GENERAL SCIENCE

FORM 1-4

CHEMISTRY SECTION

TOPICS

- SEPARATION
- MATTER
- ACIDS, BASES AND SALTS
- INDUSTRIAL PROCESSES
- OXIDATION AND REDUCTION
- ORGANIC CHEMISTRY

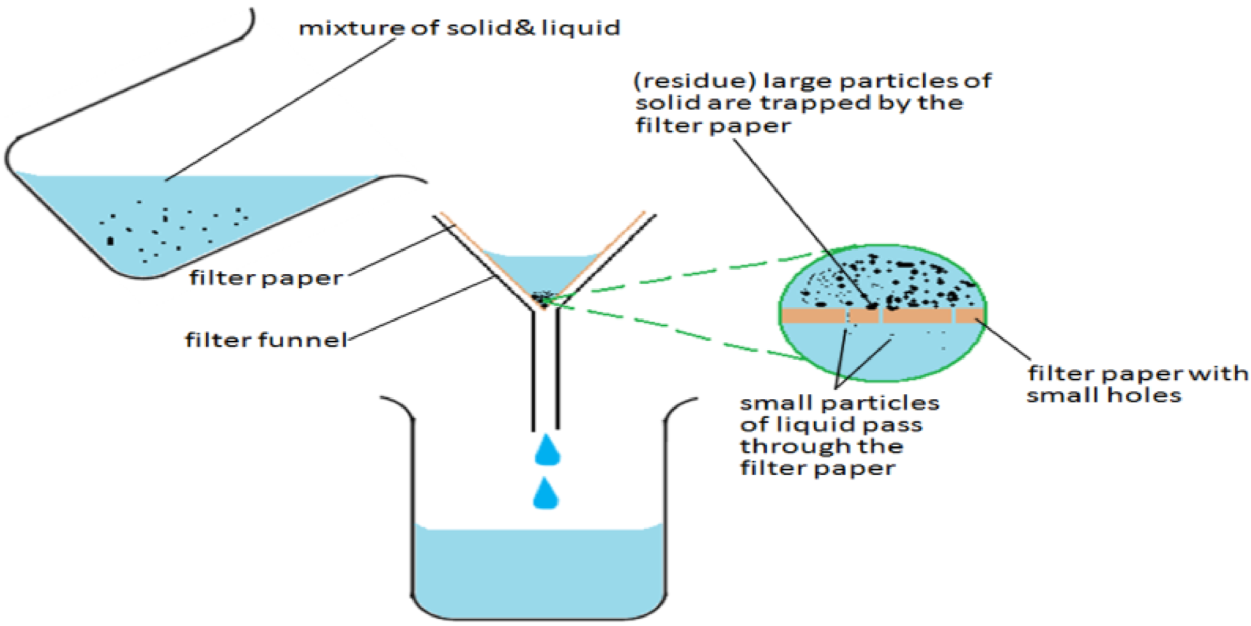
FORM ONE

SEPARATION

- *State methods of separating mixtures*

METHODS OF SEPARATING MIXTURES

Filtration



- Is used to separate insoluble solids from liquids e.g. a mixture of chalk and water
- A filter paper is placed in a funnel, on a flask and the mixture is poured on the filter paper.
- Liquid filtrate passes through the filter paper and is collected
- Insoluble substances are left as residue on the filter paper after filtration.

Evaporation

- Is used to separate a solution in which the solid is dissolved in the liquid.
- The solution is heated so that the liquid evaporates and the solid remains at the bottom of the evaporating dish.

Winnowing

- Is a used to separate solid with different densities e.g. chuff from grains.
- Shake the dish or winnowing basket vigorously from side to side. The less dense come to the top and are blown off while the grains remain the container.

Decanting

- Is used to separate liquids of different densities e.g. oil and water.
- The less dense particles (oil) come on the top and are poured off.

Magnetism

- Can be used to separate iron objects e.g. iron fillings from sulphur

MATTER

- Matter is anything that has mass and occupies space

STATES OF MATTER

- ***Identify the three states of matter***
- ***Describe the arrangement of particles in solids, liquids and gases***
- ***Describe properties of solids, liquids and gases in terms of the kinetic theory of matter***

Solid

- Particles are strongly attracted to each other
- Particles vibrate in fixed positions and have little kinetic energy
- Have definite volume and shape.
- Particles cannot be compressed

Liquid

- Particles have more energy than in the solid state so they are to move each other and flow to fill the container they are in.
- The shape can change but volume is fixed.

- Particles move freely.

Gas

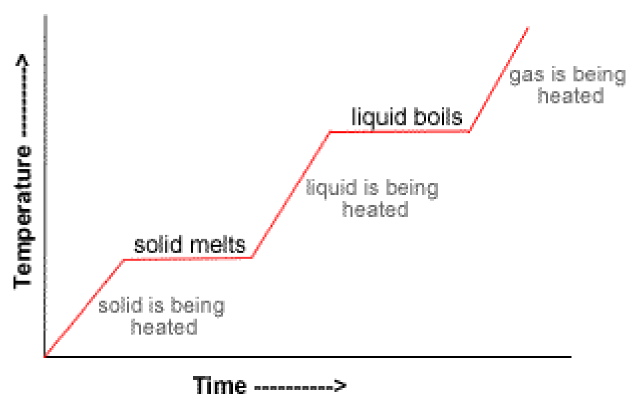
- Particles are widely spaced in random order.
- Particles can be compressed because particles are further apart
- The shape and volume of the gas can be changed.
- Particles have enough energy to escape the attractive forces between them, so they are free to move in all directions at high speed

Kinetic Theory

- The properties of solids, liquids and gases can be explained by kinetic theory.

- Kinetic theory states that matter is made of tiny particles that move all the time.
- The main points of the theory are;
- All matter is made of tiny, invisible, moving particles.
- The particles move all the time. The higher the temperature the faster they move.
- Heavier particles move more slowly than light ones at a given temperature.

Experiment on heating water



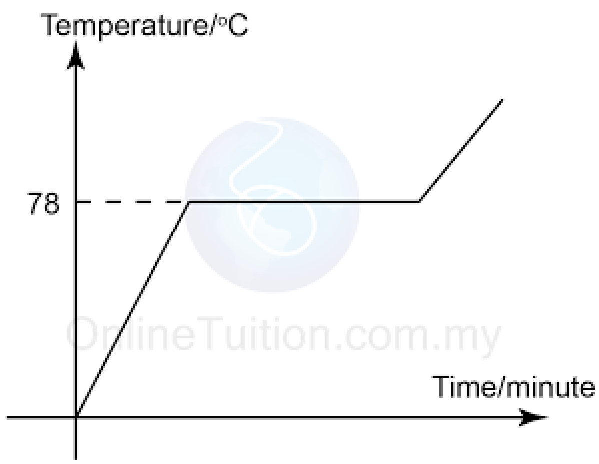
- The temperature of the solid ice on heating rises from - 10℃ to 0℃

- As heat is supplied to ice, the particles gain energy and vibrate more violently until they overcome the attractive forces and are free to move, a process called melting

- The temperature remains constant at 0℃ as the ice melts. This is because the heat absorbed is being used to break bonds between particles of a solid as it turns into a liquid (specific latent heat of fusion)

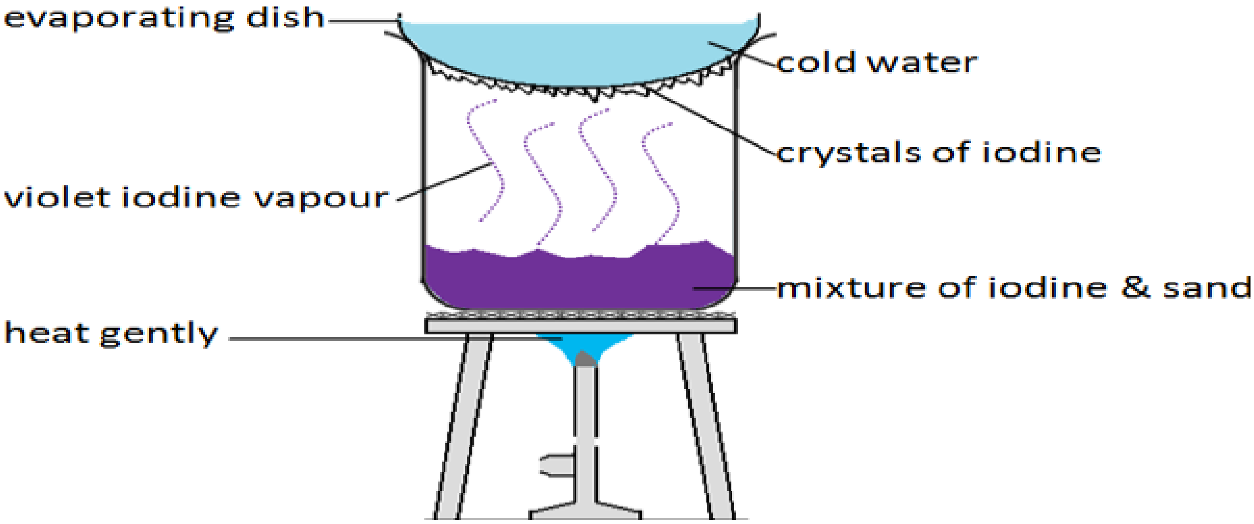
- When all the ice has melted the temperature of the liquid water rises from 0℃ to 100℃.
- As the liquid is heated up, the particles gain energy and move faster until they break away completely from each other and the liquid becomes gas, a process called evaporation/boiling
- During boiling, the temperature of water remained constant at about 100℃ because heat energy absorbed is used to break the forces between particles in the liquid turning it into a gas.(specific latent heat of vaporization)

Experiment on heating Naphthalene



- The particles in solid begin to melt. Its temperature remains constant because the heat energy absorbed by the particles is used to overcome the forces between particles and the solid turn to liquid.
- The particles in the liquid absorb heat energy and move faster. The liquid turn to gas
- When all the naphthalene has solidified, the temperature of the solid naphthalene fall again to room temperature

Heating of iodine



- If iodine is heated in a crucible, it sublimes and when the heat source is removed and the crucible allowed to cool, the iodine cools and becomes deposited as a solid.
- Grey iodine changes directly to violet or purple vapor which collects on the cold part of the glass to form black shining crystals of iodine
- Iodine vapor produced is toxic (poisonous) therefore the experiment should be done in a fume cupboard or close to a window.

SOLUBILITY

- It is the measure of how soluble a substance is.
- The **solubility** of a solute is the maximum amount of solute that can dissolve in a certain amount of solvent or solution at a certain temperature.

Describe factors that affect solubility

1. Temperature – kinetic energy of particles increases as temperature increases thus increasing rate of solubility. For liquids and solid solutes, increasing the temperature not only increases the amount of solute that will dissolve but also increases the rate at which the solute will dissolve. Generally, an increase in the

temperature of the solution increases the solubility of a solid solute. For example, a greater amount of sugar will dissolve in warm water than in cold water.

2. Stirring – particles dissolve more quickly when they are stirred because stirring increases the kinetic energy of particles causing them to collide more often with the solvent. With liquid and solid solutes, stirring brings fresh portions of the solvent in contact with the solute. Stirring, therefore, allows the solute to dissolve faster.
3. Particle size – small particles dissolve more quickly than larger ones because a large surface area of the solute is in contact with the solvent. When a solute dissolves, the action takes place only at the surface of each particle. When the total surface area of the solute particles is increased, the solute dissolves more rapidly. *Breaking a solute into smaller pieces increases its surface area and increases its rate of solubility.*

ELEMENTS, MIXTURES AND COMPOUNDS

Identify mixtures, elements and compounds

Element

- Is a substance made up of same type of atoms and cannot be split into two or more simpler substances by any chemical means e.g. hydrogen, magnesium, zinc, iron, sulphur, copper

Molecules

- Is the smallest particle of an element or compound that can exist on its own e.g. hydrogen, nitrogen, oxygen, chlorine, carbon dioxide, water

Mixture

- Two or more different substances not chemically combined together e.g. salt and sand or iron and sulphur

Compound

- Is a substance made up of two or more different elements chemically combined together which exist as molecules or ions e.g. copper sulphate, carbon dioxide, magnesium oxide.

Differences between mixture and compounds

COPMOUND	MIXTURE
Substances formed by chemical means	Substances formed by physical means
New substance is formed	No new substances formed
Substances separated by chemical means	Substance separated by physical means
Heat energy used	No heat energy used

Experiment on iron and sulphur

PERIODIC TABLE

Identify metals and non metals on periodic table

METALS	NON METALS
Lithium	**Hydrogen**
Beryllium	**Helium**
Sodium	**Boron**
Magnesium	**Carbon**
Aluminium	**Nitrogen**
Potassium	**Oxygen**

Calcium **Iron** **Copper** **Zinc**	**Fluorine** **Neon** **Silicon** **Phosphorus** **Sulphur** **Chlorine** **Argon**

ACIDS, BASES AND SALTS

By end of the topic learners will be able to

- *List properties of acids and bases*
- *Identify acids and bases using red and blue litmus*

PROPERTIES OF ACIDS AND BASE

Acids

- Turn blue litmus paper red
- Universal indicator turns red/orange
- They have a pH below 7
- They are corrosive
- They have a sour taste

Bases

- Turn red litmus paper blue
- Turn universal indicator blue/green
- Taste bitter
- Have a slippery feel
- Some are caustic e.g. potassium hydroxide

INDUSTRIAL PROCESSES

Outline production of peanut butter

Shelling

- Consist of removing the shell of peanuts with the least damage to the seeds.
- The peanuts are placed in large slotted cylindrical drums that rotate, rubbing the peanuts against each other until the shells are opened and the kennels fall through the slots.
- Shelling at home is often done by hands.

Roasting

- Peanuts are then sent through the 240^{o}C hot air roaster, which shakes to ensure evenly roasted peanuts. The peanuts turn to light brown.
- The peanuts are cooled rapidly to ensure that natural oils will remain in the peanuts.
- Roasting at home is done using a pan over a wood fire or stove.

Grinding

- The peanuts are lightly rubbed between two belts which remove their outer skins.
- The peanuts are splitted so that the bitter middle part (heart) can be removed.
- The splitted peanuts are sent to the grinder, where the peanuts are ground into a smooth peanut paste.
- In rural areas split peanuts are pounded in a mortar followed by grinding on the grinding stone (guyo)

Packaging

- The peanut butter is cooled down again to 38°C and empty jars are sent on a conveyor belt to be filled. The jars are then moved to the capping machine and are labeled.

Outline production of oil from peanut butter

- De-hull the peanuts and bring them out in a large bowl.
- Remove the fine skin layer of peanuts and wash them in cold water and then in warm water.
- Put the washed peanuts in a clean bowl and pour warm water into it. Let the peanuts soak in water for 10-15 minutes so that the peanuts get soft.
- Draw the water from the bowl and put the peanuts in the blender.
- Blend the peanuts thoroughly to get a smooth, buttery paste of peanuts
- Pour the paste in a bowl and cover the lid tightly and put in a refrigerator for at least a day.
- The oil will rise on the top through this process.
- After 24 hours strain the oil into a separate bowl.
- When the oil is completely clean after several times of straining pour it in a clean bottle

State uses of oil

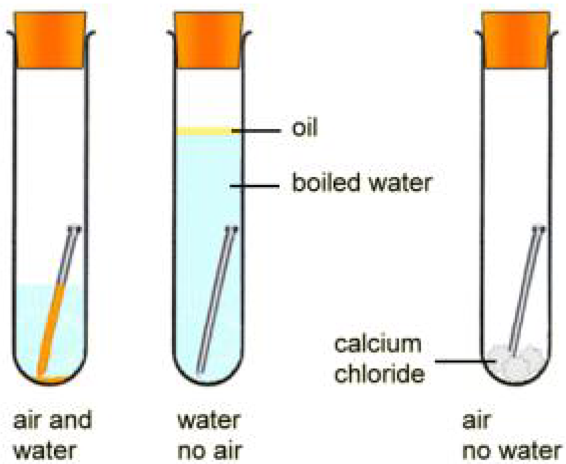
- Cooking
- Natural tonic that help boost immunity and invigorates your entire body

OXIDATION AND REDUCTION

Rusting

- Rusting – corrosion of iron and steel
- Rust – brown solid product formed during rusting
- Rust is hydrated iron (III) oxide Fe2O3 *x*H2O where water molecules vary.

State conditions necessary for Rusting



- After a few days, only nail in tube A rust. This shows that air and water is needed for rust. In boiled water, the nail doesn't rust in B as boiled water removes dissolved air while in C, CaCl keeps air dry so there's no water

Explain methods of preventing Rusting

1. Surface protection **-** covers metal with a layer of substance e.g. Paint, Grease or oil (also help to lubricate) and Plastic
2. Sacrificial protection – covering metal with thin layer of another metal (e.g. tin, chromium, silver)
3. Use of stainless steel

ORGANIC CHEMISTRY

Identify forms of fuels

- A fuel is a material that can be burnt to give out heat or have chemical energy.
- Fuels are found in three forms i.e.

1. Solid fuels e.g. wood, charcoal, coke and coal
2. Liquid fuels e.g. petrol, diesel, paraffin, ethanol
3. Gaseous fuels e.g. methane, butane, ethane , hydrogen and coal gas

Compare the efficiency of different fuels

- Fuel efficiency is the measure of the conversion of a fuel from chemical energy to heat energy.
- Heat content of a fuel can be measured by the rate at which a fuel heats up a substance to a certain temperature
-

FORM TWO

SEPARATION

By end of the topic learners will be able to

- *State the applications of filtration, winnowing, magnetism and evaporation*

MATTER

By end of the topic learners will be able to

- *Determine the concentrations by colour intensities of dissolved substances*

- *Determine the concentration of a substance by varying the amount of solute in a given solvent*

ACIDS, BASES AND SALTS

By end of the topic learners will be able to

- *Describe an acid – base reaction*

INDUSTRIAL PROCESSES

By end of the topic learners will be able to

- *Outline manufacture of soap*

OXIDATION AND REDUCTION

By end of the topic learners will be able to

4. *Define oxidation and reduction in terms of oxygen*
5. *Write simple word equations*
6. *Distinguish between physical and chemical changes*

ORGANIC CHEMISTRY

By end of the topic learners will be able to

- *Define complete and incomplete combustion of fuels*
- *List the products of complete and incomplete combustion*

FORM THREE

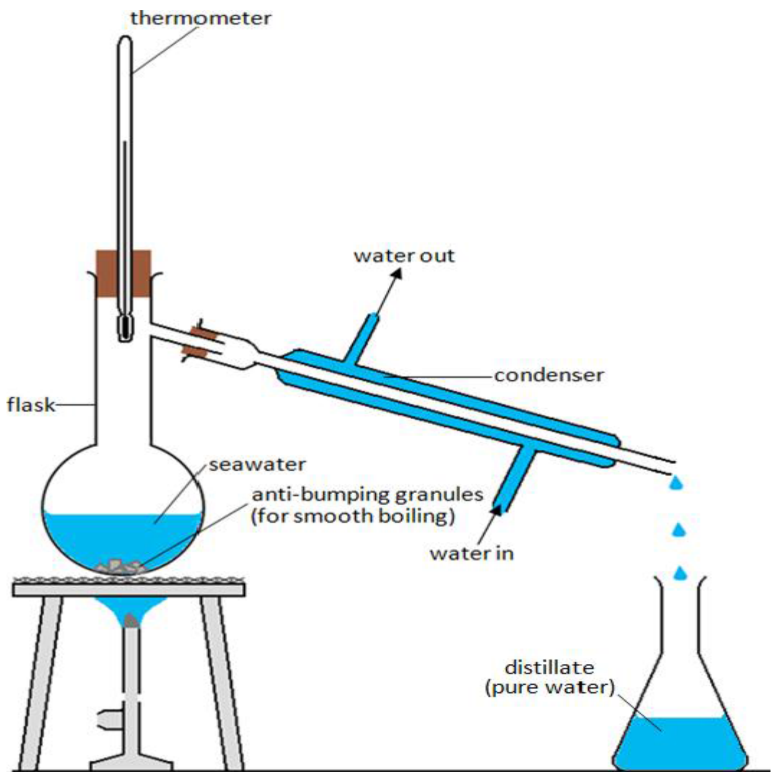
SEPARATION

By end of the topic learners will be able to

- *Describe the processes of distillation and fractional distillation*

DISTILLATION

- Is a process of separating water from dissolved solids



- Solution is heated, and steam (pure vapour) is produced.

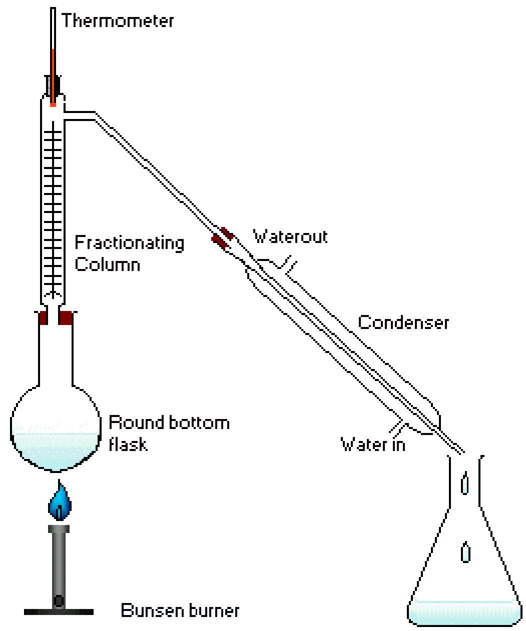
- The steam is cooled in condenser to form pure liquid.

- The solid (solute) remains behind in the flask as a residue.

- Note – The thermometer bulb should be at the level of the condenser.

FRACTIONAL DISTILLATION

- Separates mixture of miscible (soluble) liquids with widely differing boiling points.



- Mixture of ethanol and water is placed in flask and heated.
- Ethanol with lower boiling point boils and vaporises first and reach fractionating column then cools and condenses into ethanol as it passes through condenser.
- Temperature will stay constant until all ethanol is distilled.
- A mixture of gases condenses on the beads in the fractional column. So the beads are heated to the boiling point of the lowest substance in this case, so that the substance being removed cannot condense on the beads. The other substances continue to condense and will drop back into the flask.
- Water will distil the same way after all ethanol is distilled.

MATTER

By end of the topic learners will be able to

- *o*
- *Describe ionic and covalent bonding*
- *Define the Avogadro number*
- *State the relationship between the mole and molecular mass (Mr)or atomic mass (Ar)*
- *Calculate empirical formula and molecular formular*
- *Calculate concentration of solutions in mole/dm^3 and g/dm^3*

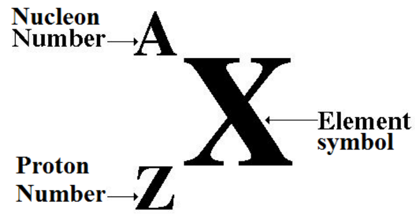
ATOMS

- Is the smallest particle of an element that can take part in a chemical reaction.
- Each atom consist of a very small, very dense nucleus, which contains protons and neutrons, surrounded by orbiting electrons

Name the sub-atomic particles, their relative charges, masses and position in the atom

Particle	Position	Charge	Mass
Proton	Nucleus	+1	1
Neutron	Nucleus	0	1
Electron	Atomic shells	-1	$\frac{1}{1840}$

NUCLIDE NOTATION



- E.g. the element carbon may be represented like this

  $^{12}_{6}c$ Meaning carbon has 12 nucleons of which 6 are protons. C is the chemical symbol for the element.

Define relative mass / mass number

- Is the number of protons and neutrons in a nucleus (nucleons)

Define the proton number / atomic number

- Is the number of protons in the nucleus of an atom.

- The atom has no charge (electrically neutral) because the number of electrons is equal the number of protons.

Isotopes

- Are atoms of the element with same number of protons and electrons but different number of neutrons in the nucleus e.g.

  1. Chlorine has two isotopes i.e. $^{35}_{17}Cl$ and $^{37}_{17}Cl$

  2. Oxygen has two isotopes i.e. $^{16}_{8}O$ and $^{18}_{8}O$

  3. Carbon has two isotopes i.e. $^{12}_{6}C$ and $^{16}_{6}C$

<u>Calculation of number of neutrons</u>

Number of neutrons = mass number – proton number

Chlorine 35 has (35 – 17) = 18 neutrons

Chlorine 37 has (37 – 17) = 20 neutrons

Oxygen 16 has (16 – 8) = 8 neutrons

Oxygen 18 has (18 – 8) = 10 neutrons

Carbon 12 has (12 – 6) = 6 neutrons

Carbon 16 has (16 – 6) = 10 neutrons

THE PERIODIC TABLE

- Is way of classifying elements
- Elements are arranged in order of increasing proton number.
- Periods are rows in the periodic table. It shows the number of shells the elements have
- Groups are columns in the periodic table. Group number shows the number of electrons in the outer most shell.
- Metals are elements in group I, II and III except Boron and Hydrogen
- Non metals are elements in group IV, V, VI, VII including hydrogen and boron
- Group 7 Halogens
- Group 8 Noble gases

DATA SHEET

The Periodic Table of the Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86
Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89 †															

*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	162 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	Pa Protactinium 91	238 U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

Key

a X b	a = relative atomic mass X = atomic symbol b = proton (atomic) number

INSERT II

Name the first 20 elements in the periodic table stating their symbols

1.	Hydrogen	H	11.	Sodium	Na
2.	Helium	He	12.	Magnesium	Mg
3.	Lithium	Li	13.	Aluminium	Al
4.	Beryllium	Be	14.	Silicon	Si
5.	Boron	B	15.	Phosphorus	P
6.	Carbon	C	16.	Sulphur	S
7.	Nitrogen	N	17.	Chlorine	Cl
8.	Oxygen	O	18.	Argon	Ar
9.	Fluorine	F	19.	Potassium	K
10.	Neon	Ne	20.	Calcium	Ca

Write the electronic configuration of the first 20 elements

- Is the arrangement of electrons in an atom

Hydrogen	1	Sodium	2.8.1
Helium	2	Magnesium	2.8.2
Lithium	2.1	Aluminium	2.8.3
Beryllium	2.2	Silicon	2.8.4
Boron	2.3	Phosphorus	2.8.5
Carbon	2.4	Sulphur	2.8.6
Nitrogen	2.5	Chlorine	2.8.7
Oxygen	2.6	Argon	2.8.8
Fluorine	2.7	Potassium	2.8.8.1
Neon	2.8	Calcium	2.8.8

The shells fill in order, from lowest energy level to highest energy level

- The first shell is filled before an electron can go into the second shell
- First shell accommodates 2 electrons while second, third and fourth can accommodate 8 electrons

BONDING

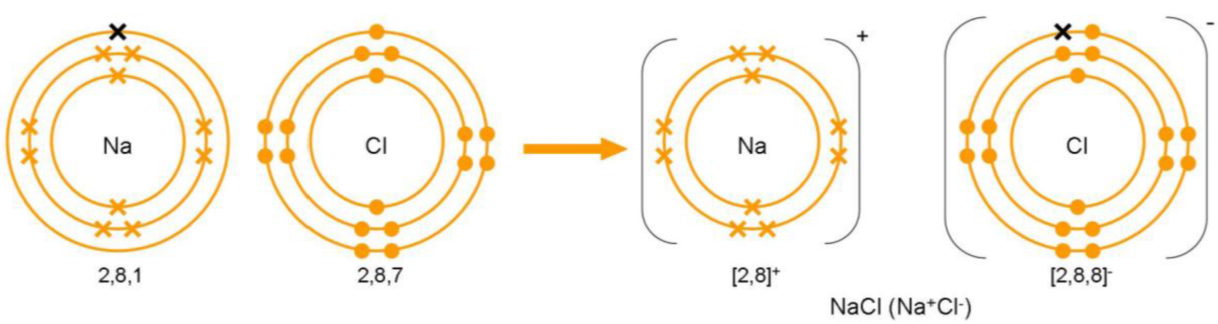
- Atoms combine with other atoms so that it has a stable configuration (noble gas configuration) by donating, accepting and sharing electrons.

Ionic bonding

- Is as a result of complete transfer of one or more electrons between metals and non- metals
- Metals (group 1-3) forms positive ions while non-metals are electron acceptors and form positive ions.

Examples

1. Sodium and chlorine react together; Sodium gives its electron to chlorine. Sodium now has 10 electrons but 11 protons so it has a positive charge while chlorine now has 18 electrons and 17 protons so it has a negative charge



2. Magnesium and oxygen

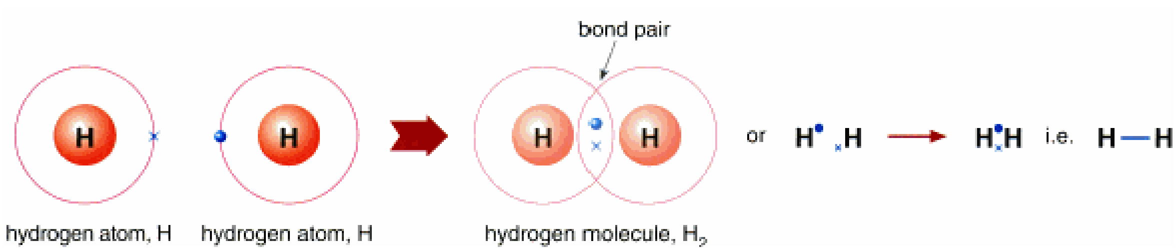
3. Sodium and oxygen

Covalent bonding

It is formed when non-metals share electrons so that each atom gains a noble gas configuration.

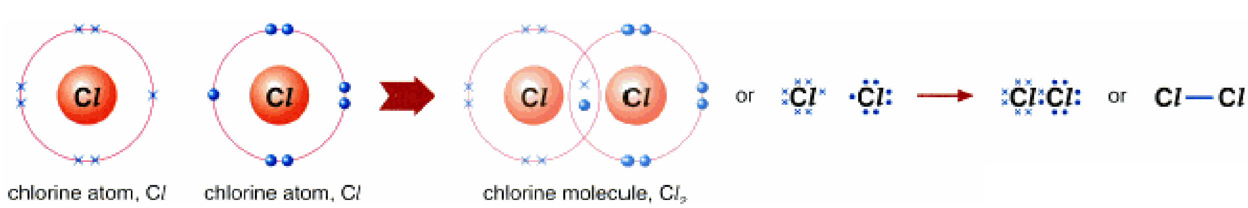
Examples

Hydrogen molecule



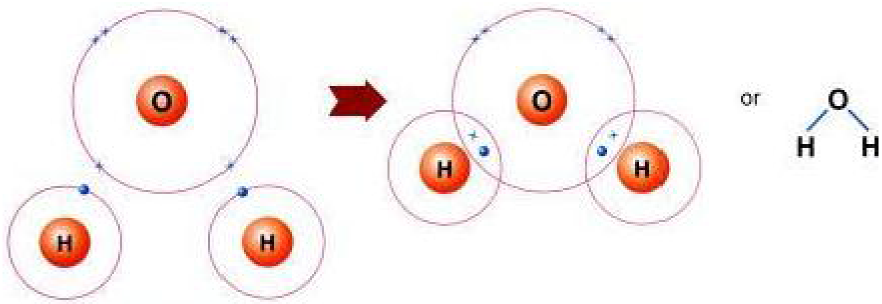
Hydrogen atom has one electron in the outermost shell. To become stable with hydrogen atom, it needs one more electron, just like helium which has 2 electrons. When 2 hydrogen atoms join, they share their electrons, on which, the share becomes 2 electrons, which is now a noble gas configuration, being shared between these 2 atoms.

Chlorine molecule



Chlorine atom has 7 electrons and needs one electron, each, to form a noble gas configuration between two Chlorine atoms. Hence they share an electron EACH to hence share 2 electrons between the atoms. Hence, each Chlorine atom now has 8 electrons which is a noble gas configuration

Water molecule



Apart from oxygen sharing between oxygen atoms, it can have electrons with other atoms. Oxygen needs 2 electrons and when bonded with hydrogen, which need an atom each, they combine to provide 2 electrons on both sides of oxygen bonded with hydrogen atoms. Each hydrogen with oxygen atom form a single bond: O – H.

THE MOLE CONCEPT

Avogadro number (L)

- Is the number of particles in one mole of an element or compound.

  $L = 6.02 \times 10^{23}$

- A mole is atomic or molecular mass expressed in grams.

- A mole is the amount of substance which contains the same number of molecules or atoms as there are atoms in 12g of $^{12}_{6}C$

  1 mol of MgO = 24 + 16 = 40g

  2 mol of HCl = 2[1 + 35.5] = 73g

  1 mol of O_2 = 2[16] = 32g

$$\textbf{Number of moles} = \frac{\textbf{mass}}{\textbf{molecular mass}} \quad \textbf{or} \quad n = \frac{m}{Mr}$$

Examples

1. Express the following in moles

(a) 10g NH_3

1mole (NH_3) = 14 + (1) 3 = 17g

10g NH_3 = $\frac{10}{17}$ = 0.59 moles

(b) 5g Na

2. Calculate the mass

(a) 0.2 moles C_2H_4

1mole (C_2H_4) = 2 (12) + 4 (1) = 28g

0.2moles =28 x 0.2 = 5.6g

(b) 0.25 moles of carbon monoxide

Molecular Mass (Mr)

- Is given by the sum of atomic masses of the elements.

Mr (NaCl) = 23 + 35.5 = 58.5g

Mr (Na_2O) = 2(23) + 16 = 62g

Mr (Na_2CO_3)

Mr (HCl)

Mr (CO_2)

Mr (NH_3)

Empirical formula

- Is a formula that shows the simplest ratio combination of atoms that form up a given substance,

Example

1. 6g of Magnesium is heated in oxygen, after cooling and reweighing it is found that there is 10g of Magnesium Oxide. Find the empirical formula for Magnesium Oxide

Ratio: Mg : O

$$\frac{6}{24} : \frac{4}{16}$$

$$= 0.25 : 0.25$$

(divide by the smallest)

$$1 : 1$$

∴empical formula =MgO

2. Calculate the empirical formulae of substances which have the following compositions by mass; 43.4% Sodium, 11.3% Carbon, 45.3% Oxygen

Ratio: Na : C : O

$$\frac{43.4}{23} : \frac{11.3}{12} : \frac{45.3}{16}$$

$$= 1.89 : 0.942 : 2.83$$

(Divide by the smallest)

$$\frac{1.89}{0.942} : \frac{0.942}{0.942} : \frac{2.83}{0.942}$$

$$= 2.01 : 1 : 3$$

∴empirical formula =Na_2CO_3

Concentration

- It is the ratio of number of moles of a solute to the volume of a solution.

$$\textbf{Concentration} = \frac{\textbf{number of moles}}{\textbf{volume}}$$

- Units are mol/dm^3 or g/dm^3

<u>Examples</u>

1. Find the number of moles of Sodium hydroxide in $25cm^3$ of solution of concentration $0.1mol/dm^3$

   Number of moles = concentration x volume

   = 0.1 x 25

   = 0.0025

2. Find volume of solution of concentration 2 mol/dm^3 that contain 0.005 moles of hydrochloric acid.

   $$\text{Volume} = \frac{\text{number of moles}}{\text{concentration}}$$

   $$= \frac{1000 \times 0.005}{2}$$

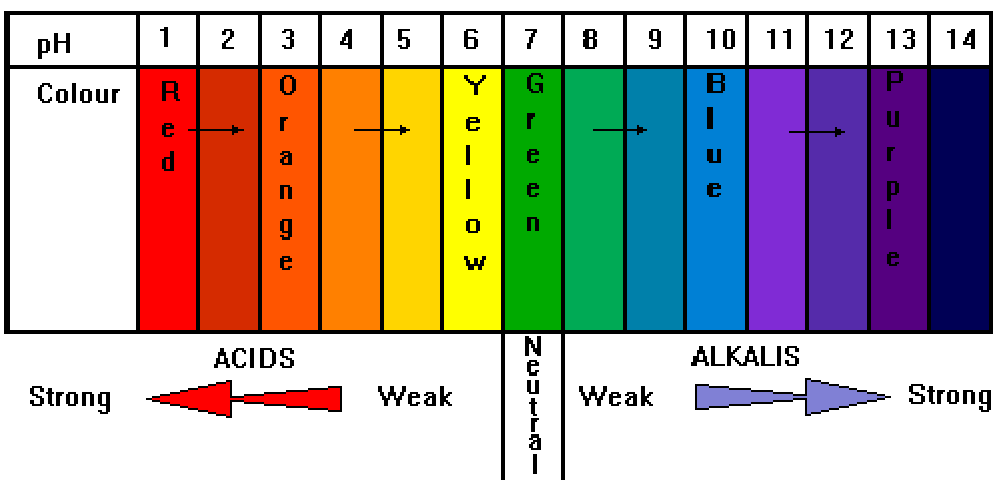
   $= 25cm^3$

ACIDS, BASES AND SALTS

Identify the regions of acidity, neutrality and alkalinity of substance on the pH scale and using universal indicator solution

The pH scale and Universal indicator

- Is the numerical measure of the acidity or alkalinity of a solution.
- The pH scale ranges from 0-14
- Acids have pH values less than 7 while alkaline have pH values greater than 7.
- If a solution has a pH value of 7 it is neutral.
- Universal indicator is used to measure the pH of a solution



Describe the reactions of acids with metal and bases

Write word and chemical equations for reactions

Reaction of acids with metals

- When an acid reacts with metal, hydrogen is displaced, leaving a salt in solution

Magnesium + sulphuric acid $\longrightarrow$ magnesium sulphate + hydrogen

$Mg\ (s) + H_2SO_4\ (aq) \longrightarrow MgSO_4\ (aq) + H_2\ (g)$

$Zn\ (s) + 2HCl\ (aq) \longrightarrow ZnCl_2\ (aq) + H_2\ (g)$

Reaction of acids with bases

- Bases reacts with acids and neutralize them, giving salt and water. During neutralization H^+ ions combine with OH^- ions to form water

  $H_2SO_4\ (aq) + 2NaOH\ (aq) \longrightarrow 2NaSO_4\ (aq) + H_2O\ (l)$

Reaction of acids with carbonates

- Carbonates react with acids to give salt, water and carbon dioxide. There is fizzing or effervescence.

  $CaCO_3\ (s) + 2HCl\ (aq) \longrightarrow CaCl_2\ (aq) + H_2O\ (l) + CO_2(g)$

  $MgCO_3\ (s) + H_2SO_4\ (aq) \longrightarrow MgSO_4\ (aq) + H_2O\ (l) + CO_2(g)$

  $CaCO_3\ (s) + 2HNO_3\ (aq) \longrightarrow Ca(NO_3)_2 + H_2O\ (l) + CO_2(g)$

INDUSTRIAL PROCESSES

Outline production of nitrogen and oxygen

- Air is cooled to -78°C and carbon dioxide and water are removed as solids.
- Remaining gases are compressed, cooled and allowed to expand rapidly causing further cooling.
- The process is repeated and temperature drops to – 200°C; oxygen and nitrogen

are liquefied.

- Liquid air is pumped into a fractionating column and it is fractionally distilled.
- The nitrogen, which has a boiling point of – 196°C, is collected from the top of the column because it evaporates first.
- The oxygen, which has a boiling point of – 183°C, remains a liquid and is removed from the bottom of the column

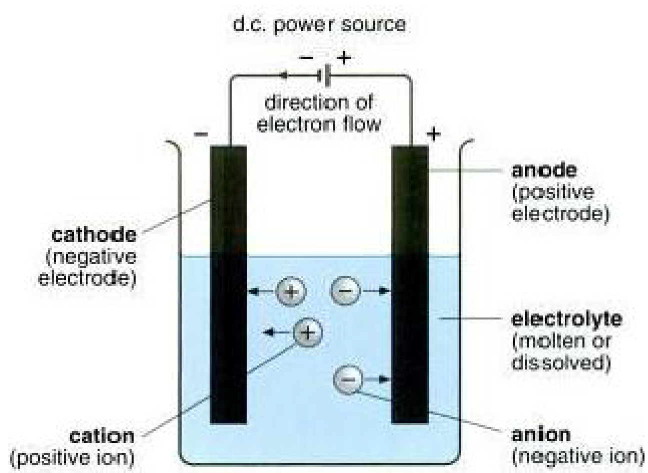
ELECTROLYSIS

Define electrolysis

- It is a process in which electricity is used to break compounds to their elements.

ELECTROLYTIC CELL

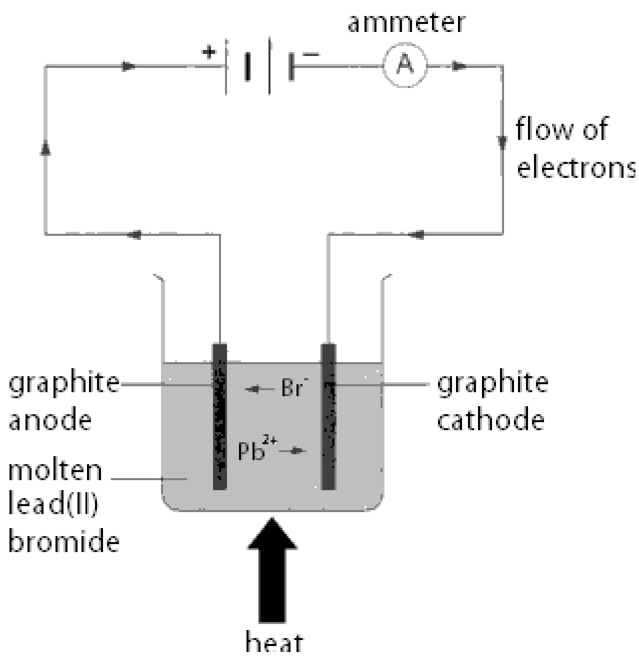
Label the general components of an electrolytic cell



ELECTROLYSIS OF MOLTEN LEAD BROMIDE

Describe anode and cathode reactions for electrolysis of molten lead bromide

State observations for the electrolysis of molten lead bromide



- To make molten lead (II) bromide, $PbBr_2$, we strongly heat the solid until it melts. To electrolyse it, pass current through the molten $PbBr_2$.
- Ions Present are Pb^{2+} and Br^-
- At the cathode lead ions gains electrons to form lead atoms. The lead will form a liquid at the bottom of the reaction vessel.

Pb^{2+} + $2e^-$ $\longrightarrow$ Pb (lead metal)

- At the anode bromide ions loses electrons to form bromine atoms which combine to form molecules of bromine gas/vapour. Bromine appears as a brown gas at the anode.

$2Br^-$ (aq) $\longrightarrow$ Br_2 (g) + $2e^-$

<u>Overall Equation</u>

$PbBr_2(l)$ $\longrightarrow$ $Pb(l)$ + $Br_2(g)$

ELECTROLYSIS OF WATER

Describe the electrolysis of water

- Inert platinum/carbon electrodes are used as electrodes.
- Water is acidified to
- Water is broken into hydrogen and oxygen in the ratios 2 : 1 respectively
- While current is flowing positive H^+ ions migrate to the cathode, accept electrons to form hydrogen atoms, which then combine to form molecules of hydrogen gas.

$$2H^+ (aq) + 2e^- \longrightarrow H_2 (g)$$

- Negative hydroxide ions migrate to the anode and give up electrons forming water and oxygen molecules.

$$4OH^- (aq) \longrightarrow 2H_2O (l) + O_2 (g) + 2e^-$$

State products formed during electrolysis of water

- Hydrogen
- Oxygen

State uses of oxygen and hydrogen

Uses of oxygen

1. Manufacture of steel
2. Cutting and welding metals
3. Medical purposes

Uses of hydrogen

1. Manufacture of ammonia

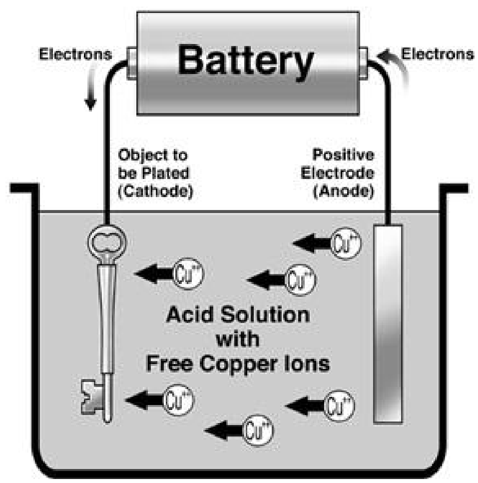
2. Manufacture of margarine

3. Welding

COPPER PLATING

State the cathode, anode and electrolyte during copper electroplating

- Anode is copper
- Cathode is the iron nail.
- Acidified copper sulphate solution is the electrolyte.



Explain the cathode process

- Copper atoms lose electrons to become copper ions which move to the cathode where they gain electrons to become copper atoms.
- The atoms stick to the iron nail, giving it a thin coating of copper

State reasons for electroplating materials

1. Prevent corrosion or rusting

2. Decoration

OXIDATION AND REDUCTION

Define oxidation and reduction

OXIDATION

- Is gain of oxygen or
- Loss of hydrogen or
- Loss of electrons

REDUCTION

- Loss of oxygen or
- Gain of hydrogen or
- Gain of electrons

Reaction of copper oxide with hydrogen

- Hydrogen removes oxygen from copper (II) Oxide.
- The copper oxide is reduced while hydrogen is oxidized to form water.

$$CuO\,(s) \quad + \quad H_2 \longrightarrow Cu\,(s) \quad + \quad H_2O\,(l)$$

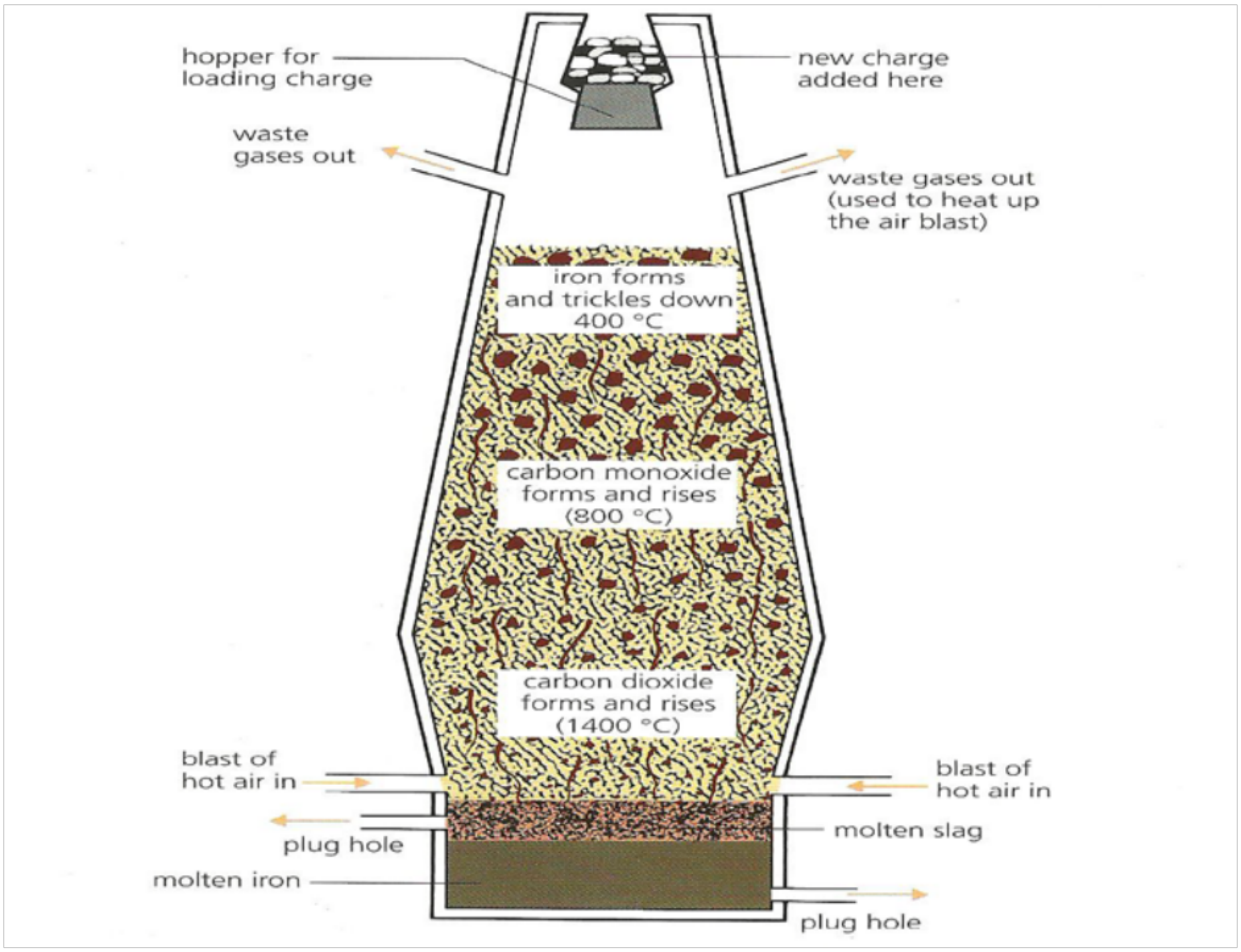
EXTRACTION OF IRON AT ZISCO

List raw materials used in the extraction of iron, their source and functions

Raw materials	Source	Uses
Limestone/$CaCO_3$		

Haematite/Iron ore/Fe_2O_3	Redcliffe/Buchwa/Ripple creek	
Coke/ Carbon	Hwange	
Hot air/Oxygen	Sable Chemicals	

The Blast Furnace



Describe reactions in the blast furnace

1. Near the bottom of the furnace, the carbon in coke combines with oxygen to give carbon dioxide.

$$C\,(s) + O_2 \longrightarrow CO_2\,(g) + \text{Heat}$$

2. In the middle of the furnace the iron oxide is reduced by carbon in the coke and the carbon monoxide reacts with iron(III) oxide to produce molten iron, which runs down to the bottom of the furnace

$$Fe_2O_3\,(s) + 3CO \longrightarrow 2Fe\,(l) + 3CO_2\,(g)$$

$$Fe_2O_3\,(s) + 3C \longrightarrow 2Fe\,(l) + 3CO\,(g)$$

- The molten iron collects at the bottom of the furnace

3. The limestone is decomposed by heat to give calcium oxide

$$CaCO_3\,(s) \longrightarrow CaO\,(s) + CO_2\,(g)$$

4. Iron ore contains many impurities (silicon, sulphur, phosphorus, etc.) Sand (silica), SiO_2, reacts with calcium oxide to produce slag (calcium silicate). Slag runs down to the bottom of the furnace, floating on top of molten iron

$$CaO\,(s) + SiO_2\,(s) \longrightarrow CaSiO_3\,(l)\ \text{(slag)}$$

- Molten iron & slag tapped off separately in furnace. Slag is for road construction.

<u>Heating Iron Oxide on a charcoal block</u>

ORGANIC CHEMISTRY

HYDROCARBONS

Define the term hydrocarbon

- Are compounds of hydrogen and carbon only e.g. Alkanes and alkenes.

Name the members of the homologous series with 3 carbon atoms

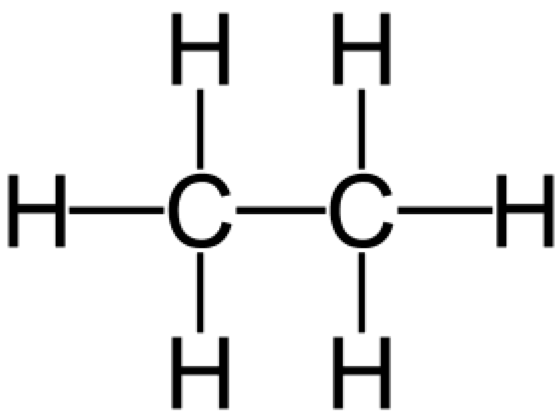
- Alkanes are hydrocarbons that have only a single C – C or C – H bond. They have a general formula $\mathbf{C_nH_{2n+2}}$ e.g. Methane (CH_4), Ethane (C_2H_6) and Propane (C_3H_8)

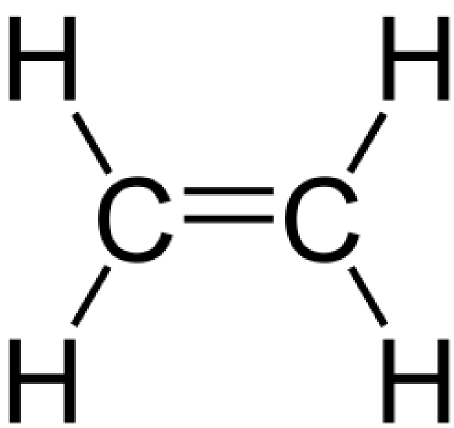
- Alkenes are hydrocarbons with a double C = C bond. They have a general formula $\mathbf{C_nH_{2n}}$ e.g. ethene (C_2H_4) and Propene (C_3H_6)

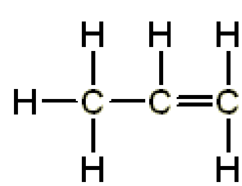
Draw the displayed structures of methane, ethane, propane, ethene and propene

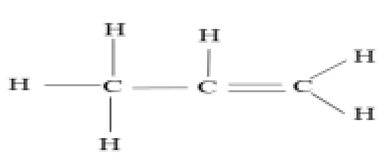
Alkanes

Methane









State uses of methane, ethane, propane, ethene and propene

BIOGAS

Outline production of biogas

- Is produced by anaerobic decomposition (fermentation) of biological wastes to recover energy from wastes.
- Fresh cow dung is collected and then mixed with water to form sludge.
- As the bacteria in the digester digest the sludge, biogas is given off and is either collected or directly used.
- The digested sludge (slurry) is collected and used as a fertiliser.
- The digester is built underground so that the heat produced during decomposition is retained and facilitates further decomposition of the cow dung

Identify factors affecting the production of biogas

- Nature of waste
- Time
- Anaerobic bacteria
- pH between 6 & 7
- Suitable temperature of about 35-55^{o}C
- Air

State uses of biogas

1. Cooking

2. Lighting
3. Operating a refrigerator

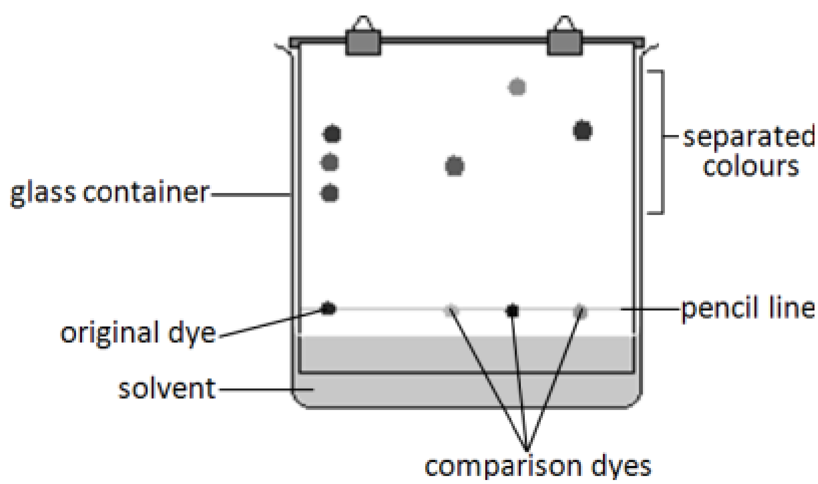
FORM FOUR

SEPARATION

Describe paper chromatography

Chromatography

- It is a method of separating and identifying mixtures.



- Obtain a dye sample then put a drop of the sample on a pencil line drawn on the filter paper then dip the paper into a solvent with the level below the spot. The dye will dissolve in solvent and travel up the paper at different speed. Hence they are separated.

State the application of paper chromatography

1. Separates and identify mixtures of coloured substances in dyes
2. Separates substances in urine, drugs & blood for medicinal uses
3. To find out whether athletes have been using banned drugs

MATTER

Describe the properties of group I, II, VII and VIII

Group I Elements – The Alkali Metals

- These are metals which react with water to form alkaline solutions. The solutions turn red litmus paper blue.
- Most reactive metals in periodic table
- Have one outer shell electrons
- Shiny, silvery solids
- Soft, easily cut with scalpel
- Low densities & melting points. These increases down the group
- Reacts easily in air. So they're kept in oil
- Reacts vigorously (may catch fire or explode) with cold water
- They make ionic compounds of +1 charge. They have similar formulae
- They become reactive down the group

Group VII Elements – The Halogens

- These are elements which react with most metals to form salts
- Very reactive elements
- Have seven outer shell electrons
- Each molecule in the element is diatomic (contains two atoms, e.g. F_2)
- Elements become darker and solidify down the group
- They have low melting and boiling points which increases down the group
- All halogens are poisonous

- Halogens become less reactive down the group
- More reactive halogen displaces less reactive halogen e.g. aqueous fluorine was added into sodium bromide solution.

Group 0 Elements – The Noble Gases

- Are least reactive elements in the state of gas. They do not form bonds
- Have stable electronic configuration with full electrons on their shells
- Coloured gases consisting of single atoms (mono-atomic)
- Low melting and boiling points

State uses of halogens

- Water purification e.g. chlorine
- Making chlorofluorocarbons (aerosols) e.g. fluorine
- Making pesticides e.g. fluorine
- Making bromine water e.g. Bromine
- Making iodised salts e.g. Iodine
- Making hydrochloric acid e.g. Chlorine
- Bleaching agents e.g. chlorine in wood pulps

Describe the reactions of metals with water, steam, air and dilute acids

Write equations for the reaction of metals with oxygen, dilute acids and water

Reaction of Metals with Water

- Potassium, Sodium and Calcium reacts vigorously with cold water t

  $2K(s) + 2H_2O\ (l) \rightarrow 2KOH\ (aq) + H_2\ g)$

  $2Na(s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + H_2\ (g)$

  $2Ca(s) + 2H_2O\ (l) \rightarrow 2CaOH\ (aq) + H_2\ (g)$
- Magnesium reacts very slowly with cold water but vigorously with steam
- Zinc do not react with cold water but reacts slowly with steam
- Iron reacts with steam but does not react with cold water. Rusting occurs very

slowly in the presence of oxygen.

$Mg (s) + H_2O (g) \longrightarrow MgO (s) + H_2 (g)$

$Zn (s) + H_2O (g) \longrightarrow ZnO (s) + H_2 (g)$

$3Fe (s) + 4H_2O (g) \longrightarrow Fe_3O_4 (s) + H_2 (g)$

- Copper have no reaction with water and steam

Reaction of Metals with dilute Acids

- Potassium and Sodium reacts explosively to with acids.
- Calcium reacts vigorously with dilute acids.
- Magnesium reacts very fast with dilute acids.
- Zinc reacts moderately with dilute acids
- Iron reacts slowly with dilute acids

$2K(s) + 2HCl (aq) \longrightarrow 2KCl (aq) + H_2(g)$

$2Na(s) + 2HCl (aq) \longrightarrow 2NaCl (aq) + H_2(g)$

$Ca(s) + 2HCl (aq) \longrightarrow CaCl_2 (aq) + H_2(g)$

$Mg(s) + 2HCl (aq) \longrightarrow MgCl_2 (aq) + H_2(g)$

$Zn(s) + 2HCl (aq) \longrightarrow ZnCl_2 (aq) + H_2(g)$

$Fe(s) + 2HCl (aq) \longrightarrow FeCl_2 (aq) + H_2(g)$

- Lead reacts with warm hydrochloric acid slowly
- Copper has no reaction with dilute hydrochloric acid

Reaction of metals with oxygen

- Potassium tarnishes in the presence of oxygen
- Sodium burns with a yellow flame
- Copper powder burns with dull red glow
- Iron powder burns with bright yellow flame
- Magnesium burns with a bright white flame to produce white solid

$4K(s) + O_2 (g) \longrightarrow 2K_2O (s)$

$4Na(s) + O_2 (g) \longrightarrow 2Na_2O (s)$

$2Cu(s) + O_2 (g) \longrightarrow 2CuO (s)$

$3Fe(s) + 2O_2 (g) \longrightarrow Fe_3O_4 (s)$

$2Mg(s) + O_2 (g) \longrightarrow 2MgO (s)$

REACTIVITY SERIES

List metals in order of decreasing reactivity

Predict the reactivity of a metal from its position in the reactivity series

- Metals can be arranged in order of their reactivity.
- The reactivity series is based on the reaction of metals with water of dilute hydrochloric acid.
- When metal reacts, the atom loses electrons to become an ion. The more readily a metal gives up electrons to form ions, the more reactive it is.

  Potassium

  Sodium

  Calcium

  Magnesium

  Aluminium

  Zinc

  Iron

  Lead

  Copper

  Silver

ACIDS, BASES AND SALTS

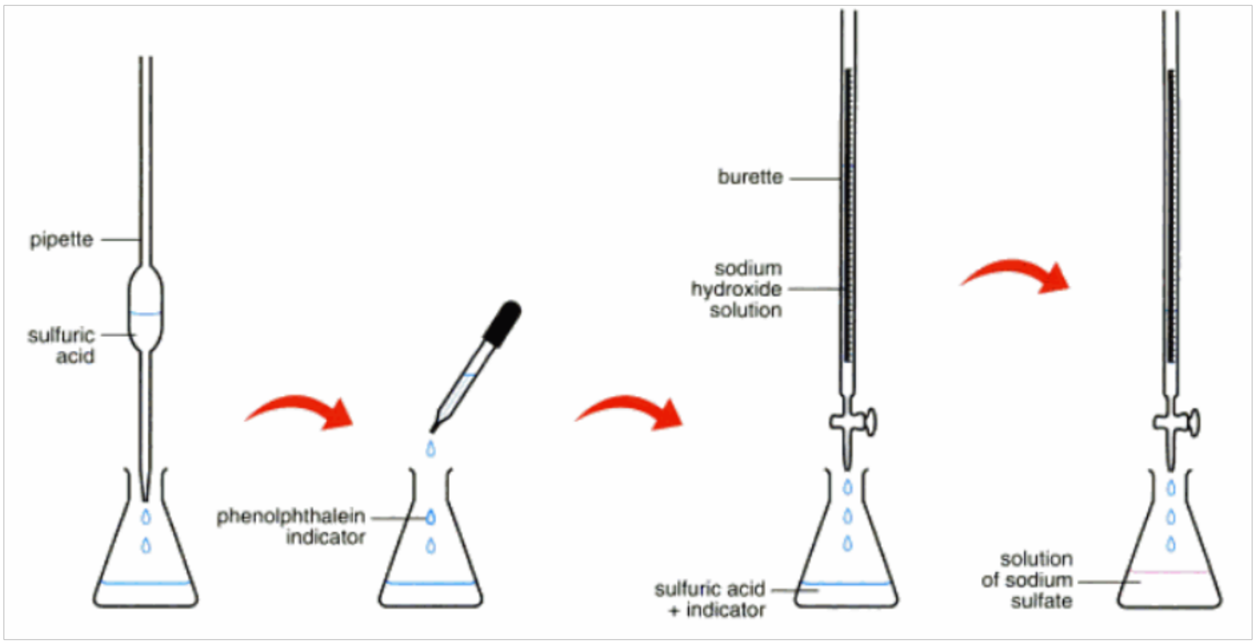
TITRATION

- Technique used to find the concentration of acids and to make soluble salts from an acid and an alkaline e.g. finding the concentration of ethanoic acid in a sample of vinegar.

Identify apparatus used in a titration

- A pipette
- Phenolphthalein.
- A burette

Describe an acid-base titration procedure



- Using a pipette, 25cm^3 of Hydrochloric acid is placed in a conical flask. A few drops of indicator e.g. Phenolphthalein are added.

- Dilute Hydrochloric acid is placed in a burette and then released into conical flask until the indicator changes colour which means all the acid has just reacted. The volume of alkali added from the burette to acid is measured.

- The experiment is now repeated. 25.0cm^3 of Hydrochloric acid is placed in a titration flask as before, but no indicator is added.

- The NaOH is placed in a burette and the same volume of this alkali is added to the flask as before.

- The flask then contains a solution of sodium chloride without excess acid or alkali.

- The sodium chloride is obtained by evaporating most of the water and crystallizing the salt.

INDUSTRIAL PROCESSES

AMMONIA

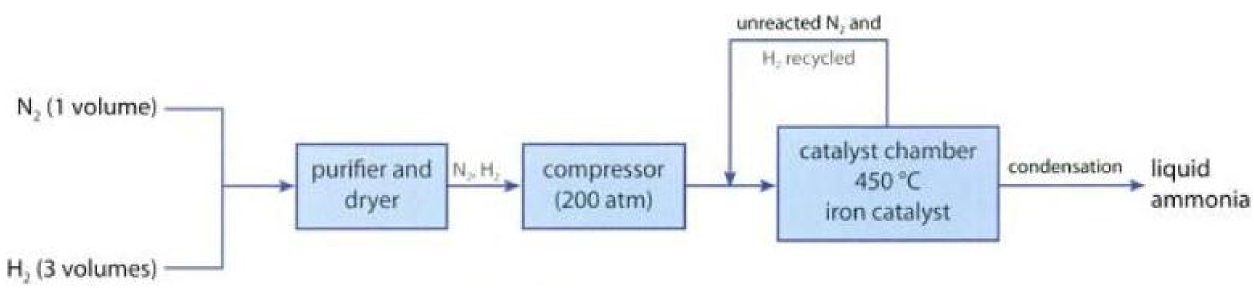
State conditions needed for the production of ammonia

List raw materials used to manufacture ammonia

Describe manufacture of ammonia

The Haber Process

- Nitrogen and hydrogen are mixed together in ratio 1:3, where nitrogen is obtained from air and hydrogen is obtained from natural gas, and passed over iron catalyst



State the industrial uses of ammonia

For producing fertilisers, nitric acid, nylon, dyes, cleaners and dry cell

List raw materials used to manufacture sulphuric acid

Describe manufacture of sulphuric acid

State conditions needed for the production of sulphuric acid

State uses of sulphuric acid

- Making of fertilizers such as superphosphate and ammonium sulphate
- Making detergents
- Cleaning surfaces of iron and steel surface before galvanization or electroplating
- To manufacture plastics and fibres
- As electrolyte in car batteries
- In refining of petroleum
- In production of dyes, drugs, explosives, paint, etc.

OXIDATION AND REDUCTION

By end of the topic learners will be able to

1. *List down alloys of iron*
2. *State the percentage composition of alloys of iron*
3. *Explain uses and properties of alloys of iron*

ORGANIC CHEMISTRY

By end of the topic learners will be able to

- *State the homologous series to which ethanol belongs*
- *Draw the displayed structural formula of ethanol*

Describe the production of concentrated ethanol

- Ethanol is produced from the fermentation of sugar, maize or glucose
- Ethanol is concentrated by fractional distillation

- Dilute ethanol solution is pumped into the middle of the distillation column.
- The ethanol boils off first since its boiling point of $78^{o}C$ is lower than that of water.
- Its vapour passes through the condenser and cools back into liquid which collects in the flask at the end of the condenser.
- Water which boils at $100^{o}C$ remains in the heated flask.
- The fractionating column is cooled at the top, so that any liquid boiling at higher temperature than $78^{o}C$ will condense and run back into the flask.
- Only ethanol reaches the top of the column as a vapour

List uses of ethanol

- Beverages
- Solvent
- Medical purposes
- To produce cosmetics, detergents, plastics and lubricants
- Fuel
-

Define the term global warming

List the causes of global warming