S4 CHEMISTRY SUMMARY NOTES

1. The Mole

One mole of a substance = GRAM FORMULA MASS

e.g. H_2SO_4 RAM from databook pg.7

2H	2 x 1	=	2
1S	1 x 32	=	32
4O	4 x 16	=	64
			98g

Mass = number of moles x Mass of 1 mole

m = n × GFM

e.g. mass of 2 moles H_2SO_4 = 2 x 98g = 196g

-

$$n = \frac{m}{GFM}$$

e.g. how many moles present in 196g of H_2SO_4?

$$\text{number of moles} = \frac{196}{98} = 2 \text{ moles}$$

2.Calculations from Balanced Equations

eg. Calculate the mass of $MgSO_4$ produced when 4.9g of magnesium reacts with excess sulphuric acid

	Mg	+	H_2SO_4	⟶	$MgSO_4$	+	H_2
RATIO	1mol				1mol		
*USED	0.2mol			→	0.2mol	**	

*WORK OUT NUMBER OF MOLES OF Mg USED

$$n = \frac{m}{GFM}$$
$$= \frac{4.9}{24.5}$$
$$= 0.2mol$$

**FIND MASS OF NUMBER OF MOLES OF $MgSO_4$

(GFM=24.5+32+64=120.5)

$$m = n \times GFM$$
$$= 0.2 \times 120.5$$
$$= 24.1g$$

3.Acids and Bases

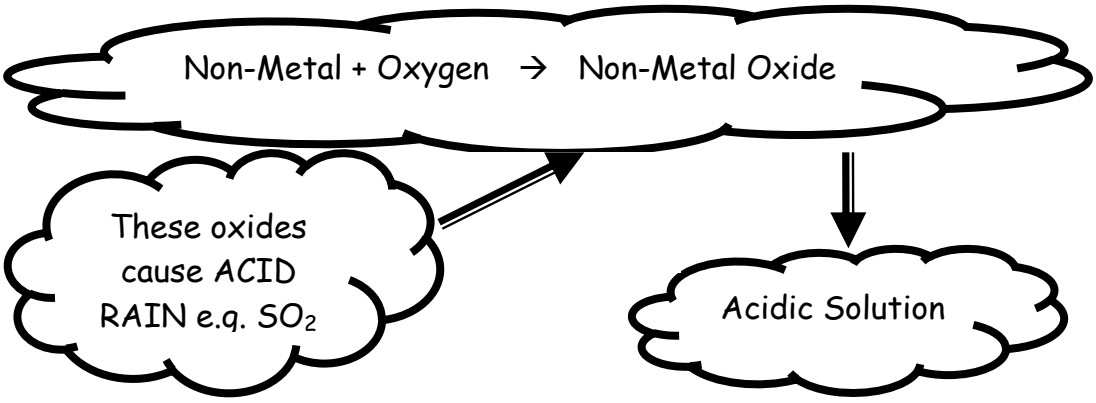
pH scale measures how acidic or alkaline a substance is.

Acids pH < 7
Neutral pH = 7
Alkalis pH > 7

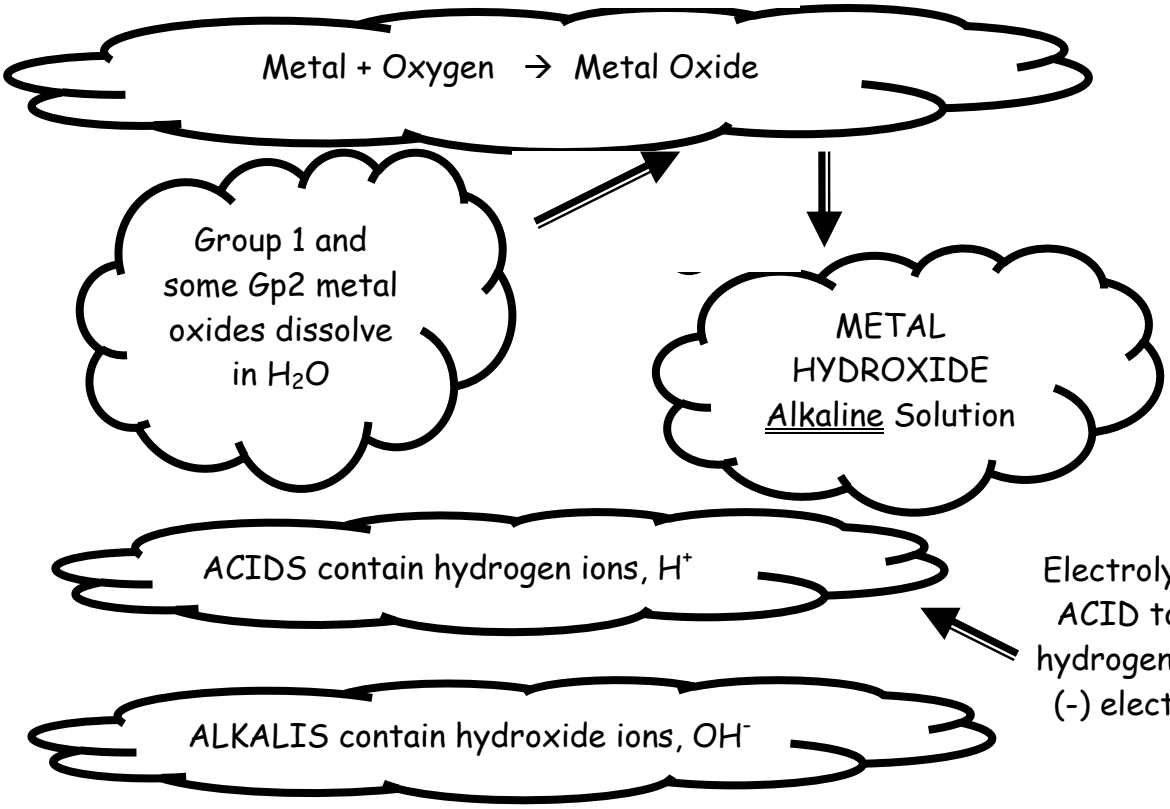
e.g. hydrochloric acid pH = 1
water pH = 7
sodium hydroxide pH = 12

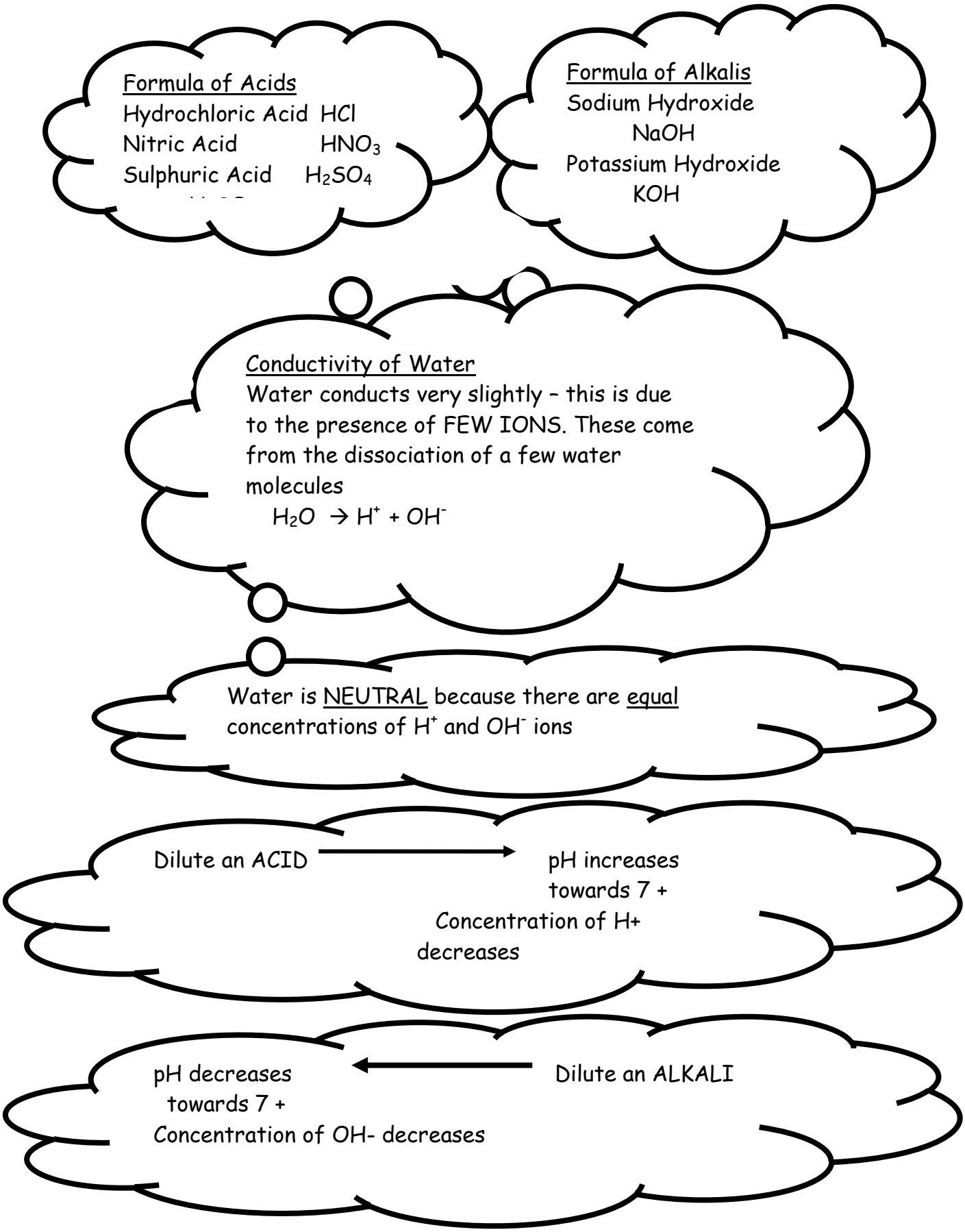
Forming acids/ alkalis from oxides

When non-metals burn in oxygen,



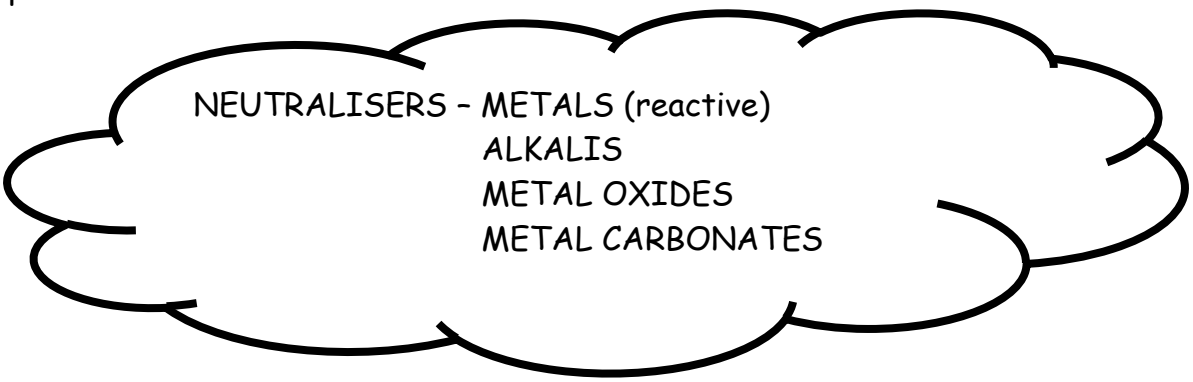
When metals burn in oxygen,




Formula of Acids
Hydrochloric Acid HCl
Nitric Acid HNO_3
Sulphuric Acid H_2SO_4
Formula of Alkalis
Sodium Hydroxide
NaOH
Potassium Hydroxide
KOH
Conductivity of Water
Water conducts very slightly – this is due to the presence of FEW IONS. These come from the dissociation of a few water molecules
$H_2O \rightarrow H^+ + OH^-$
Water is NEUTRAL because there are equal concentrations of H^+ and OH^- ions
Dilute an ACID
pH increases towards 7 +
Concentration of H+ decreases
Dilute an ALKALI
pH decreases towards 7 +
Concentration of OH- decreases

Neutralisation Reactions

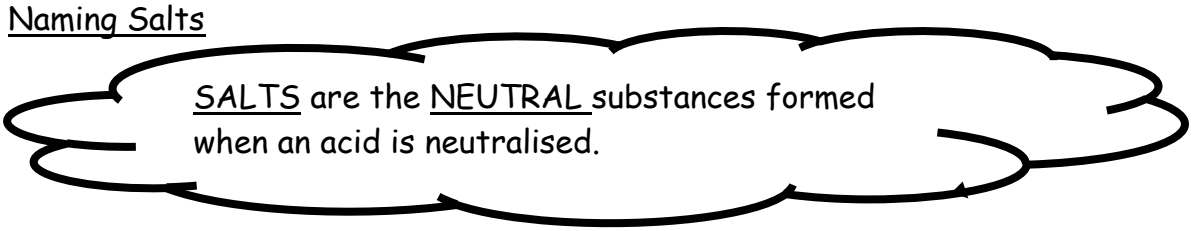
Neutralisation is a reaction of an acid with a NEUTRALISER which causes the pH to become 7



Everyday Neutralisations

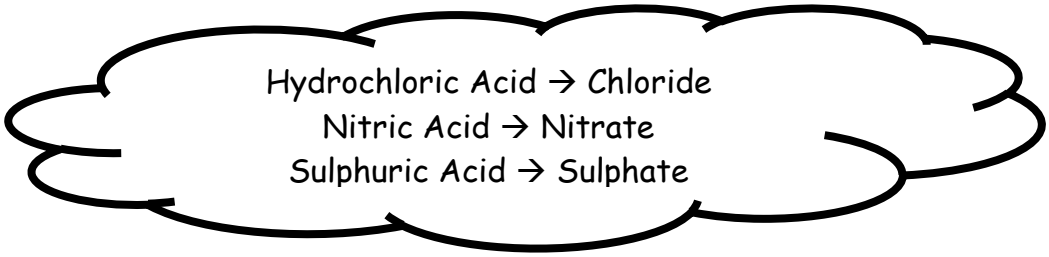
e.g. bee sting (acid) → use baking powder
wasp sting (alkaline) → use vinegar
acidic soil → lime
indigestion → indigestion remedy

Naming Salts



SALT NAME has 2 parts to it:

a. 1st part comes from the METAL name (or ammonium) of the neutraliser
b. 2nd part comes from the acid used



e.g. Sodium Hydroxide + Nitric Acid gives Sodium Nitrate

Neutralisation Reactions to make Soluble Salts

ACID + ALKALI → SALT + WATER

ACID + METAL OXIDE → SALT + WATER

ACID + METAL → SALT + HYDROGEN

ACID + METAL CARBONATE → SALT + WATER + CARBON DIOXIDE

Spectator Ions

Do not take part in the reaction
i.e. SAME ON BOTH SIDES OF EQUATION

e.g. hydrochloric acid + sodium hydroxide → sodium chloride + water

$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O$

Showing Ionic Formulae

$H^+Cl^-_{(aq)} + Na^+OH^-_{(aq)} \rightarrow Na^+Cl^-_{(aq)} + H_2O_{(l)}$

Crossing out spectator ions, equations becomes

$$H^+ + OH^- \rightarrow H_2O$$

eg. sulphuric acid + copper(ii)carbonate + → copper(ii)sulphate +water + carbon dioxide

$$H_2SO_4 + CuCO_3 \rightarrow CuSO_4 + H_2O + CO_2$$

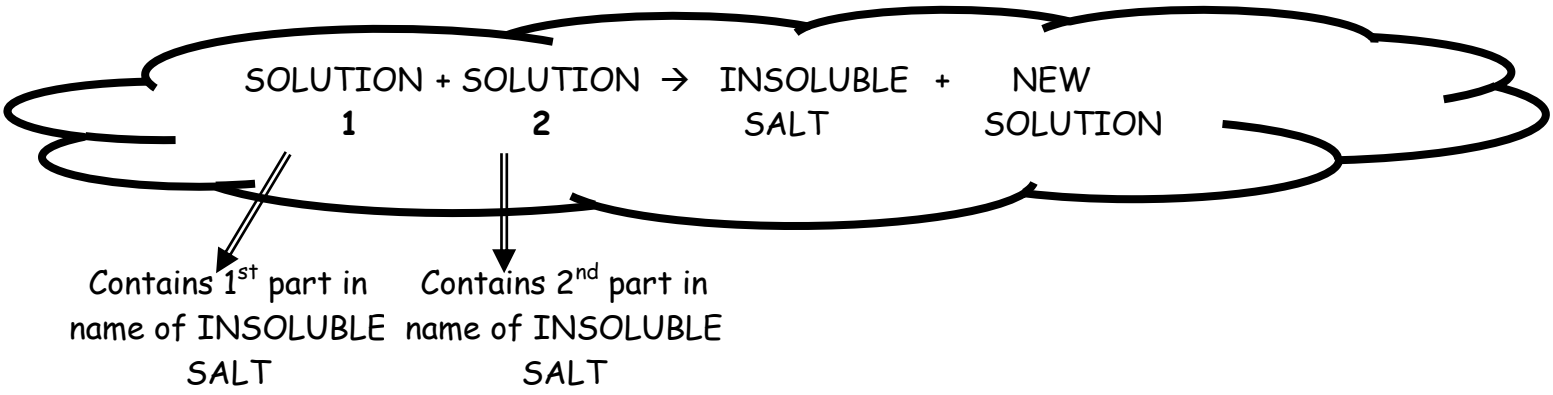
Showing Ionic Formulae

$$(H^+)_2SO_4^{2-} + Cu^{2+}CO_3^{2-} \rightarrow Cu^{2+}SO_4^{2-} + H_2O + CO_2$$

$$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$$

4. Making Insoluble Salts

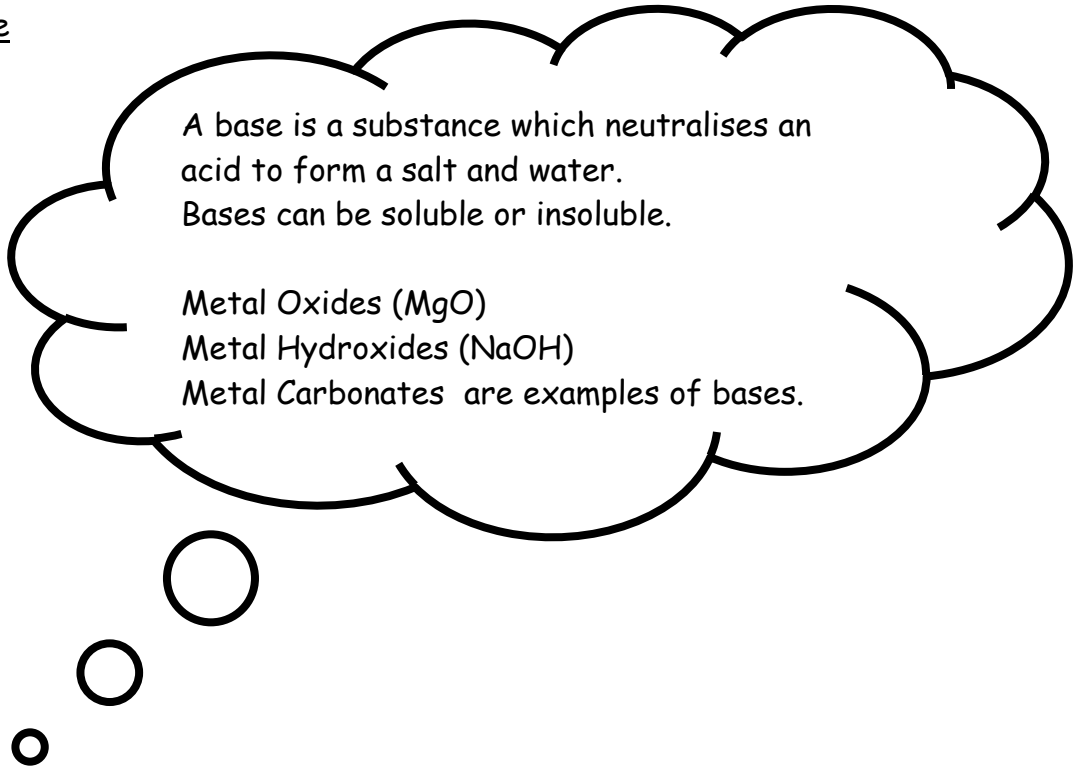
These are made by **Precipitation** where 2 solutions of soluble salts are mixed together.



e.g. Lead Nitrate + Sodium Iodide → Lead Iodide + Sodium Nitrate

$PbNO_3$ (aq) + NaI (aq) → PbI_2 (s) + $NaNO_3$ (aq)

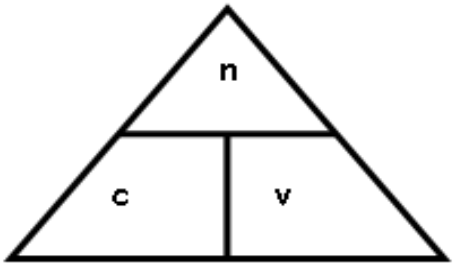
Base



5.Concentration Calculations

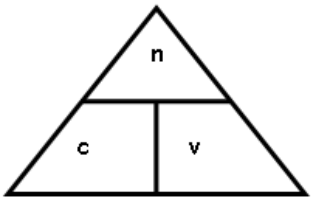
Concentration tells us the number of moles of a substance dissolved in 1 litre of solvent.

Units: **moles per litre**
mol/l or mol l^{-1}



n = number of moles
c = concentration (mol l^{-1})
v = volume (litres)

e.g. If 0.5 moles of Sodium Chloride is dissolved in 500ml of solution, what is the concentration?



n = 0.5
c = ?
v = $\frac{500}{1000}$ = 0.5l

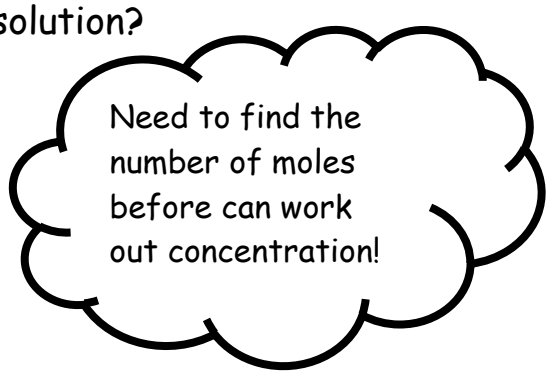
$$c = \frac{n}{V}$$

$$= \frac{0.5}{0.5} = 1 \text{ mol } l^{-1}$$

e.g. MORE COMPLICATED EXAMPLE!!!

If 6.9g of lithium nitrate ($LiNO_3$) is dissolved in 500ml of solution, what is the concentration of the solution?

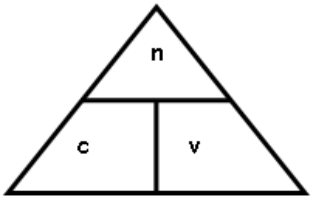
n = ?
c = ?
v = $\frac{500}{1000}$ = 0.5l



$LiNO_3$

1 Li = 1 x 7 = 7
1 N = 1 x 14 = 14
3O = 3 x 16 = $\underline{48}$
69g → 1 mole

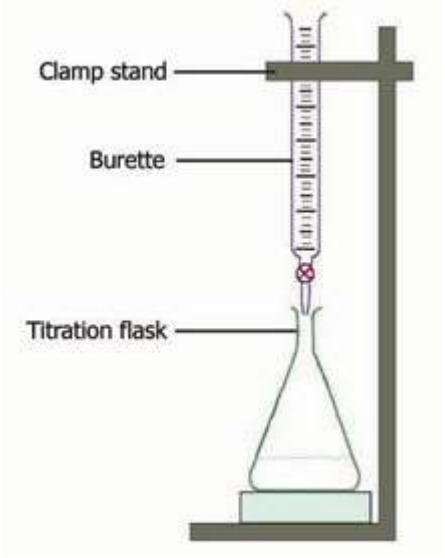
n = $\frac{\text{mass given}}{\text{mass of 1mole}}$ = $\frac{6.9}{69}$ = $\underline{0.1}$



$C = \frac{n}{v} = \frac{0.1}{0.5} = \underline{0.2 \text{ mol } l^{-1}}$

6.Titration

Titration is a technique used to find the exact volume of acid (concentration unknown) needed to neutralise a certain volume of alkali of known concentration.



Titration Calculations

e.g. 20ml of sulphuric acid (H_2SO_4) is needed to neutralise 10ml of sodium hydroxide solution (0.5 mol l^{-1}). What is the concentration of sulphuric acid used?

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

RATIO	2mol	1mol
	**	***
	0.005mol	**0.0025mol****

**FIND NUMBER OF MOLES OF NaOH THAT REACTED

$\mathbf{n = c \times V}$

$= 0.5 \times 0.01$

$= 0.005$ mol

*** FROM MOLE RATIO THIS WILL GIVE NUMBER OF MOLES OF ACID THAT REACTED.

****WORK OUT CONCENTRATION OF ACID

$$\mathbf{c} = \frac{\mathbf{n}}{\mathbf{V}} = \frac{0.0025}{0.02} = 0.125 mol l^{-1}$$

7. **Metals**

A metal's use depends on its properties e.g. copper is used in electrical cables – good conductor.

Reactions of Metals

a. METAL + OXYGEN → METAL OXIDE

$2Mg + O_2 \rightarrow 2MgO$

b. METAL + WATER → METAL HYDROXIDE + HYDROGEN

$2Na + 2H_2O \rightarrow 2NaOH + H_2$

c. METAL + ACID → SALT + HYDROGEN

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

REACTIVITY SERIES

A list of metals with most reactive metal at TOP
-similar to ELECTROCHEMICAL SERIES.

An ORE is a rock containing a METAL COMPOUND.
(a METAL OXIDE is the most common)

Extraction of metals from their ores

Extraction of a metal is an example of a REDUCTION reaction

a. By HEAT ALONE
- Only works for unreactive metals which do not hold onto oxygen very tightly

b. By HEATING WITH CARBON

METAL OXIDE + CARBON → METAL + CARBON DIOXIDE

- Only works for metals up to ZINC in reactivity series

c. By HEATING WITH CO

METAL OXIDE + CARBON → METAL + CARBON DIOXIDE
MONOXIDE

- Only works for metals up to ZINC in reactivity series

(Reactive metals need to be extracted by ELECTROLYSIS)

Carbon and carbon monoxide are examples of REDUCING AGENTS
(cause a reduction to occur, provide electrons for the reduction)

8. **BATTERIES and CELLS**

Energy change in a battery:

Chemical energy → electrical energy

(When all the chemicals get used up, the battery becomes flat)

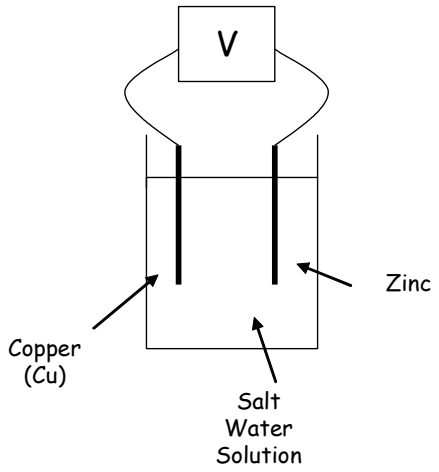
CELL is another word for a battery.

Rechargeable Batteries (e.g lead-acid battery)

Can be used again and again by recharging.

Simple Cells

Can be set up using 2 different metals and an ELECTROLYTE (solution which conducts)

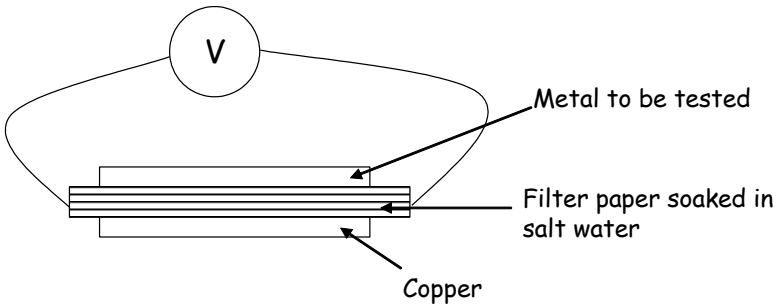


A voltage is produced

Electrochemical Series (pg. 10 Databook)

A list of metals obtained when different metals are connected in a cell to COPPER (a STANDARD)

Metal which gives biggest voltage at TOP of Electrochemical Series



Metals at TOP of Electrochemical Series lose electrons easily, and these electrons flow through the wires.

Further apart metals are in Electrochemical series the bigger the voltage.

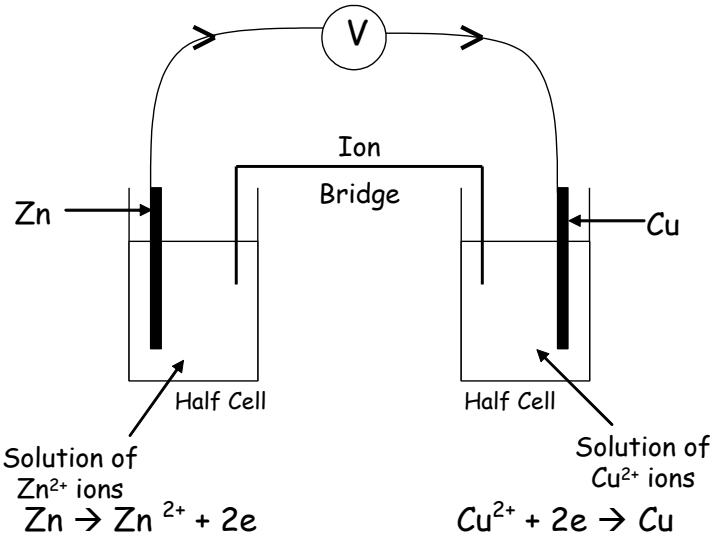
Displacement Reactions

A metal HIGHER in the Electrochemical Series will DISPLACE (push out) a metal lower from a solution

e.g. Zn will displace Cu from Cu^{2+} ions

Higher

More Cells



ION BRIDGE is needed to complete the circuit (allows ions to flow)

-
-

OXIDATION – is the LOSS of electrons by a reactant.

e.g. $Cu \rightarrow Cu^{2+} + 2e$

REDUCTION – is the GAIN of electrons by a reactant.

e.g. $Zn^{2+} + 2e \rightarrow Zn$

OIL RIG

X S O E S A
I S D I
D S U N
A C
T T
I I
O O
N N

REDOX REACTION

- Reduction and oxidation occur together.

e.g. all cell reactions, displacement reactions are REDOX

WRITING REDOX EQUATIONS

Combine the following reduction and oxidation equations:

(a) $Ag^+ + e^- \rightarrow Ag$

(b) $2Cl^- \rightarrow Cl_2 + 2e^-$

Multiply equations so that same number of electrons appear in BOTH.

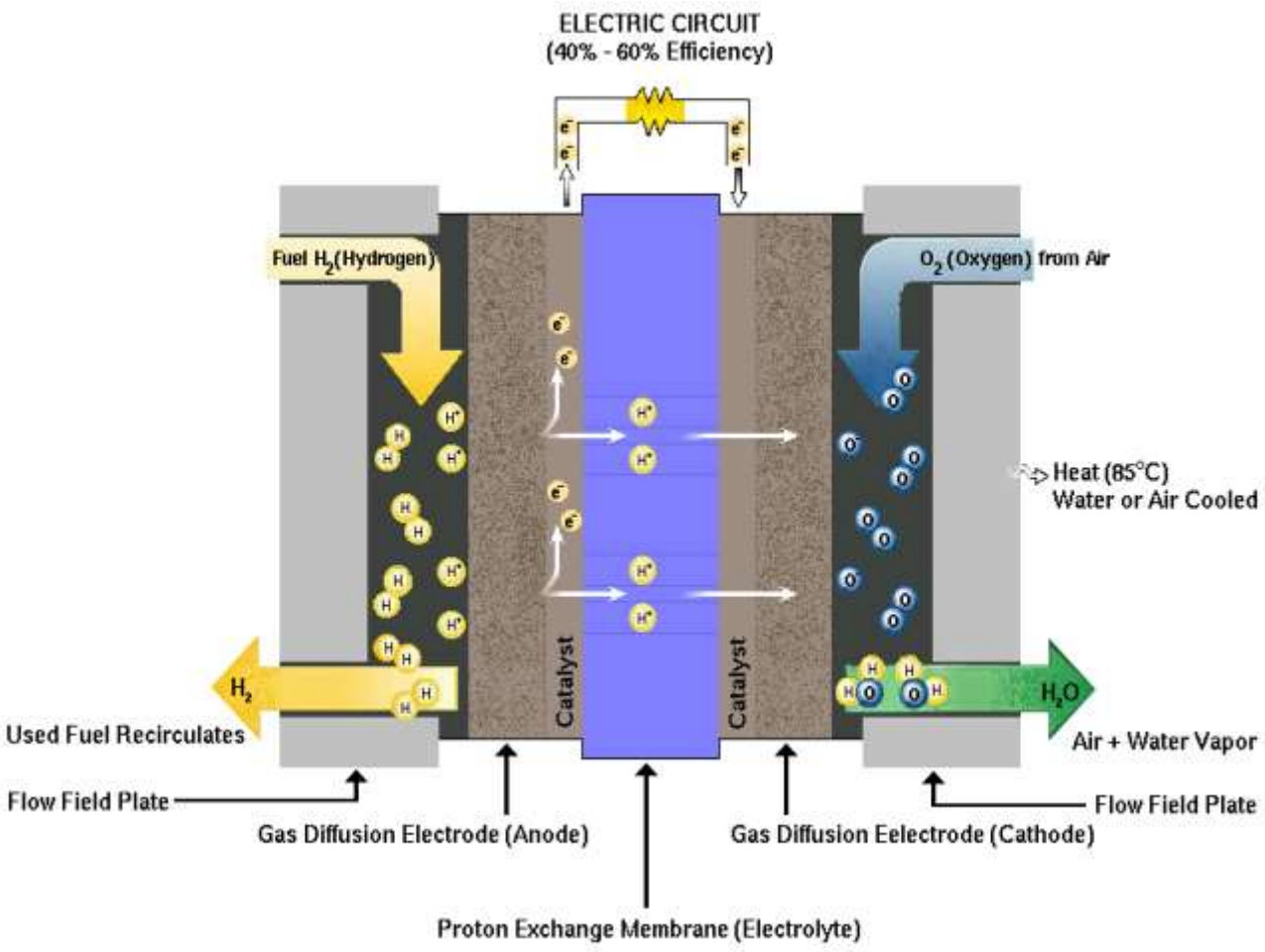
2x (a) $2Ag^+ + 2e^- \rightarrow 2Ag$

(b) $2Cl^- \rightarrow Cl_2 + 2e^-$

ADD both equations together cancelling out electrons.

$2Ag^+ + 2Cl^- \rightarrow 2Ag + Cl_2$

FUEL CELLS – these utilise REDOX reactions



A fuel cell is a device that converts chemical energy from a fuel such as hydrogen into electrical energy through a chemical reaction with oxygen or some other oxidising agent.

9. **FERTILISERS**

Plants need the elements N, P, K (essential elements)

Plants get these elements through their root in the form of soluble compounds (NUTRIENTS)

Fertilisers

- are compounds which restore essential elements (N, P, K) to the soil for plant growth.
- Can be Natural or Synthetic
- Need to be SOLUBLE

How fertilisers are made

- Ammonia (NH_3) is a very important compound in making fertilisers.

Properties of Ammonia

- Colourless gas
- Pungent smell
- Alkaline gas
- Very soluble in water forming AMMONIA SOLUTION (Ammonium hydroxide)
- Ammonium hydroxide (or ammonia) neutralises acids to form salts (fertilisers)

Haber Process

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

Reaction is REVERSIBLE

CONDITIONS TO GET BEST YIELD

- Moderately HIGH temp (400°C)
- High Pressure (200 atm)
- IRON CATALYST

If too low reaction is too slow.

The Unreacted N_2 and H_2 recycled.

Ostwald Process

- turns ammonia into NITRIC ACID (v. important for forming NITRATE fertilisers)
- PLATINUM CATALYST used
- Reaction is EXOTHERMIC (do not need to keep heating once reaction starts)

% Composition Calculations

e.g. find % of N in $(NH_4)_2SO_4$

a. FIND MASS IN 1 MOLE

$(NH_4)_2SO_4$

2N = 2 x 14 = 28
8H = 8 x 1 = 8
1 S = 1 x 32 = 32
4O = 4 x 16 = 64
132g

b. % of N = $\frac{\text{Mass of N in compound}}{\text{Mass of 1 mole}} \times 100$

$= \frac{28}{132} \times 100 \qquad = 21.2\%$

THIS METHOD IS ALSO USED TO FIND THE PERCENTAGE OF A METAL IN A METAL COMPOUND

10. **NUCLEAR CHEMISTRY**

3 TYPES OF RADIATION

(a) ALPHA α

- represented as a helium nucleus $^{4}_{2}He^{2+}$

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He$$

(b) BETA β

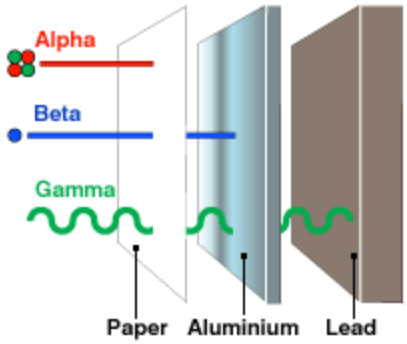
- fast moving electron thrown out by the nucleus $^{0}_{-1}e$

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$$

(c) GAMMA γ

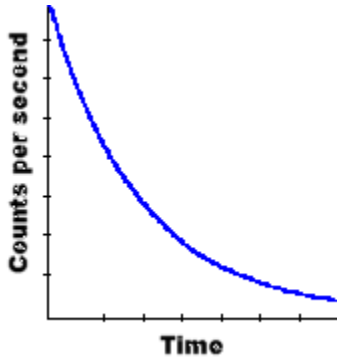
- short wave radiation

$$^{238}_{92}U \rightarrow {}^{238}_{92}U + \gamma$$



HALF-LIFE

- is the time taken for the activity of a radioisotope to **half**



USES OF RADIOISOTOPES

MEDICAL USES – beta radiation from phosphorus-32 is used to kill skin cancer

ENERGY PRODUCTION

INDUSTRIAL USES – to detect leaks in pipelines