good if the concentrations of the intermediates are low and when the induction period of the reaction is short. Low intermediate concentrations will ocur when the reactivity of the intermediates is much greater than that of the reactants.

■ **steam**

water in the vapour or gaseous state. Since at 1 bar water boils at 373 K, steam is normally thought of as "hot". In fact, the scalding properties of steam are enhanced by its anomalously large enthalpy of vaporization, 40.66 kJ mol. So, not only does the steam from the kettle scald you because it's at 373 K, you get an extra dose of 40.66 kJ heat for every mole condensed.

■ **steam cracking**

steam cracking is the industrial process using steam at high temperature to break down high molecular weight hydrocarbons into smaller molecules.

■ **steam reforming**

steam reforming is a process used to convert methane derived from natural gas into a mixture of carbon monoxide and hydrogen, which is then used to synthesise organic chemicals. The reaction occurs at about 900 °C using a nickel catalyst.

$CH_4 + H_2O ==> CO + 3H_2$

■ **Stern Gerlach experiment**

Stern and Gerlach fired silver atoms through an inhomogeneous magnetic field. The fact that the silver atoms were split up into 2 beams showed that there must be a source of angular momentum in the atom with spin angular momentum quantum number 1/2. Orbital angular momentum, governed by integral quantum numbers, could not produce a doubly degenerate state only (2l+1) fold degeneracies are possible through space quantisation of the orbital angular momentum. (The electronic configuration of a silver atom consists of a single 6s electron outside a closed shell structure the net angular momentum of closed shells/ subshells is zero, so that the angular momentum properties of the silver atom are determined by the single outer electron.)

■ **stoichiometry**

stoichiometry is the quantitative relationship between the amounts of materials involved in a chemical reaction. The total quantity of reactants (i.e. the mass of the starting materials) must be equal to the total mass of the products of the reaction.

■ **stoichiometry of electrolysis**

the stoichiometry of electrolysis is described by Faraday's Laws of Electrolysis.

■ **stopband**

the primary region of reflection or absorption of a rejection filter.

■ **stp**

standard temperature and pressure; corresponds to 0C, 1 atm.

■ **streamline**

the path taken by any particle in a steady, laminar flow.

■ **strength of acids**

the strength of acids is determined by the degree to which they are ionised in aqueous solution. For example, sulphuric acid which is a strong acid is fully dissociated, and all the displaceable hydrogen in the

acid is present in solution as hydrogen ion.
H_2SO_4 ==> H(+) + SO4
100% as H(+)
Similarly, the weak acids ethanoic acid is only partially ionised in solution, and only approximately 5% of the displaceable hydrogen in the acid is present in solution as hydrogen ion.
CH_3COOH ==> H(+) + CH_3COO(-) 5% as H(+)

■ **strong acids**

acids which dissociate fully on solution e.g. HCl, HNO_3, H_2SO_4, $HClO_3$.

■ **strong acids and bases**

strong acids and bases are acids and bases which are completely dissociated in solution.

■ **strong electrolyte**

a strong electrolyte is a substance which undergoes almost complete dissociation into ions in solution. Solution of a strong electrolyte consist almost entirely of positively charged ions and negatively charged ions, which are stabilised in solution by solvation (i.e. by being associated with aggregates of molecules of the solvent). Examples of strong electrolytes include almost all salts, the caustic alkalis and the mineral acids in dilute solutions.

■ **strontium**

group 2 element, symbol Sr, an alkaline earth metal, Z = 38, Ar = 87.62.

■ **structural biology**

a branch of biology dedicated to the study of the three dimensional structures of proteins and other molecules to help understand the function of these molecules in the cell.

■ **structure of crystals**

the structure of crystals is described in terms of the geometry of a unit cell of the crystal structure.

■ **sublevel**

one part of a level, each of which can hold different numbers of electrons.

■ **sub-orbitals**

atomic sub-orbitals are the sections of orbitals containing paired electrons of opposite spin. Each atomic sub-orbital can hold one pair of electrons.

■ **substitution reactions**

along with addition and elimination, one of the fundamental classes of chemical reaction in which one atom or group is substituted for another.

■ **substrate**

a molecule acted upon by an enzyme.

■ **suicide substrate**

an enzyme substrate that itself is not toxic but that produces a toxic metabolic product.

■ **superconductor**

a material which has no resistance to electricity. When passing current through a superconductor, there is no loss of electrical power due to these materials.

■ **supercritical liquid**

a liquid which exists at temperatures above the normal boiling point; this is brought about through high pressure. Reactivity of solutes in these liquids can be changed drastically with minor changes in temperature and pressure.

■ **superfluid**

a fluid that flows without viscosity (ex He-II)

■ **superhigh surface area carbon**

any carbon which has a specific surface area greater than 2630 square meters per gram

■ **superionic materials**

materials which exist largely in the ion phase. These are extremely useful in making conductors which work via ionic migration.

■ **supernatant**

when one has a solution from which a precipitate has been formed, the supernatant liquid is simply the remaining solution above the solid.

■ **superoxide dismutase**

a copper and zinc containing enzyme present in all oxygen using organisms that scavenges free radicals and converts them into hydrogen peroxide and oxygen.

■ **supersaturated solution**

a supersaturated solution is one in which too much solute has

been dissolved in a solvent. As a rule, hot solvents can dissolve more solute than the same quantity of cold solvent, so that when a hot saturated solution is cooled, a supersaturated solution tends to form at lower temperatures.

■ **supersaturated vapour**

a vapor which will spontaneously begin to condense in the presence of nucleation centers.

■ **surface adsorption**

surface adsorption is the phenomenon whereby a substance is attracted to the surface of a material and becomes attached to that surface. The phenomenon explains the mechanism of action of catalysts and the mechanism of separation in chromatography.

■ **surface area of solids**

the surface area of solids is area of the interface between the solid and the gas to which it is exposed. Surface area is an important factor in catalysis, as it is this surface area which is available to absorb gases, vapours or liquids. The chemical reactions then take place on the surface of the catalysts.

■ **surface tension**

(gamma); the force F per unit length L that acts across any line in a surface, tending to pull the surface closed.

■ **surfactant**

a species that is active between two phases. It accumulates at the interface and changes the surface tension.

■ **suspended solids**

suspended solids are the particles of insoluble matter which are present in natural waters and sewage effluents. The latter have high levels of suspended solids, which must be subjected to treatment before discharge to the aquatic environment.

■ **symmetry**

symmetry is the property of a molecule, whereby the molecule has the same observed physical structure and appearance when viewed from different orientations in space.

■ **syngas**

a mixture of gases (largely carbon monoxide and hydrogen)

that results from heating coal in the presence of steam. Can be used as a fuel.

■ synthesis

a synthesis is the name given to a chemical reaction in which a chemical compound is made.

■ synthesis of ammonia

the synthesis of ammonia is an important industrial process for the fixing of atmospheric nitrogen, thereby making it available for incorporation into a range of other compounds.

■ synthesis reaction

a synthesis reaction is a reaction in which an inorganic compound is formed directly by the combination of its elements.

■ synthetic chemistry

a branch of chemistry in which chemists devise ways to make specific compounds of interest and/or develop new chemical reactions for this purpose.

■ TDFS

time-dependent fluorescence shifts

■ tem

transmission electron microscopy. What you do is take the sample, grind it up, then place an aqueous suspension of it on a grid where the electron microscope can get at it.

■ temperature

temperature is the thermodynamic property which defines the internal energy of a system. The absolute scale of temperature results from the physical properties of gases. There are a number of other temperature scales in use. The Celsius Scale of Temperature uses the freezing point and boiling point of water as the two fixed points and assigns the values 0 and 100 to these fixed points, respectively and divides the scale between them into 100 degrees.

■ temporal coherence

how much waves stay in step along a beam path

■ temporary hardness

temporary hardness is that fraction of the hardness of water that is due to dissolved calcium bicarbonate. Tempo-

rary hardness is removed on boiling, when the calcium bicarbonate is converted to calcium carbonate.

■ **term**

each compound or element in a chemical equation.

■ **termination**

termination is the final step in a free radical mechanism that results in the stopping of the free radical reaction. Normally, termination occurs only after a significant number of propagation steps in the free radical process have occurred.

■ **tertiary alcohol**

tertiary alcohols are aliphatic alcohols in which the hydroxyl group [-OH] is attached to a tertiary carbon atom (i.e. a carbon atom which has no hydrogen atoms attached directly to it).

■ **tertiary treatment**

tertiary treatment is the polishing process to which a sewage effluent is subjected after it has received secondary treatment in order to reduce further its nutrient content.

■ **tetrachloroethylene**

chemical name of perchloroethylene.

■ **theoretical plates**

represents how many times you do a separation in purification; can be used to describe column chromatography, GC, or HPLC.

■ **theories of catalysis**

the theories of catalysis explain the influence of the catalysts on the rate of a reaction by describing the detailed mechanism by which the catalyst is involved in the steps of the chemical reaction.

■ **thermal motion**

chaotic, random motion of molecules due to the temperature

■ **thermal neutrons**

neutrons that have not been slowed down and have reached equilibrium with matter at room temperature

■ **thermal pollution**

thermal pollution is the increase in temperature of natural waters resulting from the discharge to these waters of hot

effluents from industrial and power plants. The higher temperatures reduce the concentration of dissolved oxygen in the receiving waters and promote eutophication.

■ **thermionic emission**

you can get a current to flow from a heated filament to a positive electrode in a vacuum; this emission is simply electrons flowing from the filament to the positive electrode.

■ **thermistor**

a substance which changes its resistance with temperature. Those developed as infrared detectors are known as bolometers.

■ **thermochemistry**

thermochemistry is the investigation of the transfer of energy in the form of heat during the course of a chemical reaction, which are called the heats of reaction. In every chemical reaction, there is a difference between the intrinsic energy in the reactants and the intrinsic energy in the products. This energy, which is either adsorbed or released during the course of the reaction, is the heat of reaction. The heat of reaction (i.e. the change in the energy during the course of a reaction) is expressed as dH, (i.e. "delta-H"), which has positive values for endothermic reactions and negative values for exothermic reactions . The unit of heat is the joule. Another unit of heat which is widely used in thermochemistry, the calorie (i.e. the amount of heat required to raise 1 g of water through 1 °C) which is equal to 4.18 joules.

■ **thermocouple**

two metals are put together side by side when heated, one metal expands more than another due to differences in the coefficients of thermal exansion, and the strip bends. This can be used as a switch, as in a thermostat.

■ **thermodynamics**

the study of heat and energy flow in chemical reactions.

■ **thermogravimetric analysis**

when you heat a sample to observe weight changes; used

when studying the loss of waters of hydration or CO_2.

■ **thermoplastic material**

thermoplastic materials are polymeric materials which can be repeatedly softened by heating and hardened again on cooling.

■ **thermoplastics**

plastics that can be softened by heating and return to their original state on cooling.

■ **thermopneumatic detector**

when the radiation incident on a gas in a closed chamber increases the temperature and pressure of a gas, a mirror on the cell wall moves. This movement is measured optically, and can be used to determine the amount of radiation incident on the cell.

■ **thermosetting material**

thermosetting plastics are those rigid plastic which are moulded into shape at the time of manufacture (i.e. at the time of polymerisation) and they an extensively cross-linked structure. These plastics cannot be remoulded to another shape as their rigidity is due to the highly cross-linked structure formed between the molecules at the time of polymerisation. "Bakelite" is an example of a thermosetting polymer.

■ **thermovoltaic detector**

an IR detector where temperature changes of a junction of dissimilar metals because of changes in the level of incident radiation causes a change in voltage.

■ **Thomas Graham**

a British chemist, Thomas Graham (1805-1869) formulated Graham's Law of Gaseous Diffusion which states that the diffusion rate of a gas is inversely proportional to the square root of its density.
He also discovered the colloidal state, while working on diffusion and osmosis.

■ **time dilation**

the idea that time travels slower for somebody in a moving reference frame; consequence of relativity.

■ **time-of-flight**

when you apply the same translational energy to all particles;

the lighter particles will travel a shorter distance over a charged plate because there is less momentum to carry them forward.

■ **titration**

titration's involves taking a definite volume, usually 20 ml, of a liquid whose concentration is unknown, and slowly adding a solution of a reagent with which the solution reacts, until reaction is complete. An indicator is used to denote the end-point of the titration. The volume of the solution added is noted, and allows the concentration of the unknown to be calculated.

■ **titration curve**

titration curves are the plots of pH versus the volume of reagent delivered during the course of a titration. The inflection point in the titration curve marks the end-point of the titration.

■ **total binding energy**

energy required to break a nucleus into its component protons and neutrons

■ **total internal reflection second harmonic generation**

this is what happens when you shine the exitation beam and probe beam on a liquid-liquid surface. What you are counting on happening is that the beams will reflect off of the bottom liquid and give the second harmonic signal you're looking for.

■ **toxaphene**

commercial name of an insecticide, a mixture of isomers obtained by chlorination of camphene. It was used primarily to control insect pests on cotton and other crops. It is classified as a POP.

■ **toxin**

a poisonous substance.

■ **transducer**

a device that turns one kind of energy to another (like a loudspeaker turns electrical energy to sound); a device that converts a light signal into an electrical signal

■ **transference number**

different ions carry different fractions of the current because different ions move at different speeds under the same potential gradient. The transference number of an ion is the fraction of the total current that is carried by that ion during electrolysis. In general, a cation and an anion differ in the amount of current they can carry during electrolysis.

■ **transient grating techniques**

what you do in one of these studies is to get several beams coming into a sample that have different circular polarity. Their interference sets up a diffraction grating which can be used to run experiments.

■ **transistor**

a device used to give current and power amplification

■ **transition elements**

elements that have incompletely filled d subshells or readily give rise to cations that have incompletely filled d shells.

■ **transition state**

the activated form of a molecule that has partly undergone a chemical reaction.

■ **transverse relaxation time (t2)**

the time it takes after a pulse in NMR for the spins to get out of phase with one another. This is also called the spin-spin relaxation time.

■ **transverse wave**

when a wave has the property that the particles of the wave move perpindicular to the motion of the wave itself, such as a water wave.

■ **trepr**

time-resolved electron paramagnetic resonance; a way of identifying transient radicals

■ **tri**

a prefix meaning three.

■ **triads**

the triads are the three groups of elements, each of three metals, in Group VII Elements of the periodic table.

■ **trichloroethylene**

trichloroethylene is mainly used in the degreasing of met-

als. Under the VOC Directive, its use in that application is restricted to enclosed systems in all new installations; old installations will have to comply with stringent emission limits after April 2007. Trichloroethylene also is used to a much lesser extent in adhesive and aerosol formulations and as a chemical process intermediate in polyvinyl chloride (PVC) and fluorochemical production. See other information and comments under "Chlorinated Solvents".

■ trichroism

exhibits different colors in 3 different directions when viewed by transmitted light.

■ trihydric alcohol

trihydric alcohols (i.e. Triols) are organic compounds containing three hydroxyl groups. The simplest trihydric alcohol is 1,2,3-propane-triol, $CH_2(OH).CH(OH).CH_2(OH)$, which is also known as glycerol (from the Greek glykys meaning sweet) or glycerin. Glycerol is commercially produced by the hydrolysis of Fats.

Fats + Alkali ==> Soap + Glycerol

Fats are triesters of glycerol, and when they are hydrolysed with sodium hydroxide, yield glycerol, $CH_2(OH).CH(OH).CH_2(OH)$, and soap, R_1COONa, which is a mixture of the sodium salt of the fatty acids.

Glycerol is a by-product in the soap industry and is recovered by suitable means.

■ triple bond

the triple bond between carbon atoms in alkynes involves a total of six electrons (i.e. three shared pairs of electrons). These bonds are formed in different ways and the first bond behave differently in chemical reactions from the second and third bonds.

■ tungsten filament

an IR light source where the emitter is a tungsten filament; the IR output range is limited by the window material, although the window material may actually heat up enough to serve as a blackbody emitter.

■ **tunneling**
the penetration of a particle into a classically-forbidden region.

■ **turbulent flow**
when a moving liquid exhibits erratic, whirlpool-like currents.

■ **turing pattern**
patterns that arise from oscillatory coupled cells.

■ **two-dimensional NMR**
a method in which you can take NMR peaks that are stuck on top of each other and separate them. The plot has one axis as the normal NMR axis, and the other corresponds to the spectrum when you hit the sample with 90 degree radiation.

■ **Tyndall effect**
the scattering of visible light by a colloidal dispersion.

■ **UHV**
ultrahigh vacuum.

■ **ultrasonic**
sound waves that have frequency higher than we can hear (20,000 Hz).

■ **ultraviolet radiation**
the shorter wavelength spectral region adjacent to the visible region.

■ **uniphase**
a wavefront is uniphase if it has the same phase at all points.

■ **unsaturated compound**
an unsaturated compound is an organic compound in which at least one bond between the carbon atoms is a double or triple bond. These compounds tend to react with other compounds by undergoing addition reactions to form saturated compounds.

■ **unsaturated solution**
an unsaturated solution is a solution which contains less than the maximum amount of solute that can be dissolved in the solvent at that temperature. If added, more solute will dissolve in an unsaturated solution.

■ **vacuum ultraviolet (vuv)**
uV radiation of high enough frequency that air will absorb it. UHV is ultrahigh vacuum-

UV, which is of higher frequency still.

■ valence electrons

the electrons in the outermost shell of an atom.

■ valency

valency is the combining power of an element (i.e. the number of bonds which the atom can form with other atoms). Valency is governed by the number of electrons in the outermost electronic shell of the atoms of that element (i.e. the valency electrons). These valency electrons are given up to other atoms or are received from other atoms to make Ionic Bonds, or the valency electrons are shared with other atoms to make Covalent Bonds. The process of transferring electrons between atoms or of sharing electrons between atoms results in the formation of compounds, where the atoms in the compound achieve the stable electronic configuration of the Nobel Gas elements

■ Van der waals equation

an equation for non-ideal gasses that accounts for intermolecular attraction and the volumes occupied by the gas molecules.

■ Van der Waal's force

the Van der Waal's Force is the attractive force between molecules, which is caused by the induced temporary polarisation of molecules by the dipole moments of molecules.

In complex covalent compounds, an attraction occurs between the protons of one molecule and the electrons of another. As two molecules of the compound approach one another, the electrons in the outer shells of both molecules which have a negative charge begin to repel each other. When the molecules are a certain distance apart, the forces of attraction and repulsion are equal and opposite (i.e. the forces are balanced at that distance).

Graphite, which is a crystalline form of carbon, consists of flat planes of carbon atoms. The carbon atoms in each plane are held together by covalent bonds. However, there are no covalent bonds between the planes, and the only forces be-

tween the planes are the weak intermolecular interactions (i.e. the Van der Waal's Force). The planes can slip and slide over each other with ease, a fact which helps to explain why graphite is soft and a good lubricant.

The Van der Waal's Force give rise to intermolecular attractive forces between the molecules of gases, and are responsible for the deviation of the behaviour of real gases from the ideal gas laws.

■ **Van der waals picture of condensed matter**

molecular dynamics of dense fluids are determined primarily by the size and shape of molecules; that is, the short-range repulsive internuclear forces.

■ **vcm**

vinyl chloride monomer or chloroethylene, a colourless, flammable gas, used principally in making polyvinyl chloride, an important synthetic resin.

■ **vector**

a quantity that has both direction and magnitude, such as velocity.

■ **velocity**

speed of an object; the change in position over time.

■ **velocity selector**

used with molecular beams; slotted disks that make sure only particles with the desired speed reach the target.

■ **venturi tube**

a pipe with a narrow constriction; if it has an opening at this constriction, it will tend to pull a vacuum through it equal to the vapor pressure of the liquid; a consequence of Bernoulli's principle.

■ **vinyl chloride**

vinyl chloride, $CH_2=CHCl$, is the monomer used in the synthesis of the industrially important plastic, polyvinylcloride, PVC.

■ **viscosity**

the internal friction of a liquid.

■ **visible spectrum**

radiation of wavelength 400-750nm.

■ **vital force**

the vital force was the entity presumed to confer the prop-

erties of life in the organic compounds found in animals and plants. Wohler's synthesis of urea an organic compound, from the inorganic compound, ammonium cyanate discredited the theory of the existence of a vital force.

■ **voltage**

equal to the potential difference between two things.

■ **voltaic cell**

voltaic cells are the electrochemical cells that are constructed to be a source of electric current to power external devices.

■ **volume**

measures the size of an object using length measurements in three dimensions.

■ **volumetric analysis**

volumetric analysis is the quantitative analysis of liquids and gases. In the case of liquids, the concentration of a solution of unknown strength is determined by causing the solution to react with another solution of known concentration. Volumetric analysis is mainly concerned with methods of titrating various pairs of solutions, one against the other, and with the calculations arising from such titration's. In the case of gases, the main technique involves reacting or absorbing gases in graduated containers over mercury, and measuring the volume change during the course of reaction.

■ **vom**

volt-ohm-meter; a multimeter that measures voltage, current and resistance.

■ **Walden reductor**

a metal reduction column filled with silver.

■ **Walsh diagram**

a diagram that shows the variation of orbital energy with molecular geometry.

■ **water**

water, H_2O, covers three quarters of the surface of the globe, and is a prerequisite for the existence of life as we know it on Earth. It is the most important solvent.

■ **water pollution**

water pollution is the degradation of the quality of water re-

sources as a result of physical, chemical and/or microbiological contamination. In general, polluted surface waters result when water contains either too little dissolved oxygen, or too high a concentration of toxic substances, such that they cannot support living organisms. The most common causes of water pollution are the discharge of untreated treated domestic sewages, detergents and industrial trade effluents from point sources to rivers and streams, the presence of nutrients, fertilisers and pesticides in the diffuse run off from agricultural sources to ground waters and surface waters, and the presence of oils, contaminated suspended solids in the storm water runoff from urban areas to surface waters.

■ **water resources**

water resources are the bodies of water which are available for exploitation for beneficial purposes.

■ **water treatment**

water treatment is the purification of water, by a physical, chemical or biochemical process, to render it suitable for a specific use.

For example, water must undergoes treatment to render it suitable for use as drinking water.

■ **wave**

a signal which propagates through space, much like a water wave moves through water.

■ **wavelength**

on a periodic curve, the length between two consecutive troughs (low points) or peaks (high points).

■ **wavelength of light**

the wavelength of light is the distance between successive crests of the transverse electromagnetic wave. The wavelength of each colour of visible light is different.

■ **weak acid**

substances capable of donating hydrogen but do not completely ionise in solution.

■ **weak bases**

substances capable of accepting hydrogen but do not completely ionise in solution.

■ **wedge prism**
used for beam steering.

■ **Welsbach mantle**
a gauze mesh, similar to the one in gas lanterns, impregnated with ThO_2 and a small amount of CeO_2 which is heated by either a burning gas or electric charge. It gives off IR radiation between 10-100 microns.

■ **Werner Karl Heisenberg**
a German mathematical physicist, Werner Karl Heisenberg (1901-1976) is the Father of Quantum Mechanics. He is remembered for his Uncertainty Principle, that rejects the notion that the properties of an atom can be described exactly by the solutions to mathematical matrices.

■ **Winkler titration**
the Winkler titration is the back titration used to determine the concentration of Dissolved Oxygen in a sample of water.

■ **work**
expression of the movement of an object against some force.

■ **x-ray fluorescence spectroscopy (xrf)**
measures the energies of the inner electrons of an atom by knocking them off with X-rays; good for about 35 elements. Handy because it is not a destructive method of analysis - the electrons are simply elevated to outer orbitals and the relaxation to the inner orbitals is measured.

■ **yield of a chemical reaction**
the yield of a chemical reaction is the percentage of the calculated stoichiometric quantity of the principal produce which was obtained in the reaction. Few organic reactions give quantitative yield (i.e. 100% yield) of a single product.

■ **Young's modulus**
the ratio of longitudinal stress to longitudinal strain.

■ **Zeeman effect**
this is the effect of overcoming the normal degeneracy of electron spin states by applying a magnetic field which can interact with the magnetic moment of the electron. This is ob-

served when atoms are subjected to a powerful magnetic field resulting in the spectral lines being split into a number of component lines.

■ **zeroth law of thermodyamics**

if A is in thermal equilibrium with B and B is in thermal equilibrium with C, then A and C are in thermal equilibrium.

■ **zirconium hydroxide**

$Zr(OH)_4$, a toxic, amorphous white powder; insoluble in water, soluble in dilute mineral acids; decomposes at 550°C; used in pigments, glass, and dyes, and to make zirconium compounds.

■ **zirconium nitride**

ZrN, a hard, brassy powder that is soluble in concentrated acids; melts at 2930°C; used in refractories, cermets, and laboratory crucibles.

■ **zirconium oxide**

ZrO_2, a toxic, heavy white powder that is insoluble in water, soluble in mineral acids; melts at 2700°C; used in ceramic glazes, special glasses, and medicine, and to make piezoelectric crystals. Also known as zirconia; zirconic anhydride; zirconium dioxide.

■ **zirconium oxychloride**

$ZrOCl_2.8H_2O$, white crystals that are soluble in water, insoluble in organic solvents, and acidic in aqueous solution; used for textile dyeing and oil-field acidizing, in cosmetics and greases, and for antiperspirants and water repellents. Also known as basic zirconium chloride; zirconyl chloride.

■ **zirconium phosphate**

$ZrO(H_2PO_4)_2.3H_2O$, a toxic, dense white powder that is insoluble in water, soluble in acids and organic solvents; decomposes on heating; used as an analytical reagent, coagulant, and radioactive-phosphor carrier. Also known as basic zirconium phosphate; zirconium orthophosphate.

■ **zirconium tetrachloride**

$ZrCl_4$, toxic, alcohol-soluble, white lustrous crystals; sublimes above 300°C and decomposes in water; used to make pure zirconium and for water-

repellent textiles and as an analytical reagent. Also known as zirconium chloride.

■ **zone refining**

a technique used for reducing the level of impurities in certain metals, alloys semiconductors, and other materials. It is based on the observation that the solubility of an impurity is generally different in the liquid and solid phases of a material.

Notes

Notes