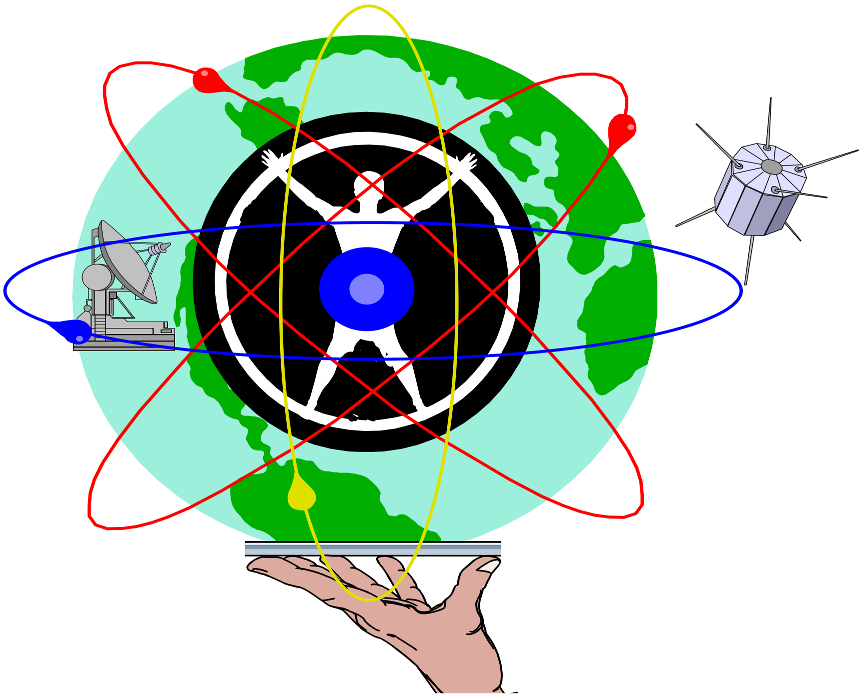
YEAR 10 SCIENCE

Advanced Chemistry Course



ADVANCED CHEMISTRY CONTENTS

CHEMICAL CALCULATIONS

THE MOLE

- **Mole Calculations notes**
- **Moles – Method of Attack Guidesheet**
- **Guide to Mole Calculations Notes**
- **What's in a mole worksheet**
- **Moles worksheet 1 and 2**

PERCENTAGE COMPOSITION

- **Percentage Composition notes**
- **Activity 9: Percentage composition of MgO**
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REACTION STOICHIOMETRY (CALCULATIONS INVOLVING EQUATIONS)

- **How to do Calculations Involving Chemical Equations Sheet**
- **Calculations Involving Chemical Equations – Type Examples**
- **Calculations from Equations Flowchart (An Alternative Method)**
- **Activity 11: Decomposition of sodium hydrogencarbonate**
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CHEMISTRY IN CONTEXT

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FINAL TESTS

- **Test A: Laboratory Test – writing equations and observations**
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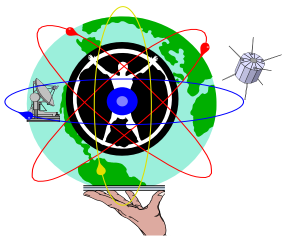


ADVANCED CHEMISTRY ASSESSMENT

All classes must complete:

MAJOR TESTS:

Advanced Chemistry Test	**40**
Laboratory Test	**10**

MAJOR SCIENCE INVESTIGATION (one report per group) **10**
(A lot of this will be done at home or at other non-class time and will assist in determining your Investigating Scientifically Level)

IN CLASS TEST BASED ON INVESTIGATION 10

Optional tasks (make up to 100 marks)

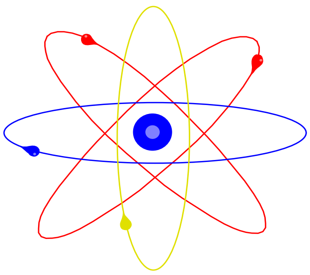
OPEN INVESTIGATION – PEER ASSESSED
(This will assist in determining your Investigating Scientifically Level)

SELECTED CLASS ACTIVITIES and IN-CLASS SKILLS
(These are selected at random so make sure all activities are completed)

MINING ASSIGNMENT OR POSTER

SHORT TESTS BASED ON SKILLS eg equation writing

TOTAL	**100**



Sample Year 10 Chemistry Program (based on the new edition of Fundamentals of Science 4)

Content area	Objectives	Text: Fundamentals of Science 4	Questions	Activities
Atoms and Ions *3 periods* **13.5 week course**	• Compare charge and mass for protons, neutrons, and electrons. • Describe the composition of the nucleus and outer region. • Define and show an understanding of Atomic number. • Define and show an understanding of Mass number and use $^{A}_{Z}X$ notation to compare the composition of various atoms and isotopes. • Compare the structure of an atom and its ion. Consider: *numbers of sub atomic particles* *electron configuration using the 2,8,8 model.*	Chap 21 p208 – 213 ***Introductory Chemistry Study Guide*** by Lucarelli & Proctor [Introduction to Chemical Calculations by Matthews and Winter are other sources of problems]	Chap Quest 5-13 p214 ***Study Guide*** Set 1 p5 ***Study Guide*** Set 2 p13	Atoms and ions worksheet
Elements *1 period* (⇓ *4 periods*)	• Differentiate between metal and non-metal elements. Consider: *Physical properties such as: appearance, conductivity, malleability, and ductility.* *Position in the periodic table.* *Ion charge, ie only metal elements form positive ions (exceptions H^+, NH_4^+),* *non metal atoms form negative ions.* *Show an understanding of this idea by classifying elements as metallic or non metallic according to their valency.*			Properties and Uses of elements assignment Properties and Uses of elements assignment check test
Ionic compounds *5 periods* (⇓ *9 periods*)	• Define and differentiate between elements, compounds and mixtures. • Show an understanding that ionic compounds consist of a combination of metal elements (or NH_4^+) and non metal elements, ie identify ionic compounds from their chemical formula. • Show an understanding of the electron transfer between metal and non metal elements during the formation of ionic compounds. • Understand the gain and loss of electrons involved in the formation of ionic compounds and describe this in terms of oxidation and reduction. (Half equations are not required but these may be useful in understanding the processes.) • Describe the lattice structure of ionic compounds.	Chap 22 p216 p220 - 225	Chap Quest 1-2 p226 Practice Ex 1-3 p225 Chap Quest 8-13 p226	**Activity 1** Dissociation of ionic compounds **Activity 2** Charge possessed by metal & non-metal ions

Content area	Objectives	Text: Fundamentals of Science 4	Questions	Activities
Ionic compounds ***(continued)***	• Show an understanding that ionic compounds will be more stable than the elements from which they form because of the attraction between the opposite charged ions in the ionic lattice. • Write balanced formula for ionic compounds using the following valencies: • STUDENTS NEED TO KNOW THESE VALENCIES H^+, Na^+, Mg^{2+}, Al^{3+}, K^+, Ca^{2+}, Cu^{2+}, Zn^{2+}, Ag^+, Pb^{2+}, Br^-, I^-, S^{2-}, Cl^-, O^{2-}, F^-, OH^-, NO_3^-, CO_3^{2-}, SO_4^{2-}, NH_4^+, (new) Fe^{2+}, Fe^{3+}, Ba^{2+}, NO_2^-, SO_3^{2-}, HCO_3^-, HSO_4^-, PO_4^{3-}, CH_3COO^-		***Study Guide*** Set 3 p18 ***Study Guide*** Set 5 p27 Set 6 p28	Formula writing work sheets (Ionic compounds)
Solutions *5 periods* (⇓ *14 periods*)	• Define the terms, soluble, insoluble, solute, solvent and solution. • Show an understanding of the dissolving process for a soluble ionic compound. • Know that concentration of a solution can be expressed in mol L^{-1} and g L^{-1}. • Demonstrate an awareness of the independent nature of the ions in an ionic solution. • Use a table of solubilities to predict the solubility of various ionic compounds. • Use a table of solubilities to predict the formation of a precipitate when two ionic solutions are mixed. • Write net ionic equations to show the formation of a precipitate from mixing two ionic solutions.	Chap 25 p248	Prac Ex 1-2 p248 Chap Quest 7 p252 ***Study Guide*** Set 11 p48	**Activity 3** Precipitation reaction
Covalent molecular substances *3 periods* (⇓ *17 periods*)	• Show an understanding that covalent molecular substances (elements or compounds) consist of a combination of non metal elements only, ie identify covalent molecular substances from their formula. (At this stage not expected to know covalent network exceptions). • Describe covalent bonding between a pair of atoms in terms of a sharing of electrons. • Describe the structure of a molecule in terms of two or more non metal atoms covalently bonded into a single entity. • Be able to interpret or sketch molecular diagrams or structural formula (not molecular shape) for simple covalent molecular substances.	Chap 22 p216- 220	Chap Quest 1-7, 14-16 p 226 ***Study Guide*** Set 4 p19	**Activity 4** Molecular models

Content area	Objectives	Text: Fundamentals of Science 4	Questions	Activities
Covalent molecular substances *(continued)*	• Describe the structure of a covalent molecular substances as consisting of a large number of molecules with very little attraction between the molecules. • Know the names and formula for the following covalent molecular elements and compounds: N_2, O_2, F_2, Cl_2, Br_2, I_2, H_2O, CO_2, CO, NO_2, SO_2, SO_3, HNO_3, HCl, H_2SO_4, H_3PO_4, CH_3COOH.			Formula Sheet – Selected molecular compounds and elements

$\xrightarrow{\text{Heat}}$

$\xrightarrow{\text{Heat}}$

Reactions *7 periods* (⇓ *24 periods*)	• Use coefficients to balance a partially completed equation (given formula). • Write a balanced equation give a word equation. • Know the formula and name of the acids: H_2SO_4, HNO_3, HCl, H_3PO_4, CH_3COOH. • Know the general reaction types and associated observations: *acid + metal → salt + hydrogen gas* *acid + carbonate → salt + water + carbon dioxide gas* *acid + hydrogen carbonate → salt + water + carbon dioxide gas* *acid + metal hydroxide → salt + water* *carbonate metal oxide + carbon dioxide gas* *hydrogencarbonate metal oxide + water + carbon dioxide gas* *metal + oxygen → metal oxide* *non-metal + oxygen → non-metal oxide* • Predict the formula of the products or reactants for the above reaction types given either the reactants or products. • Write balanced equations for the above reaction types given the formula or names of the reactants.	Chap 25 p242 – 244 p228 p246-247	Prac Ex 1-2 p245 Prac Ex 1-3 p247 Chap Quest 3-6, 9-11 p251 - 252 *Revision Assignment Atoms & Formulae* OR *Advanced Chemistry Revision Exercise Sheet* ***Study Guide*** Set 7 p33 Set 8 p34 Set 9 p39 Set 10 p47	**Activity 5** Acid - metal **Activity 6** Acid - carbonate **Activity 7** FANTAstic fun with CO_2 **Activity 8** Acid - base Is it an acid or base worksheet Predicting products work sheet General Reactions worksheet General Reactions Summary Sheet

				LABORATORY TEST
Content area	**Objectives**	**Text: Fundamentals of Science 4**	**Questions**	**Activities**
Open Investigations *8 periods* (⇓ *32 periods*)	• Understand what is meant by Open Investigations. • Understand the Curriculum Framework Science Learning Area Strands and Levels. • Use an Investigation Guide to do a trial investigation. • To undertake an Investigating Scientifically Levelling Exercise. • To conduct a Major Science Investigation Project, individually or in groups. • To write up and display the Major Science Investigation.	*Most of the write-up and display for the Major Investigation will be done out of school hours*		Open Investigations Booklet (notes, trial investigation, investigation assessment, key terms, investigation guide, major science investigation, writing up and displaying a research project)
CHEMICAL CALCULATIONS **The Mole** *6 periods* (⇓ *38 periods*) **YOUR TEACHER**	• Define the mole in terms of Avogadro's number of particles. • State and use the molar relationship between the moles of each constituent atom or ion in a substance and the moles of the substance given its formula. e.g. $n(Cl) = 3 \times n(AlCl_3)$ • Use the relationship Nº particles = $n \times 6.02 \times 10^{23}$ to convert between numbers and moles: *for atoms in monatomic species like Zn, Ag, O, Cl.*	Chap 29 p312 – 321	Prac Ex 1-2 p316 1-8 p320 1-3 p321 Chap Quest	Calculations in Chemistry - Moles Moles – Method of Attack Guidesheet

WILL EITHER FOLLOW THE PROGRAM FOR CHEMICAL CALCULATIONS AS SHOWN OR WILL USE THE *Introductory Chemistry Study Guide p51-95*	*for atoms or molecules in molecular substances like O_2, H_2O, H_2SO_4.* *for ions or atoms in ionic substances like NaCl, $Al_2(SO_4)_3$.* • Define and locate (from a Periodic Table) the atomic mass of the elements. • Determine the Molar Mass of a substance given its formula. • Calculate the moles of a substance from its mass using: $n = \frac{m}{M}$ • Know that the volume of a fixed mass of gas is affected by its temperature and pressure. • Know that the volume occupied by 1 mole of any gas at S.T.P. is 22.4 L. • Calculate the moles of a gas at S.T.P. using: $n = \frac{V}{22.4}$	Chap 32 p349 – 353	1-18 p322 Prac Ex 1-4 p353 Chap Quest 1-8 p357	Guide to Mole Calculations What's in a mole worksheet Moles Worksheet 1 Moles Worksheet 2
CHEMICAL CALCULATIONS **Percentage Composition** *3 periods* (⇓ *41 periods*)	• Calculate the percentage composition of elements in compounds. • Calculate the percentage composition of water in hydrated compounds. • Calculate the mass composition of the constituents in a given quantity of a compound and vice versa.	Chap 30 p330 – 332	Prac Ex 1-4 p332 Chap Quest 11-20 p334	**Activity 9** Percentage composition of MgO **Activity 10** Water of Crystallisation

Content area	Objectives	Text: Fundamentals of Science 4	Questions	Activities
CHEMICAL CALCULATIONS **Reaction Stoichiometry** *9 periods* (⇓ *50 periods*)	• Use the coefficients in a balanced chemical equation to write the mole relationship for the molar amounts of any two substances appearing in a balanced chemical equation. • Perform calculations on equations relating the amounts of any two substances. *Types of calculation include:* *mole to mole* *mole to mass* *mass to mole* *mass to mass* *mass to gas volume$_{(STP)}$* *gas volume$_{(STP)}$ to mass* *gas volume$_{(STP)}$ to gas volume$_{(STP)}$*	Chap 30 p324- 330 Chap 31 p337 – 346 Chap 32 p353 – 357 [Other sources of problems can be found in: **M&W** **Set 28-37,p83]**	Prac Ex 1-4 p330 Chap Quest 1-10 p333 Prac Ex 1-5 p341 1-4 p343 1-4 p344 1-5 p345 Chap Quest 1-23 p346 Prac Ex 1–5 p354 1–4 p356 Chap Quest 9-28 p358	Calculations Involving Equations Sheet Calculations from Equations Flowchart (An alternative Method) **Activity 11** Decomposition of $NaHCO_3$ **Activity 12** Mole relationship between Cu and Fe **Activity 13** Molar volume of H_2
Chemistry in Context *4 periods* (⇓ *54 periods*) **13.5 weeks**	<u>Mining and mineral processing Western Australia</u>. • State some of the minerals that are mined or processed in WA and be aware of their approximate location. Examples may include Bauxite, Iron ore (hematite, limonite), Gold, Nickel, Mineral sands. • Describe some mineral exploration techniques. Consider some of these, satellite imagery, aeromagnetic survey, seismic survey, RAB drilling, diamond drilling, surface sampling. • Describe mining methods and relate these to the type of ore body. Examples may include, Open pit mining, Strip mining, Dredging, Underground mining. • Describe mineral concentration methods. Consider some of these, froth flotation, gravity separation, magnetic separation, electrostatic precipitation. • Explain how Carbon reduction and Electrolysis are used to extract a metal. • Relate extraction techniques to metal activity and ease of reduction. • Demonstrate a detailed awareness of the mining activities carried out by one Western Australian mining company. (See above for aspects to consider.)	Chap 27 p274 – 279 p280 – 282 p282 – 286 p 302 Chap 26 p 265 – 271 Chap 28 p 289 – 308	Chap Quest 1-15 p287 **REVISION FOR FINAL TEST** ***Study Guide*** **Test 1 p111** **Test 2 p116** **(omit 18-20, and 30)**	**Activity 14** Copper metal from copper ore *OR* **Activity 15** Smelting **Mining Research assignment** **Chemistry of Mining poster** ***FINAL TEST***

ATOMS AND IONS WORKSHEET

Use the words below to complete the description. Words can be used more than once.

positive
negative
reduction
electron cloud
neutron
proton
nucleus
oxidation
central
electron

Atoms have a _____________ (the ____________ region of the atom) that contains POSITIVE charged particles called ____________ and particles that have NO charge called ____________________ .

Protons are TIGHTLY held within the atoms nucleus so protons cannot be gained or lost from the atom.

Atoms also contain NEGATIVE charged particles called _______________, which are located in the _______________________________. This is the biggest region of the atom, extending from the edge of the nucleus to the outer edge of the atom. Outer electrons are LOOSELY held to the atom and so they can be GAINED or LOST from the atom.

[ANALOGY of an atom: Bees / Beehive]

Atoms are normally NEUTRAL as the number of ______________________ equals the number of _________________________ .

Draw a clearly labelled 2D sketch showing the components of a typical atom

An atom can become charged by gaining or losing one or more ELECTRONS (but never protons- they are too tightly held). An atom that has become charged is known as an ION. An ion may be positive or negative in charge.

If an atom gains one or more electrons, then the ion it forms will have a ________________ charge. The process of gaining one or more electrons is also known as r___________________. When an atom loses one or more of its electrons, then the ion it forms will have a ______________ charge. Chemists call this loss of electrons o__________________.

Gaining and losing electrons are simultaneous actions that happen between at least two atoms at a time.
ie for an atom to have gained an electron this electron must first be released from the electron cloud of some other atom.

Complete a sketch showing an ${}^{19}_{9}F$ and an ${}^{23}_{11}Na$ atom forming ions as the Fluorine atom gains an electron from the sodium atom. Label your sketch showing the correct number of all particles and use an arrow to show the electron transfer process.

ATOMS AND IONS WORKSHEET
Complete the following table

Ion symbol	Number of protons in the ion	Number of electrons in the ion	Number of electrons gained or lost when forming the ion	Is this ion formed by reduction or oxidation?
Na^{+}				
Cl^{-}				
Mg^{2+}				
N^{3-}				
Al^{3+}				
O^{2-}				
	3	2		
	20	18		
	19			
	15	18		
	35		1 electron ____?____.	reduction
	56		2 electron ____?____.	oxidation
	26		2 electron ____?____.	oxidation
	26		3 electron ____?____.	oxidation
	16		2 electron ____?____.	reduction

PROPERTIES AND USES OF ELEMENTS ASSIGNMENT:

Name ____________________ **Due** _____________________

1. Classify the following elements as metals or non-metals.

HYDROGEN	**HELIUM**	**FLUORINE**	**NEON**	**MAGNESIUM**
SODIUM	**LEAD**	**OXYGEN**	**ALUMINIUM**	**NITROGEN**
SULFUR	**CHLORINE**	**ARGON**	**CALCIUM**	**PROTACTINIUM**
TITANIUM	**CHROMIUM**	**COBALT**	**COPPER**	**GERMANIUM**
KRYPTON	**YTTRIUM**	**ZIRCONIUM**	**TUNGSTEN**	**POTASSIUM**

2. What are the typical physical and chemical properties of metal elements, list five such properties, at least one must be a chemical property.

3. From the list of elements (question 1) choose **three** metals. For each metal chosen list two distinctly different **uses** for it and describe the **properties** that make the metal suited to the uses you have found out about. Indicate if the properties are **physical** or **chemical**.

4. Some elements are difficult to clearly classify as either metal or non metal. These are known as semi metals or metalloids. An element like this is silicon. Find out about the physical properties of silicon and hence explain why it is difficult to classify.

CHECK TEST ON PROPERTIES AND USES OF ELEMENTS ASSIGNMENT

NAME________________

1. Classify the following elements as metals, non-metals, or semi metals (metalloids)

germanium _______________ calcium __________________sodium _______________

nitrogen ______________ zinc ______________________cobalt ________________ (6 marks)

2. Consider the elements with the properties indicated and classify these as metals, non-metals, or semi metals (metalloids), ie complete the last row of the table.

Property	element A	element B	element C	element D
malleable	yes	unknown	unknown	no
melting point	330 ^oC	1400 ^oC	113 ^oC	3700 ^oC
produce hydrogen with acid	yes	no	no	no
brittle	unknown	yes	no	unknown
appearance	silver solid	unknown	unknown	black solid
electrical conductivity	unknown	poor	poor	good
Classification				

(4 marks)

3. Name one metal, give two of its uses and indicate the property, which allows it to be used this way

Metal ________________

Use 1____

Relevant property ____

Use 2 ____

Relevant property ____(4 marks)

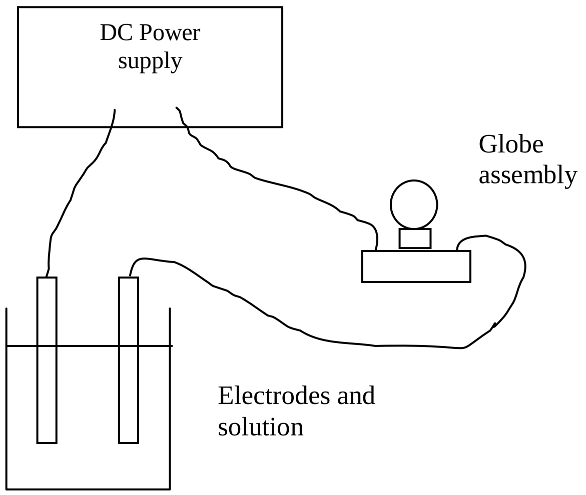
ACTIVITY 1: DISSOCIATION OF IONIC COMPOUNDS

AIM: To show ionic compounds dissociate (separate into ions) when dissolved in water.

EQUIPMENT: Ten different stations around the room.
Ten stations containing one of the following: solid samples of ammonium nitrate, sodium sulfate, copper nitrate, copper sulfate, ammonium chloride, sodium hydroxide, 50 mL of distilled water, 50 mL of very dilute sodium chloride solution, 50 mL of dilute sodium chloride solution, 50 mL of concentrated sodium chloride solution.
Plus 100 mL beaker, stirring rod, power pack, 6V globe and holder, 3 electrical leads, distilled water, spatula, stainless steel electrodes assembly.

PROCEDURE: **TAKE CARE!!** WEAR SAFETY GLASSES

1. Go to one of the ten stations and set up the equipment as shown in the diagram below.



2. At the stations with solids: Dissolve a small amount of solid in 50 mL of distilled water. Test whether the solution conducts electricity when the voltage is adjusted to 6 volts, DC. The brightness of the globe is related to the concentration of the ions (charged atoms or groups of atoms) in the solution.

3. At the stations with **no** solids: Pour 50 mL of the solution or distilled water into the beaker and then test whether the solution conducts electricity when the voltage is adjusted to 6 volts, DC.

4. Draw up a table to record your results as follows:

Ionic Solid or solution	Does it conduct electricity?	Ionic Equation to show dissociation into ions
e.g. $NaCl_{(s)}$	Yes	$NaCl_{(s)} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

QUESTIONS:

1. Why does concentrated $NaCl_{(aq)}$ cause the globe to glow brighter than very dilute $NaCl_{(aq)}$?

2. Why does the globe not glow when distilled water only is used?

3. $NaCl_{(s)}$ is made up of ions and **does not conduct** electricity. $NaCl_{(aq)}$ is made up of ions and water molecules and **does conduct** electricity. Try to explain this observation.

ACTIVITY 2: WHAT CHARGE IS POSSESSED BY METAL IONS? WHAT CHARGE IS POSSESSED BY NON-METAL IONS?

PREDICTION: In a few words write answers to the above questions.

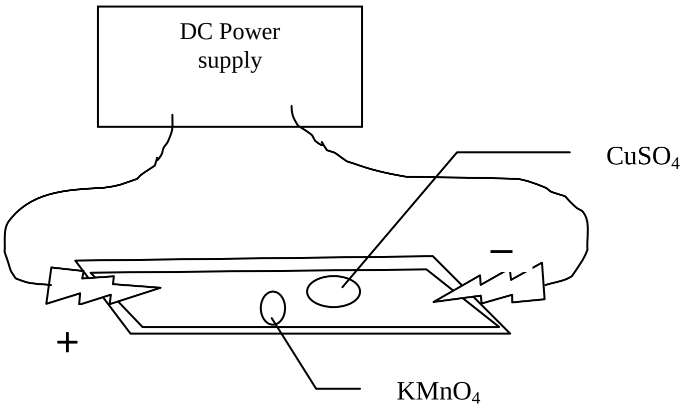
THE TEST: Test your prediction by performing the following activity.

EQUIPMENT:

Strip of chromatography paper or filter paper
Microscope slide
Two electrical leads with alligator clips
Power pack
Popstick spatula
Copper(II) sulfate crystals (crushed) $CuSO_4$
Potassium permanganate crystals (crushed) $KMnO_4$

PROCEDURE: **TAKE CARE!!** WEAR SAFETY GLASSES

1. Place the strip of chromatography or filter paper on a microscope slide. Hold it in place with the alligator clips as shown.



2. Moisten with a few drops of tap water. (Do not soak it!)
3. Connect the leads to a 12V DC power supply.
4. Using the popstick spatula, place crystals of copper sulfate and potassium permanganate on the paper as shown.
5. Switch on the power pack and observe any changes that occur.

OBSERVATIONS:

QUESTIONS: What can you conclude about the charge carried by metal and non-metallic ions?

NAMING AND WRITING FORMULAS FOR IONIC COMPOUNDS

Exercise 1

For each of the following ionic compounds**, identify the cation and the anion** (by symbol and by name of the compound.

FORMULA	CATION	ANION	NAME
KCl	K^+ Potassium	Cl^- Chloride	Potassium chloride
NH_4OH			
$ZnCl_2$			
$Al(OH)_3$			
$CuSO_4$			

Exercise 2

Assume that A^+, B^{2+}, C^{3+}, DE^{2+} and FG_4^+ are five cations and V^-, W^{2-}, X^{3-} and YZ^- are four anions. Write the formulas of the compounds that would result, if each of these ions were paired with one another. Complete the table below.

	V^-	W^{2-}	X^{3-}	YZ^-
A^+				
B^{2+}				
C^{3+}				
DE^{2+}				
FG_4^+				

Exercise 3

Write the ionic formulas for the following compounds in the spaces provided.

Potassium bromide ____________________

Sodium hydroxide ____________________

Calcium chloride ____________________

Calcium hydroxide ____________________

Potassium nitrate ____________________

Calcium nitrate ____________________

ACTIVITY 3: PRECIPITATION OF INSOLUBLE IONIC COMPOUNDS

AIM: To test the solubility of ionic compounds.

BACKGROUND: When some ionic solutions are mixed, the ions sometimes react to produce **insoluble** (or sparingly soluble) **solids** that are called **precipitates**.

EQUIPMENT: Dropper bottles of 0.1 mol L^{-1} solutions of:

sodium chloride	barium chloride
sodium carbonate	copper(II) nitrate
sodium nitrate	lead nitrate
sodium hydroxide	calcium nitrate
sodium sulfate	magnesium nitrate

silver nitrate (*** Be very careful as it stains your skin for about 2 weeks)
Plastic sheets to put drops on.
Teacher to supply worksheet (see next page)

PROCEDURE: **TAKE CARE!!** WEAR SAFETY GLASSES - Be very careful with silver nitrate solution.

1. Place the plastic sheet over the worksheet.
2. In the squares put a couple of drops of each solution and see if a precipitate is produced and its colour.
3. Record your results.

QUESTIONS:

1. What families of chemicals are insoluble and what are the exceptions to the rule? (families are things like chlorides, carbonates, sulfates etc)

2. What families of chemicals are soluble and what are the exceptions to the rule? (families are things like chlorides, carbonates, sulfates etc)

PRECIPITATION REACTIONS WORKSHEET

X	Sodium chloride $NaCl_{(aq)}$	Sodium carbonate $Na_2CO_{3(aq)}$	Sodium nitrate $NaNO_{3(aq)}$	Sodium hydroxide $NaOH_{(aq)}$	Sodium sulfate $Na_2SO_{4(aq)}$
Barium chloride $BaCl_{2(aq)}$					
Copper(II) nitrate $Cu(NO_3)_{2(aq)}$					
Lead nitrate $Pb(NO_3)_{2(aq)}$					
Calcium nitrate $Ca(NO_3)_{2(aq)}$					
Magnesium nitrate $Mg(NO_3)_{2(aq)}$					
Silver nitrate $AgNO_{3(aq)}$					

ACTIVITY 4: MOLECULAR MODELS ACTIVITY

AIM: To use molecular model kits to show the structure of covalent molecular substances.

BACKGROUND:

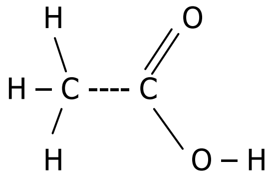
Covalent molecular substances are made up of molecules. The atoms in the molecule bond with each by sharing electrons so that a full or stable outer or valence shell is obtained. This usually means 8 electrons in the outer shell.

EQUIPMENT:

Molymod 001: Introductory ORGANIC Molecular Model Set or
Molymod 009: Student Set: INORGANIC ORGANIC Molecular Model Set

PROCEDURE:

1. Take note of the colour of the atoms. Carbon – black; hydrogen – white; nitrogen – blue; oxygen – red; chlorine – green; sulfur – yellow.
2. Use the coloured spheres and grey links to represent the following molecular substances. Use the longer flexible grey links when you have to form double or triple bonds.
3. Draw up a table to illustrate your results. An example is given below.

NAME	MOLECULAR FORMULA	STRUCTURAL FORMULA	USE
e.g. acetic acid	CH_3COOH		Vinegar for preserving and flavouring foods.
Water			
Hydrogen chloride			
	NH_3		
Carbon dioxide			
	H_2S		
Sulfur dioxide			
	PCl_3		
methane			
ethane	C_2H_6		
propane	C_3H_8		
Ethyne (acetylene)	C_2H_2		
	O_2		
Chlorine gas			
Ethanol	C_2H_5OH		
Chloromethane	CH_3Cl		
dichloromethane	CH_2Cl_2		
trichloromethane	$CHCl_3$		
tetrachloromethane	CCl_4		
DHMO (dihydrogen monoxide)			

QUESTION:

1. How many covalent bonds can the following atoms form?
Hydrogen ___; carbon ___; oxygen ___; nitrogen ___; chlorine ___; phosphorus ___.

FORMULA OF COMMON MOLECULAR SUBSTANCES [ELEMENTS AND COMPOUNDS]

Substance	Formula	Comment
Oxygen	O_2	element, each molecule has two O atoms tightly bonded, colourless gas
Nitrogen	N_2	
Fluorine	F_2	
Chlorine	Cl_2	
Bromine	Br_2	
Iodine	I_2	
Water	H_2O	
Hydrogen peroxide	H_2O_2	
Carbon dioxide	CO_2	
Carbon monoxide	CO	
Hydrochloric acid	HCl	
Sulfuric acid	H_2SO_4	
Nitric acid	HNO_3	
Carbonic acid	H_2CO_3	
Acetic acid	CH_3COOH	
Phosphoric acid	H_3PO_4	
Sulfur dioxide	SO_2	
Sulfur trioxide	SO_3	
Nitrogen monoxide	NO	
Nitrogen dioxide	NO_2	
Dinitrogen tetroxide	N_2O_4	
Hydrogen sulfide	H_2S	
Ammonia	NH_3	
Methane	CH_4	

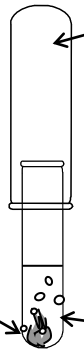
ACTIVITY 5: CHEMICAL REACTIONS - ACIDS AND METALS

AIM: To identify any patterns of behaviour for the reaction between ***acids*** and ***metals*** by looking for similarities in the reaction between a variety of acids (sulfuric acid H_2SO_4, hydrochloric acid HCl) and metals (zinc, calcium, iron, copper, magnesium).

APPARATUS: 4.0 mol L^{-1} solutions of sulfuric acid H_2SO_4 and hydrochloric acid HCl (in dropper bottles), small pieces of zinc, calcium, iron, (steel wool) copper, magnesium), two test tubes (one semi micro that will fit into a normal sized test tube), wax taper, matches.

METHOD: **Take Care !!!** Wear eye protection, acid splashed into an eye is very painful!

1. Place 2 small pieces of calcium into a small test tube (you will need to remove the oil using a paper towel).
2. From a dropper bottle add 5 mL of HCl(aq).
3. Place a second (larger) test tube over the reaction test tube to collect any gas produced.
4. When you think you have collected sufficient gas (this depends upon the rate of reaction). You can try a pop test to see if any hydrogen gas was formed.
5. Repeat the procedure with any acid metal combinations from the available materials.



RESULTS:

Metal - Acid combination	Observations- what happens in the reaction test tube	Pop test result
Ca and HCl		

QUESTIONS & CONCLUSIONS: **(Show your working for any calculations)**

1. In which cases did the pop test indicate that hydrogen gas formed as a result of the acid metal reactions?

2. Where you found hydrogen gas was formed then the reaction also produces a salt. What will be the chemical formula of the salt for each of your acid metal reactions? Remember a salt is the compound formed when the hydrogen of an acid is replaced by a metal element.

ACTIVITY 6: CHEMICAL REACTIONS - ACIDS & CARBONATES

AIM: To identify any patterns of behaviour for the reaction between ***acids*** and ***carbonate or hydrogen carbonate compounds*** by looking for similarities in the reaction between a variety of acids (nitric acid, HNO_3, sulfuric acid H_2SO_4, hydrochloric acid HCl) and carbonates or hydrogen carbonates (sodium carbonate Na_2CO_3, copper carbonate $CuCO_3$, calcium carbonate $CaCO_3$ sodium hydrogen carbonate, $NaHCO_3$).

APPARATUS: Gas preparation and delivery apparatus (see sketch), 1.0 mol L^{-1} solutions of nitric acid HNO_3, sulfuric acid H_2SO_4, hydrochloric acid HCl (in dropper bottles), jars of sodium carbonate Na_2CO_3, copper carbonate $CuCO_3$, calcium carbonate $CaCO_3$, sodium hydrogen carbonate $NaHCO_3$, lime water (60 mL per group).

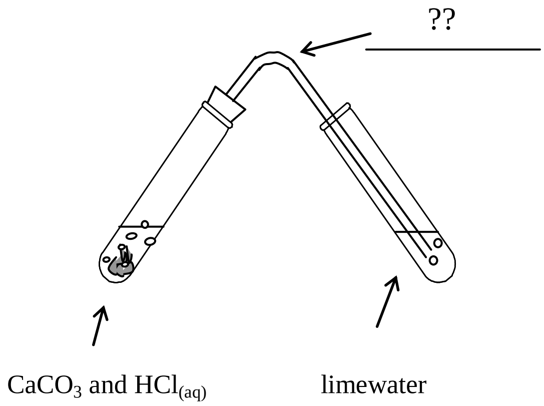
METHOD: Take Care !!! **USE SAFETY GLASSES – acids are dangerous**

The limewater is easily neutralised by the slightest contact with acid. Avoid the acid bubbling over through the delivery tube to the limewater.
Be organised, step one and two need to be completed quickly and carefully as the reaction is fast and can be over in a few seconds.
Safety, wear eye protection, acid splashed into an eye is very painful!

1. Place a small amount of calcium carbonate $CaCO_3$ into the test tube and add sufficient HCl to cover the marble chips.

2. Fit the delivery tube and bubble the gas produced into a second test tube containing a few mL of limewater.

3. Rinse both test tubes and repeat with any other combinations of acid and carbonate. Record all observations as you go.



RESULTS:

Acid carbonate combination	Observations- what happens in the reaction test tube	Effect on limewater
$CaCO_3$ and HCl		

QUESTIONS:

1. What gas is produced when an acid **and** carbonate or hydrogen carbonate is reacted?

2. In each of these reactions water and a salt is also produced. Determine the chemical formula of the salt for each of your acid and carbonate or hydrogen carbonate combinations. Remember a salt is the compound formed when the hydrogen of an acid is replaced by a metal element.

ACTIVITY 7: FANTASTIC FUN WITH CO_2

TRY THIS: Make your own fizzy orange flavoured soft drink.

WHAT YOU NEED:

One clean 100 mL measuring cylinder, 85-90 mL of orange cordial concentrate (Sunquick), 3.9 g citric acid ($H_3C_6H_5O_7.H_2O$), 4.2 g bicarbonate of soda (sodium bicarbonate, $NaHCO_3$), a 600 mL soft drink bottle with screw cap (must be soft drink bottle), two electronic balances (measuring ± 0.1 g), **safety glasses**.

PROCEDURE: **Take Care !!!** Considerable pressure will be produced inside your drink bottle.

Safety glasses must be worn at all times just in case ......

1. Using the clean measuring cylinder provided measure 85-90 mL of orange cordial concentrate and add this to your soft drink bottle
2. Add tap water so that a space of around 100 mL volume remains inside your soft drink bottle.
3. Measure, on a clean piece of scrap paper, 4.2 g of sodium hydrogen carbonate. Add this to your soft drink bottle. Safety glasses !!
4. Measure, on a clean piece of scrap paper, 3.9 g of citric acid. *Loosely* *wrap* this in a small piece of glad wrap (say 5 cm by 15 cm).
5. Now add the citric acid wrapped in glad wrap to your drink mixture and quickly screw on the top. Shake gently to release the citric acid. Now watch as the fizz gets underway.
6. Wait a few minutes, unscrew and enjoy !!!

CHALLENGE QUESTIONS: CAN YOU ANSWER ANY OF THESE?

1. Write an equation for the reaction between citric acid (a triprotic acid like H_3PO_4) and $NaHCO_3$?

2. Many students say the orange soft drink they have made tastes a little salty, like staminade or a sports drink. Can you account for this salty taste?

3. Why don't most fizzy drinks have a salty taste?

4. You probably had around 100 mL space inside your sealed drink bottle, estimate the pressure in this bottle when the reaction is over. You may assume one third of the CO_2 is dissolved in the drink bottle

ACTIVITY 8: CHEMICAL REACTIONS - ACIDS AND BASES

AIM: To identify any patterns of behaviour for the reaction between ***acids*** and ***bases*** by looking for similarities in the reaction between a variety of acids (nitric acid,HNO_3, hydrochloric acid HCl) and bases (barium hydroxide, $Ba(OH)_2$, sodium hydroxide NaOH, calcium hydroxide $Ca(OH)_2$).

EQUIPMENT: 1.0 mol L^{-1} solutions of nitric acid, HNO_3, sulfuric acid H_2SO_4, sodium hydroxide NaOH and barium hydroxide, $Ba(OH)_2$, (in dropper bottles), a jar of calcium hydroxide $Ca(OH)_2$, an electronic balance ($\pm$ 0.1 g) universal indicator and an indicator colour chart.

BACKGROUND: Universal indicator can be used to test the acidity of a solution. If a solution is neutral the indicator colour is green, yellow through to red indicates increasing acidity and blue to purple indicates an increasingly basic solution.
When an acid and base react they are said to neutralise each other. The products of the neutralisation reaction are water and a salt. As the products are effectively* neutral then the reaction mixture of an acid with a base should be close to neutral when the reaction between the acid and base is complete.
[* *Some salts are slightly acidic or basic*.]

PROCEDURE: **Take Care !!!**
Wear eye protection, acid or base splashed into the eye is very painful!

1. Use a clean measuring cylinder to measure 15 mL of distilled water and place this into a clean 100 mL conical flask. Add 4 drops of universal indicator. Record the indicator colour.

2. Add 20 drops (try to keep these uniform in size) of 1.0 mol L^{-1} nitric acid, HNO_3 solution. Record the indicator colour.

3. Add sufficient sodium hydroxide, NaOH to neutralise your HNO_3 solution (use the indicator colour as a guide). Swirl the solution as you go and add the NaOH solution carefully so that you don't have excess sodium hydroxide. Record the number of drops used.

4. Repeat steps 1 to 3 using (a) 1.0 mol L^{-1} solutions of HNO_3, and $Ba(OH)_2$
(b) 1.0 mol L^{-1} solutions of H_2SO_4 and NaOH
(c) 1.0 mol L^{-1} solutions of H_2SO_4 and $Ba(OH)_2$

5. Carefully weigh 0.20 g of $Ca(OH)_2$ into a 100 mL conical flask then add 10 mL of water to it. Record the appearance of the mixture.

6. Add two drops of universal indicator and record its colour.

7. Slowly add HNO_3 solution until the mixture is slightly acidic. Record the change in appearance of your mixture as you add the HNO_3 solution (apart from the indicator colour change).

QUESTIONS:

1. Write an equation for each of the reactions occurring in your experiments?

2. Account for the appearance of your $Ca(OH)_2$ water mixture in step 6.

3. Account for the change in appearance of your $Ca(OH)_2$ water mixture in step 7.

IS IT AN ACID OR A BASE?

BACKGROUND: Oxides and hydroxides are compounds that contain O and OH respectively. When added to water some of these compounds turn water ACIDIC while others may turn it BASIC and some have no effect at all. The clue is in the formula, can you find it?

WHAT TO DO: Write chemical formula for the following oxides and hydroxides in the correct column. Can you see the clue in the formula that tells whether the oxide or hydroxide is acidic **(A)** or basic **(B)**?

potassium oxide (**B**)
iron(II) oxide (**B**)
sulfur dioxide (**A**)
nitrogen dioxide (**A**)
manganese(II) hydroxide (**B**)
phosphorous pentoxide (**A**)
sodium hydroxide (**B**)
calcium hydroxide (**B**)
sulfur trioxide (**A**)
copper oxide (**B**)
nickel(II) hydroxide (**B**)
barium oxide (**B**)
sulfur hydroxide (sulfuric acid) $SO_2(OH)_2$ (**A**)
silver oxide (**B**)
barium hydroxide (**B**)
nitrogen hydroxide (nitric acid) NO_2OH (**A**)
carbon dioxide (**A**)
chlorine hydroxide (hypochlorous acid) ClOH (**A**)
carbon hydroxide (carbonic acid) $CO(OH)_2$ (**A**)
phosphorous hydroxide (phosphoric acid) $PO(OH)_3$ (**A**)

Acidic oxide	Acidic hydroxide	Basic oxide	Basic hydroxide

FOLLOW UP:

1. Can you see it? If so what's the clue in the formula that tells us if the oxide/hydroxide is acidic or basic.

2. Write chemical formula for the following and using your hypothesis classify them as acidic or basic.

Name	Formula	Acidic or basic?
potassium hydroxide		
magnesium oxide		
sulfur trioxide		
sodium hydroxide		
dinitrogen tetroxide		
lithium oxide		

3. Some oxides and hydroxides like Al_2O_3 and ZnO are said to be AMPHOTERIC, use your text book to find out what this means.

4. The following compounds are mixed with water and then small pieces of red and blue litmus are added to the mixture. What colour does the litmus become?

calcium hydroxide   sodium oxide   sulfur dioxide   sodium hydroxide

nitrogen dioxide   cobalt hydroxide   carbon dioxide   phosphorous pentoxide

CHEMICAL REACTIONS - PREDICTING PRODUCTS

1. **Acid - Metal Reactions**
Atoms from the metal replace the hydrogen atom(s) contained in the acid. The resulting substance is called a salt. Hydrogen gas, formula H_2, is also produced. Use this idea to write formulas for the products formed when the following acids and metals react.

REACTANTS		**PRODUCTS**
1.	$Zn + HCl$	______________________
2.	$Zn + H_2SO_4$	______________________
3.	$Zn + HNO_3$	______________________
4.	$Mg + H_2SO_4$	______________________
5.	$Fe + HCl$	______________________

2. Reactions involving "**Acids & Bases**", or "**Acids & Carbonates**"

(a) Acids, bases and carbonates may be considered to consist of a pair of ions. In each of the following, determine what these ions are then write their symbols.
The first two are completed for you.

1.	NaOH, ***Na^+ and OH^-***	2.	HCl, ______________
3.	Na_2CO_3, ***Na^+ and CO_3^{2-}***	4.	H_2SO_4, ______________
5.	$Ca(OH)_2$, ______________	6.	HNO_3, ______________
7.	$ZnCO_3$, ______________	8.	KOH, ______________
9.	$Al(OH)_3$, ______________	10.	$NaHCO_3$, ______________
11.	$Al_2(SO_4)_3$, ______________	12.	$Fe(HCO_3)_2$, ______________

(b). Determine the products formed when each of the following pairs of compounds react together. Do this by ***swapping*** the pair of ions in each compound to work out the products that form. Use ***valencies*** to write correct formula for the products. Also if H_2CO_3 is a product it is actually quite ***unstable*** and quickly decomposes to form H_2O and CO_2 so if H_2CO_3 is the product then actually H_2O and CO_2 are formed instead. Notice $CO_2 + H_2O = H_2CO_3$. Also HOH (hydrogen hydroxide) is usually written as ??????
Complete the table by writing formula for the reactants or products in the space provided.

REACTANTS	PRODUCTS	REACTANTS	PRODUCTS
1. $NaOH + HCl$		9. $NaHCO_3 + HCl$	
2. $KOH + HNO_3$		10.	$NaNO_3 + H_2O$
3. $HCl + Na_2CO_3$		11.	$ZnSO_4 + H_2O$
4. $NaOH + H_2SO_4$		12. $Ca(OH)_2 + H_2SO_4$	
5. $MgCO_3 + HCl$		13.	$CaCl_2 + H_2O + CO_2$
6. $Zn(OH)_2 + HCl$		14. $ZnHCO_3 + HNO_3$	
7. $Ca(OH)_2 + HNO_3$		15.	$Mg(NO_3)_2 + H_2O + CO_2$
8. $H_2SO_4 + CaCO_3$		16.	$Zn_3(PO_4)_2 + H_2O$

GENERAL REACTIONS WORKSHEET

For each of the following reactions <u>predict</u> the products or reactants as required. Write the correct formula for each species and then balance the complete equation.

1. $HC1 + MgO \rightarrow$ ________ + ________

2. ________ + ________ $\rightarrow ZnC1_2 + H_2$

3. $MgCO_3 \xrightarrow{\text{Heat}}$ ________ + ________

4. $HC1 + KOH \rightarrow$ ________ + ________

5. $HNO_3 + (NH_4)_2CO_3 \rightarrow$ ________ + ________ + ________

6. ________ + ________ $\rightarrow A1C1_3 + H_2$

7. ________ + ________ $\rightarrow CaSO_4 + CO_2 + H_2O$

8. $NaHCO_3 \xrightarrow{\text{Heat}}$ ________ + ________ + ________

9. ________ + ________ $\rightarrow Na_2SO_4 + H_2O$

10. $HC1 + Sn(HCO_3)_2 \rightarrow$ ________ + ________ + ________

11. $CH_4 + O_2 \rightarrow$ ________ + ________

12. $H_2SO_4 + Mg \rightarrow$ ________ + ________

13. ________ + ________ $\rightarrow CaCl_2 + H_2$

14. $Na_2CO_3 + H_2SO_4 \rightarrow$ ________ + ________ + ________

15. ________ + ________ $\rightarrow K_2SO_4 + H_2O + CO_2$

16. ________ + ________ $\rightarrow NaNO_3 + H_2O$

17. $LiOH + H_3PO_4 \rightarrow$ ________ + ________

18. $Al + HNO_3 \rightarrow$ ________ + ________

19. ________ + ________ $\rightarrow CuCl_2 + H_2O + CO_2$

20. $CH_3COOH + KOH \rightarrow$ ________ + ________

GENERAL REACTIONS SUMMARY

Complete the following list of common chemical reactions.

1. **ACID + METAL HYDROXIDE →** __________ **+** __________

   eg

2. **ACID + METAL OXIDE →** __________ **+** __________

   eg

3. **ACID + METAL CARBONATE →** ________ **+** _______ **+** ______________

   eg

4. **ACID + METAL HYDROGENCARBONATE →** _______ **+** _______ **+** _____________

   eg

5. **ACID + METAL →** _______ **+** _______

   eg

6. **METAL CARBONATE** $\xrightarrow{\text{HEAT}}$ ______________ **+** _______

   eg

7. **METAL HYDROGENCARBONATE** $\xrightarrow{\text{HEAT}}$ _______ **+** _______ **+** ____________

   eg

8. **ACID + BASE →** _______ **+** _______

   eg

9. **METAL + OXYGEN →** _____________

   eg

10. **NON-METAL + OXYGEN →** _____________

    eg

REVISION ASSIGNMENT – ATOMS AND FORMULAE

NAME: ____________________ ____ /40 MARKS

1. Two different types of atoms are isolated and their atomic and mass numbers are identified.

If the atoms can be represented as $^{88}_{38}X$ and $^{127}_{53}D$
Determine (using a Periodic Table where necessary):

(a) Number of **protons** in each type of atom

X: ______________

D: ______________ (2)

(b) Number of **valence electrons** of each atom

X ______________

D ______________ (2)

(c) the **ion** that each atom would be expected to produce if they reacted together.

________________________ ____________________ (2)

(d) the **formula of the compound** made by reacting X and D together.

______________________ (1)

2. Explain the difference between a **period** (or row) and a **group** in the Periodic Table. What do each of these tell us about the properties of elements.

____

____

____

____

____

____

____
(2)

3. What is the difference between a MONATOMIC ION and a POLYATOMIC ION?
____

____ (1)

4. Complete the table by putting in the **formulas**. The first one has been done for you.

	Negative Ions					
Positive Ions	Chloride	Sulfide	Hydroxide	Nitrate	Sulfate	Phosphate
Potassium	***KCl***					
Calcium						
Tin (II)						
Lead						
Iron (III)						
Ammonium						

(18)

5. **Correct** the following formulae **if necessary**

Iron II carbonate	$Fe_2(CO_3)_3$	____________________
Sodium chloride	$NaCl_2$	____________________
Copper II oxide	Cu_2O	____________________
Barium hydroxide	$BaOH_2$	____________________
Iron II sulfate	$FeSO_4$	____________________
Sodium hydrogencarbonate	$NaHCO_3$	____________________
Iron III chloride	FeCl	____________________
Silver carbonate	$AgCO_3$	____________________

(8)

6. Give the **chemical names** for the following formulae.

FORMULA	**NAME**
$ZnSO_4$	______________________
NH_4Br	______________________
$Cu(HCO_3)_2$	______________________
$CaCO_3$	______________________

(4)

ADVANCED CHEMISTRY REVISION EXERCISE

1. **Define** and give an **example** of each of the following:
   (a) element (b) ion (c) salt (d) indicator
   (e) molecule (f) compound (g) atom (h) isotope

2. Write the **formula** for the following substances:

   oxygen, nitrogen, chlorine, ammonia, carbon dioxide

   water, sulfuric acid, nitric acid, hydrochloric acid, iodine

   sulfur dioxide, dinitrogen pentoxide, aluminium sulfate, zinc nitrate

   calcium phosphate, iron(II) hydroxide, chromium (III) nitrate

3. **Describe** in terms of electron transfer and ion formation the **ionic bond** that results when Na and S react together to form Na_2S.

4. **Name** four **metals** and give a **use** for each metal.

5. **Sketch** the two isotopes of oxygen $^{16}_{8}O$ and $^{18}_{8}O$ showing the sub-atomic particles contained in each isotope.

6. **Copy and complete** the following table:

Particle	Number of Protons	Number of Neutrons	Number of Electrons	Atomic No.
$^{14}_{7}N$				
$^{23}_{11}Na^{+}$				
$^{35}_{17}Cl^{-}$				
	14	15	10	

7. **Classify** the following elements as metals, non metals or metalloids.

   Na Zn S O C Fe Ca Cl I K P

8. **Describe** three **tests** you could use to determine if an unknown solution contains an **acid**. What **results** would you expect if it did.

9. Write the **formula** for any substances that would be produced when the following pairs of substances react with each other.

(a)	Mg and HCl	(b)	Mg and O_2	(c)	Al and H_2SO_4
(d)	K_2CO_3 and HCl	(e)	ZnO and HNO_3	(f)	NaOH and H_2SO_4

10. **Copy and complete** the general equations listed here.

(a) ACID + METAL $\rightarrow$ ______________ + ________________

(b) ACID + BASE $\rightarrow$ ______________ + _________________

(c) ACID + CARBONATE $\rightarrow$ ___________ + ___________ + _________

(d) METAL + OXYGEN $\rightarrow$ ___________

(e) ACID + METAL OXIDE $\rightarrow$ ______________ + ________________

(f) METAL CARBONATE $\rightarrow$ (with heat) ______________ + ________________

11. Give the **name or formula** of the following:

(a) a green coloured metal carbonate _______________________________

(b) a metal that is not silvery grey in colour ___________________________

(c) a metal that does not produce hydrogen gas when it is reacted with dilute acid _________

(d) a gas used in treating commercial swimming pools __________________

(e) a compound used to clear blocked drains (common name is caustic soda) _____________

(f) an acid used to clean brickwork _______________________

(g) an acid used in car batteries __________________________

(h) an acid found in cool drinks __________________________

(i) an acid that makes up about 3 – 5% of vinegar _________________

(j) a positively charged polyatomic ion ______________________

(k) a blue coloured compound ___________________________

(l) a solution that stains your fingers brown when exposed to sunlight ___________________

(m) the gas used in bunsen burners in the laboratories ______________________________

(n) a gas used in portable barbecues and camping stoves ___________________________

(o) three metals that are found in ores less than 150 km from Perth _______ ________ _____

OPEN INVESTIGATIONS

OPEN INVESTIGATIONS are experiments, activities or investigations where you have to solve a problem by designing your own experiment.

Some of the assessment for **Advanced Chemistry** is on your ability to conduct investigations. You have to undertake a Major Science Investigation in a group of two or three where you can choose from a list of investigations or select your own topic to research.

Rather than throw you in at the deep end we will do a sample open investigation as a class so that when you get the actual problem to investigate you will have a framework to assist you.

In **OPEN INVESTIGATIONS** you are given a problem to investigate and you have to design and conduct your own experiments.

For example: Investigating how a ball bounces.

- You could alter the heights from which you dropped a ball onto a surface.
- Or you could use three different types of balls and drop them from the same height.
- Or you could drop the same ball from the same height but falling on different surfaces.

You will have to do a **major science investigation** in a small group which will earn marks towards this unit and test your ability in the Investigating outcome in Science.

OPEN INVESTIGATIONS – the continuing story!

At the end of this topic you will have to do a science investigation which is worth marks towards this topic.

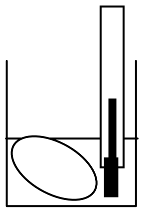
Therefore we are going through a trial open investigation and modelling the *PLANNING, CONDUCTING, PROCESSING DATA* and *EVALUATING* steps by using the INVESTIGATION GUIDE SHEETS.

BACKGROUND INFORMATION TO GET YOU THINKING:

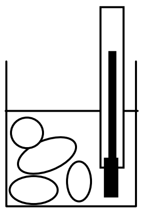
Some reactions happen quickly, others slowly.

Fast rate ⟷ **Slow rate**

Exploding Dynamite	Burning Paper	Smouldering Wood	Clotting Blood	Fermenting Wine	Rusting Car



To cook a potato slowly



To cook a potato quickly

Sometimes you may want to change the rate of reaction. For example, the rate of cooking in the kitchen can be changed. This is done in a number of ways.

Try to spot three variables that have been changed in the two unlabelled pictures to speed up the cooking process. You are going to investigate these variables on your own in your groups.

MACARONI TRIAL INVESTIGATION

Macaroni can be cooked using a Bunsen burner and some water. Your teacher, with your assistance, will lead you through the ***Investigation Guide*** to test the hypothesis that each of the three variables in the picture above affects the cooking time of macaroni.
It is very important that you take care in the planning stage.
You might like to take 15 pieces of macaroni.
Make sure you have a copy of the *Key Terms Used in Science Investigations* Sheet and the *Investigation Guide* to write down what you, the class and your teacher work out.
You should only change one variable at a time. Can you think why?

1. You will have to decide:
   a) Which independent variable is investigated first.
   b) How to control the other variables for a fair comparison.
   c) How to tell when the piece of macaroni is cooked *(measurement)*
2. You will have to write out an outline of your plan in your book. Include a diagram.
3. Carry out your investigation. Your teacher may decide to give one variable to each group to investigate and share findings at the end rather than do all three investigations.
4. Present your results in a suitable written form (table, chart, graph etc)
5. In evaluating your investigation you could ask yourself:
   a) What parts of your investigation went well? Why?
   b) What parts did not go well?
   c) Is there anything you would do differently if you started again?

KEY TERMS USED IN SCIENCE INVESTIGATIONS

HYPOTHESIS:

A possible idea to be tested in an investigation stated as the relationship between the independent and dependent variables. e.g. The more fertiliser you put on wheat the faster it grows. You can write down the hypothesis using an IF .... THEN statement:
e.g. IF you put more fertiliser on wheat THEN it will grow faster.

VARIABLE:

A factor that can be changed, kept the same or measured in an investigation.

INDEPENDENT VARIABLE:

The variable that is changed in an investigation to see what effect it has on the dependent variable.
e.g. the amount of fertiliser on plants.

DEPENDENT VARIABLE:

The variable that changes in response to changes in the independent variable. Often it is the variable that is measured in an experiment.
e.g. the growth of the plants after different amounts of fertiliser have been added.

CONTROLLED VARIABLE:

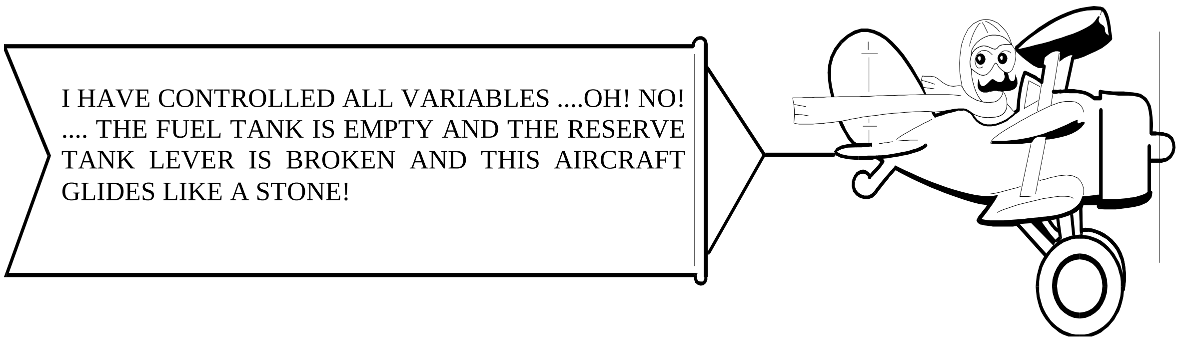
A variable that is kept the same throughout the investigation so you can be sure that it is the change in the independent variable (amount of fertiliser) that is causing the change in the dependent variable (growth of the plants).
An example of controlled variables would be the amount of water added to each pot, the type of soil, the amount of soil etc.

PRELIMINARY TRIALS:

These represent a trial run of the procedure used to fine tune the method and measurement techniques before doing the actual experiment and collecting the data.

REPEAT TRIALS:

These are conducted to collect more data and to eliminate any errors that might have been present if only one trial was used.
e.g. if you were investigating the brakes on a bike you would do many trials and average the results.



INVESTIGATION GUIDE

STUDENT NAME: ______________________________ **DATE:** ______________

OTHER MEMBERS OF YOUR GROUP:

____

The abbreviations at the end of each question or statement have the following meanings:

PL refers to **Planning Investigations**
C refers to **Conducting Investigations**
PD refers to **Processing Data**
E refers to **Evaluating Findings**

This should assist you in identifying the areas that require improvement in order to reach the next Level.

What are you going to investigate? What is your hypothesis? **PL**

____
____
____
____
____

What do you think will happen? Explain why? **PL**

____
____
____
____
____

TABLE OF VARIABLES: **PL**

What will I keep the SAME?	What will I CHANGE?	What will I MEASURE?
CONTROLLED VARIABLES	**INDEPENDENT VARIABLE**	**DEPENDENT VARIABLE**

How will you make your investigation a fair test? **PL**

What equipment will you need? **PL**

List the steps in your procedure or method. **PL**

Do the investigation. **C**

What happened? Describe your observations and record your results. **PD**

Note: You may display your numerical data as a table.

Can your results be represented as a graph? **PD**

TITLE: ____

What do your results tell you? (What is your conclusion?) **PD**
Are there any patterns or trends in your results? **PD**

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Can you EXPLAIN the patterns or trends in your results? **E**

Try to use some SCIENCE IDEAS to help explain what happened? **E**

Are there any changes that would have IMPROVED the way the investigation or experiment was conducted? **E**

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OPEN INVESTIGATION ASSESSMENT

This investigation is to be used to determine your mark for the Investigating outcome in Science. You can EITHER do the investigation below OR you can choose one of the more challenging topics on the next page.

The investigation is on factors affecting the rate of chemical reactions. You are required to investigate **three** variables which could change the speed of reaction between hydrochloric acid and marble chips (calcium carbonate)

As you know one of the products formed is a gas which is released into the atmosphere. The faster the reaction, the more quickly the gas is produced and given off. So a faster reaction loses solid mass more quickly. A sensitive balance could be used.

1. **Fill out an Investigation Guide sheet** about the three variables you investigated, plus an outline of your procedure.

2. **Make a summary sentence** about how reactions can be sped up.

3. Use your conclusions or summary sentences to **explain why:**

    (a) Powders that neutralise stomach acid work faster than tablets which do the same job.
    (b) Car exhaust pipes rust much faster than other parts of a car.
    (c) Sawdust and twigs burn faster than tree trunks.
    (d) Fruit ripens quickly during a hot summer.
    (e) Freezers keep food from "going off" quickly.
    (f) Chips cook faster than boiled potatoes.
    (g) Pure oxygen is used in welding equipment to produce a very hot flame.
    (h) Most plants do not grow well in winter.
    (i) Battery acid destroys clothes but acid in fruit does not.

Open Investigation (alternative topics)

You have to select a chemistry topic to investigate by selecting from the list below or coming up with your own ideas. You can work on your own or in groups of up to three students. You have to **plan** your own experiment, **conduct** the experiment, **process** quantitative data, **evaluate** the findings, **write up** a formal report and **display** your investigation. Students will be able to order basic science equipment and chemicals but will have to obtain most of their equipment and chemicals such as Mars bars and cat food from other sources!

TOPIC LIST:

1 **What factors increase the rate of chemical reactions?**

2 **What washing detergent cleans the best?**

3 **Do all metals react at the same rate in acids?**

4 **Does acid rain affect plant growth?**

5 **What materials are best for soaking up oil spills in water?**

6 **What affect does acid rain have on various materials?**

7 **Which acid produces the most hydrogen gas when mixed with a metal?**

8 **What affect does temperature have on the amount of chlorine in pools?**

9 **What methods are most effective for stopping iron from rusting?**

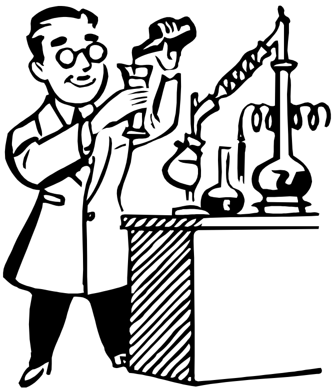
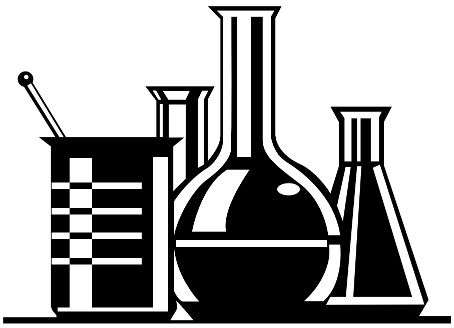
10 **What is the most efficient stain remover?**

11 **What are the factors affecting froth flotation of ores?**

12 **What are the factors affecting the electrolytic purification of copper?**

13 **What are the factors affecting the strength of concrete?**

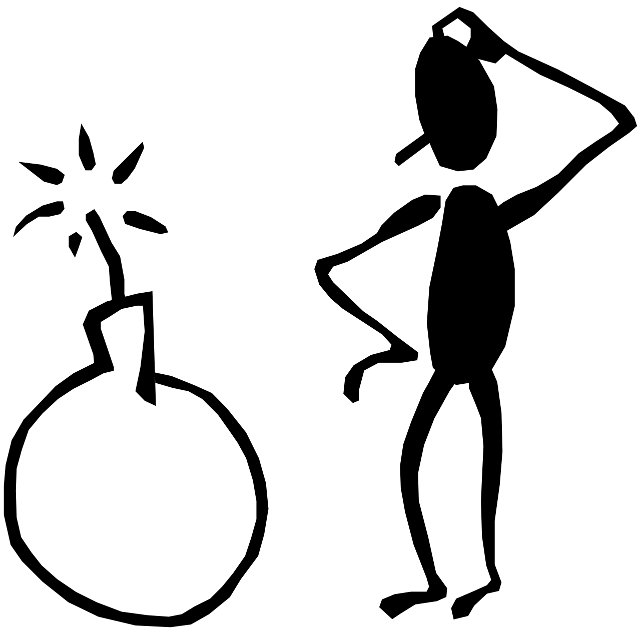
YOUR OWN TOPIC - it has to be approved by your teacher.

SOME HELPFUL INFORMATION

TIMELINE:

WEEK 1:	Start thinking about a suitable topic or choose from the above list. Brainstorm by getting as many ideas as you can as quick as you can. Ideas that are ridiculous today might be brilliant tomorrow. Narrow possibilities and choose your topic. Discuss it with your teacher. Do some background reading and research on the topic. Complete the planning stage using the Investigation Guide Sheet.
WEEK 2:	Prepare list of equipment and give to your teacher. Complete preliminary trials. Refine plans and equipment needs.
WEEK 3: **(in class)**	Begin observations and measurements. Begin writing the early sections of your report.
WEEK 4: **(in class)**	Continue the investigation. Complete data collection and analysis. Continue writing your report. Complete the write-up and display chart (three A-3 sheets) for your investigation.



HOW TO WRITE UP AND DISPLAY A SCIENCE INVESTIGATION REPORT

A science investigation report is different to reports done in other subjects.

Science Reports are based on investigation and research. They present information objectively, formally and clearly. They are written in the past tense because you are reporting work that has already been done. e.g. "The solution was heated to 100° C"

Reports bring together the aims, methods, results and conclusions in the following format:

1. **TITLE or COVER PAGE**
2. **SUMMARY**
3. **INTRODUCTION**
4. **METHODS AND MATERIALS**
5. **RESULTS**
6. **DISCUSSION**
7. **CONCLUSION**
8. **ACKNOWLEDGMENTS**
9. **REFERENCES**
10. **APPENDIX**

TITLE

This is the cover page of your report. Make sure you include the title of the report, your name, school, year and date.

e.g. AN INVESTIGATION INTO HOMEMADE FERTILISERS,
Fred Manures, Rossmoyne Senior High School, Year 10, August 2010.

SUMMARY

You write the summary after you have written the rest of the report. It is a brief explanation of what the research was about, and the conclusions reached.

INTRODUCTION

Explain briefly the aims and objectives of your investigation and any hypothesis you made. Give some background scientific information that you have discovered about the subject from reading books or surfing the net. Maybe you could say why you decided to choose this topic for your investigation.

METHODS AND MATERIALS

Give information about how to set up the experiment, what equipment and materials you used and what methods of observation were tried. A diagram and list of equipment should be included.
The method or procedure should be written down (like a recipe) that can be easily repeated.
Use exact quantities and units of measurement. Use the standard names of chemicals and organisms (plants and animals)
Describe the dependent variable (the one that is measured in the investigation.
e.g. height of the plant)
Describe the independent variable (the one that is changed in the investigation.
e.g. amount of fertiliser added)
Describe the controlled variables (the ones you kept the same at all times.
e.g. amount of soil, type of soil, amount of water added etc.)
Explain any safety precautions.

RESULTS

Present a summary of the results, including measurements and observations.
Use tables, graphs and diagrams where necessary.

DISCUSSION

Point out the meaning of the results. Relate them back to your hypothesis.
Point out any trends or patterns in your results.
Comment on the strengths and weaknesses of your investigation.
Suggest any future improvements and ideas for follow-up research.

CONCLUSION

Explain whether the hypothesis was supported or rejected.
Explain why the results happened as they did.

ACKNOWLEDGMENTS

Mention the assistance other people or organisations have made to your investigation and report briefly, thanking them.

REFERENCES

Alphabetically list your sources as follows:
Author(s)' Surname and Initials. Title. Publisher. Date of Publication
e.g. Bolton, W., *Physics Investigations*, McGraw-Hill, 1996
or Bolton, W., "Physics Investigations", McGraw-Hill, 1996

APPENDIX

Include any extra information which may give more detail or help others attempting to repeat the research investigation.

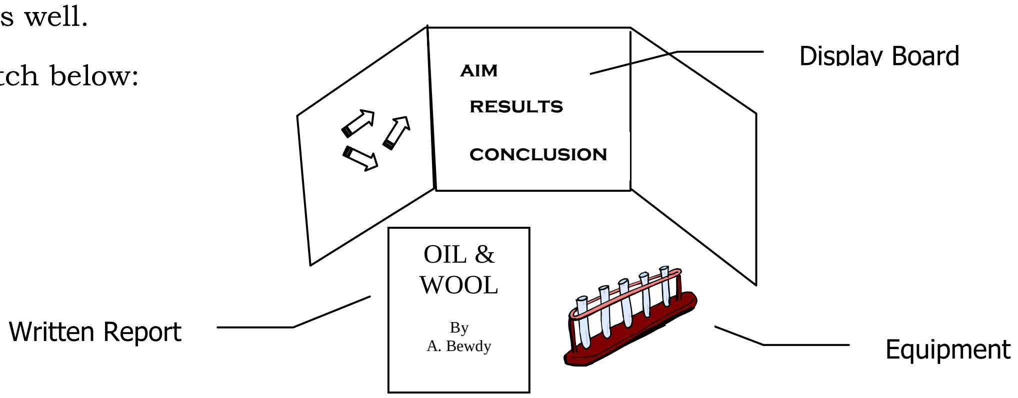
DISPLAYING YOUR INVESTIGATION

A **display board** should be set up that summarises your investigation in an eye catching manner. The board should consist of three A-3 pieces of thick card or plywood that are joined together in some manner (e.g. with Velcro strips) so that the board can stand on a bench top.

Your **written report** should be placed in a display book with plastic sleeves with an artistic cover.

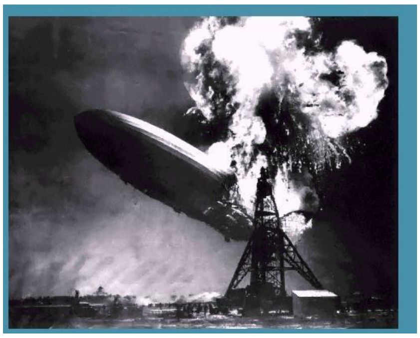
Any **other material**, such as some of your equipment or specimens could be displayed on the bench as well.

See sketch below:



CALCULATIONS IN CHEMISTRY - MOLES

The hydrogen 'pop test' is great fun, but when the Hindenberg airship exploded into flames no one had fun! The only difference between these two reactions is the **amounts** of the substances (reactants or reagents) that 'popped'.



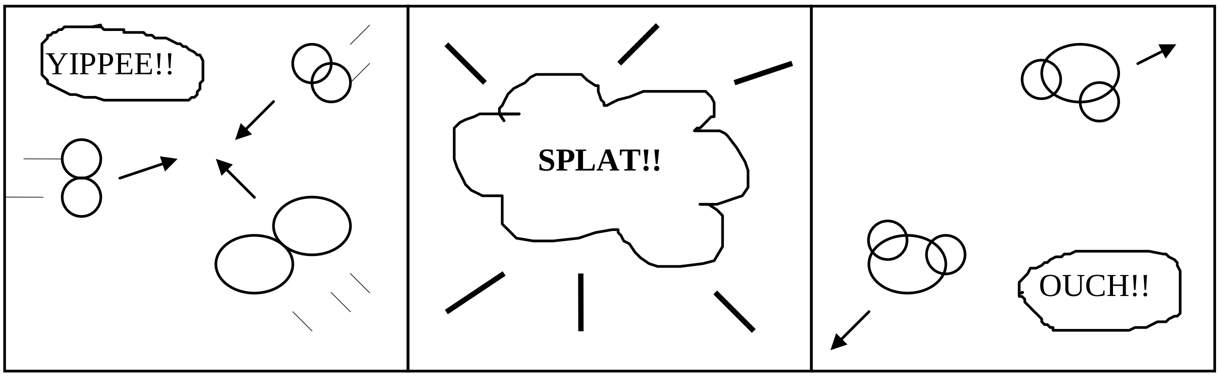
Chemists must answer questions of amounts all the time.
Questions such as:
"How much oxygen is needed to ......?"
"How much iron can be recovered from ...?"
"How much energy will be released when ...?"

We have learned how to write and balance equations for chemical reactions and these help us to answer questions of amounts. Let us look again at the 'pop test'. Its balanced equation looks like this:

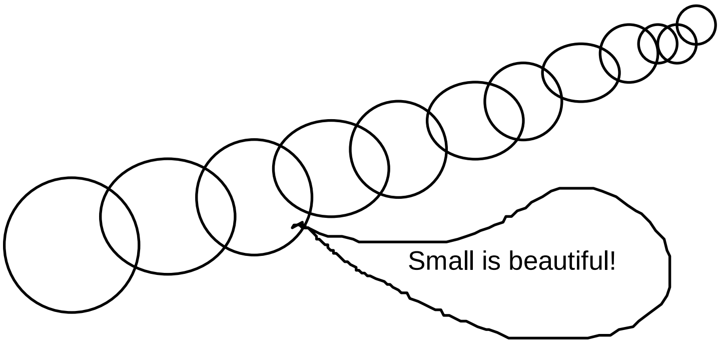
$$2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$$

This tells us something about amounts. It says that "two molecules of hydrogen gas join with one molecule of oxygen gas to make two molecules of water."

This comic gives you the general idea.



But what does it really mean?
Not much as far as amounts go! Atoms are so amazingly tiny it is impossible to see them in the normal sense of the word. It is impossible to weigh them with normal equipment. If every person in Australia contributed one atom to an atomic line-up, the line would be about 2 mm long.



There are about 100 000 000 000 000 000 000 atoms of iron in a staple. i.e 10^{20} atoms.

COUNTING ATOMS IS NOT REALLY A GOOD WAY TO MEASURE REAL AMOUNTS BECAUSE WE NEED SO MANY OF THEM.

When there are just too many things to count, people often count special bundles or groups. Some examples are:

eggs	**dozens**	12
sheets of paper	**reams**	about 500
cool drink cans	**cartons** **slabs**	24 30
matches	**boxes** **cartons**	approx. 50 approx. 500

The group or bundle for atoms and molecules has to be HUGE, because they are so small. The group is called a **mole**. The number is huge. It is called AVOGADRO'S NUMBER and was named after an Italian scientist.

1 **mole** means 6.02×10^{23} or 602 000 000 000 000 000 000 000

Therefore 1 **mole** of iron contains 6.02×10^{23} atoms of iron.
1 **mole** of water contains 6.02×10^{23} molecules of water.

MOLES and NUMBERS

Use the equation below to help you.

$$\boxed{n = \frac{\text{number of particles}}{6.02 \times 10^{23}}}$$

where:
n = moles

EXAMPLE 1: How many **moles** of iron in a sample containing 1.204×10^{24} atoms?

$$n = 1.204 \times 10^{24} \div 6.02 \times 10^{23} = 2 \text{ moles}$$

EXAMPLE 2: How many **particles** are there in 5 moles of a substance?

Rearranging the equation gives:
Number of particles = $n \times 6.02 \times 10^{23}$
$= 5 \times 6.02 \times 10^{23} = 3.01 \times 10^{24}$ particles

SET 1: Write the answers to the following in your notebook:

1. How many **moles** of copper in a sample containing 1.806 x 10^{24} atoms?

2. How many **moles** of water in a sample containing 3.01 x 10^{24} molecules?

3. How many **particles** are there in 2.5 moles of a substance?

4. How many **molecules** are there in 0.25 moles of ammonia gas?

MOLES and MASS

In the laboratory we need to be able to measure out amounts of chemicals. Weighing is the easiest way to do this, but as we have seen before, we want to know the amount in moles which is a number of particles.

To convert moles to a mass and vice versa we must be able to use atomic weights (correctly called **relative atomic mass**)

Every element has a **relative atomic mass (atomic weight).** You do not need to learn them because you can use a chart like the one below. For our calculations we will define relative atomic mass (atomic weight) as:

Atomic weight is the mass of one mole of an element.

Element	symbol	atomic weight	Element	symbol	atomic weight	Element	symbol	atomic weight
aluminium	Al	27	lead	Pb	207	radium	Ra	226
calcium	Ca	40	magnesium	Mg	24	silicon	Si	28
carbon	C	12	mercury	Hg	201	silver	Ag	107.9
chlorine	Cl	35.5	nickel	Ni	59	sodium	Na	23
chromium	Cr	52	nitrogen	N	14	strontium	Sr	87.6
copper	Cu	63.6	oxygen	O	16	sulfur	S	32
helium	He	4	phosphorus	P	31	tin	Sn	119
hydrogen	H	1	plutonium	Pu	244	uranium	U	238
iron	Fe	56	potassium	K	39	zinc	Zn	65

SET 2: <u>Use the above Atomic Weight Table to answer these questions:</u>

1. Why do you think mercury and lead are called heavy metals?
2. Why are hydrogen and helium used in balloons and airships?
3. Which metal, aluminium or iron, is best for building planes?
   Give a reason for your answer.
4. What is the atomic weight of uranium?

Most substances exist with the atoms joined together.

To find the **Molar Mass** (i.e. mass of 1 mole or mass of 6.02 x 10^{23} molecules) of a molecular substance, we just add up all the atomic weights. This is sometimes called the **Molecular Weight**.

EXAMPLE: Find the **Molar Mass (Molecular Weight)** of water.

H_2O: contains 2 hydrogen atoms = 2 x 1 = 2 g
and 1 oxygen atom = 1 x 16 = 16 g
Therefore Molar Mass (M) = 18 g

SET 3: Calculate the Molar Mass (M) of the substances below.
Set out your work as shown in the example above.

a) carbon dioxide
b) oxygen gas
c) dinitrogen oxide (nitrous oxide or laughing gas) N_2O
d) methane
e) benzene C_6H_6
f) chlorine gas
g) sulfur dioxide
h) sugar - $C_{12}H_{22}O_{11}$
i) alcohol - CH_3CH_2OH
j) acetic acid (vinegar) - CH_3COOH
k) ammonia gas - NH_3
l) hydrogen peroxide - H_2O_2

CALCULATING MOLES FROM A GIVEN MASS OF A SUBSTANCE

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

Where **n** is the **n**umber of **moles**
m is the **m**ass in grams
M is the **M**olar Mass

EXAMPLE 1: How many **moles** are there in 36 g of water?

$$n = \frac{m}{M} = \frac{36}{18} = 2 \text{ moles}$$

Molar Mass: H_2O = (2 x 1) + (1 x 16) = 18 g

STEP 2:
Use this equation to find the number of moles when you are given the mass in grams.

STEP 1:
Find the Molar Mass by adding the atomic weights.

EXAMPLE 2: How many **moles** are there in 22 g of propane gas ($CH_3CH_2CH_3$)?

$$n = \frac{m}{M} = \frac{22}{44} = 0.5 \text{ moles}$$

Molar Mass: $CH_3CH_2CH_3$
= (3 x 12) + (8 x 1) = 44 g

SET 4: Now try these and set them out as above:

Calculate the number of <u>moles</u> in:

1. 196 g of sulfuric acid.
2. 68 g of ammonia gas
3. 128 g of sulfur dioxide
4. 78 g of benzene (C_6H_6)
5. 63 kg of nitric acid (watch it - the mass is given in kilograms!)
6. 20 mg of water (watch it - the mass is given in milligrams!)

CALCULATING MASS FROM A GIVEN NUMBER OF MOLES OF A SUBSTANCE

EXAMPLE 1: Find the **mass** of 2 moles of water.

STEP 1: Re-arrange the equation

$n = \frac{m}{M}$ so it becomes $m = n \times M$

$m = n \times M$
$m = 2 \times 18 = 36$ g

<u>Molar Mass</u>:
H_2O = (2 x 1) + (1 x 16) = 18 g

<u>STEP 2</u>:
Find the Molar Mass by adding the atomic weights

EXAMPLE 2: Find the **mass** of 0.8 moles of oxygen gas (O_2).

STEP 1: Re-arrange the equation

$n = \frac{m}{M}$ so it becomes $m = n \times M$

$m = n \times M$
$m = 0.8 \times 32 = 25.6$ g

<u>Molar Mass</u>:
O_2 = (2 x 16) = 32 g

<u>STEP 2</u>:
Find the Molar Mass by adding the atomic weights

SET 5: Calculate the mass of:

1. 1.5 moles of carbon monoxide
2. 2.5 moles of ammonia gas
3. 6.0 moles of hydrogen chloride gas
4. 234.2 moles of sulfuric acid

You have been doing chemical calculations with molecular substances. Molecular substances are composed of non-metallic elements. For example CO_2 and NH_3.
But you can do the same sort of calculations with ionic compounds. Ionic compounds are made up of metal and non-metallic elements.
For example, copper chloride, zinc carbonate, lead nitrate.

Remember the following points:

1. If you need to find the Molar Mass then add the atomic weights together.

2. If you have to find the number of moles and you are given the mass of the compound:

Use the equation: $$n = \frac{m}{M}$$

3. If you have to find the mass and you are given the number of moles of the compound then re-arrange the above formula to give:

$$m = n \times M$$

SET 6: Now try the following calculations:

1. How many moles in 250 g of sodium chloride (NaCl)?
2. How many moles in 475 g of copper sulfate ($CuSO_4$)?
3. Find the mass of 0.25 mole of aluminium hydroxide - $Al(OH)_3$
4. Find the Molar Mass of $Na_2CO_3.10H_2O$
5. How many moles in 145 g of zinc carbonate?
6. Find the mass of 28 moles of magnesium nitrate.
7. Which has the highest Molar Mass, sulfuric acid or magnesium sulfate?
8. Which contains the greatest number of moles?

   40 g of iron chloride or 40 g of sodium hydroxide?
9. An aluminium saucepan weighs 100g when empty and 300 g when full of water.
   a) How many moles of water are present?
   b) How many moles of aluminium in the saucepan?
10. If gold sells for $200 a gram, how much would 35 moles of gold be worth?

    (This one will test your analytical skills!!)

MOLES – METHOD OF ATTACK GUIDESHEET FOR CALCULATIONS WHERE YOU HAVE TO FIND MOLES OR MASS OR VOLUME OF A GAS OR NUMBER OF PARTICLES OF A CHEMICAL

1. QUESTION MARK (?) THE UNKNOWN SUBSTANCE AND TICK (✓) THE KNOWN (GIVEN) SUBSTANCE.
THESE ARE OFTEN THE SAME SUBSTANCE

2. FIND MOLES OF THE KNOWN SUBSTANCE.

You will be given the moles already **OR** you will have to calculate the number of moles by using one of the following formulas:

$n = \frac{m}{M}$ (use when given the **mass** of the known substance)

$n = \frac{\text{No of particles}}{6.02 \times 10^{23}}$ (use when given the **number of particles**, i.e. atoms/molecules/ions)

$n = \frac{V}{22.4}$ (use when given the **volume of a gas**)

3. FIND MOLES OF THE UNKNOWN SUBSTANCE.

If the known and unknown substances are the **same chemical** then the answer to step 3 is the **same** as the answer to step 2.

If the known and unknown substances are **different chemicals** then calculate the moles of the unknown by using one of the formulas below:

IF UNKNOWN IS PART OF A COMPOUND: (e.g.TO FIND AMOUNT OF OXYGEN IN CO_2 : **multiply** n(known) by 2 because there are 2 atoms of oxygen in CO_2)

n(unknown part of compound) = n_{known} x number of unknown atoms or ions in the formula of the chemical

IF UNKNOWN IS THE COMPOUND: (e.g.TO FIND AMOUNT OF CO_2 THAT HAS AN AMOUNT OF OXYGEN IN IT: **divide** n(known) by 2 because there are 2 atoms of oxygen in CO_2)

n(unknown compound) = n_{known} ÷ number of known atoms or ions in the formula of the chemical

4. WORK OUT THE ANSWER IF YOU HAVE NOT ALREADY OBTAINED IT IN STEP 2 OR 3.

If you have to find **mass** rearrange $n = \frac{m}{M}$ to give **m = n x M**

If you have to find **Nº of particles** rearrange

$n = \frac{\text{No of particles}}{6.02 \times 10^{23}}$ to give **Nº of particles = n x 6.02 x 10^{23}**

If you have to find **volume of a gas** rearrange

$n = \frac{V}{22.4}$ to give **V = n x 22.4**

EXAMPLES TO ILLUSTRATE THE METHOD OF ATTACK GUIDESHEET FOR MOLE CALCULATIONS

EXAMPLE 1:

? ✓

How many moles of CO_2 in 88 g of CO_2?

1. **QUESTION MARK (?) THE UNKNOWN SUBSTANCE AND TICK (✓) THE KNOWN (GIVEN) SUBSTANCE.**

2. **FIND MOLES OF THE <u>KNOWN</u> SUBSTANCE.**

$n(CO_2) = \frac{m}{M} = \frac{88}{44} =$ **2 mol CO_2** (this is your answer so you need to go no further)

EXAMPLE 2:

? ✓

How many aluminium ions are in 306 g of Al_2O_3?

1. **QUESTION MARK (?) THE UNKNOWN SUBSTANCE AND TICK (✓) THE KNOWN (GIVEN) SUBSTANCE.**

2. **FIND MOLES OF THE <u>KNOWN</u> SUBSTANCE.**

$n(Al_2O_3) = \frac{m}{M} = \frac{357}{102} = 3.5$ mol Al_2O_3

3. **FIND MOLES OF THE <u>UNKNOWN</u> SUBSTANCE.**

$n_{unknown} = n_{known}$ **x** number of unknown ions in the formula of the chemical

$n(Al^{3+}) = 2 \times 3.5 = 7.0$ mol Al^{3+}

4. **WORK OUT THE <u>ANSWER</u>.**

№ of particles = n x 6.02 x 10^{23} = 7.0 x 6.02 x 10^{23} = **4.21 x 10^{24} ions of aluminium**.

EXAMPLE 3:

? ✓

Calculate the mass of propane gas (C_3H_8) that contains 200 g of carbon.

1. **QUESTION MARK (?) THE UNKNOWN SUBSTANCE AND TICK (✓) THE KNOWN (GIVEN) SUBSTANCE.**

2. **FIND MOLES OF THE <u>KNOWN</u> SUBSTANCE.**

$n(C) = \frac{m}{M} = \frac{200}{12} = 16.666$ mol C

3. **FIND MOLES OF THE <u>UNKNOWN</u> SUBSTANCE.**

n(unknown compound) = n_{known} ÷ number of known atoms in the formula of the chemical

$n(C_3H_8) = 16.666 \div 3 = 5.555$ mol C_3H_8

4. **WORK OUT THE <u>ANSWER</u>.**

mass (C_3H_8) = n x M = 5.555 x 44 = **244.4 g C_3H_8**

GUIDE TO MOLE CALCULATIONS

Terms To Understand:

Atomic mass (Relative Atomic Mass, Atomic weight): A_r

This is the mass of an atom compared with one-twelfth the mass of an atom of carbon-12.
These are available by looking at a Periodic Table or a list of Relative Atomic Masses.

Example: The atomic mass of sodium is 23; the atomic mass of oxygen is 16.00 (no units)

Molecular mass (Relative Molecular Mass, Molecular weight): M_r

This is the mass of a molecule compared with one-twelfth the mass of an atom of carbon-12.
These are calculated by adding together the atomic masses of the atoms that make up the molecule.

Example: Calculate the molecular weight of CO_2

$M_r(CO_2)$ = atomic mass of carbon + (2 x atomic mass of oxygen) = 12.01 + (2 x 16) = **44.01**

Example: Calculate the molecular weight of oxygen gas (O_2). Oxygen gas exists as diatomic molecules.
$M_r(O_2)$ = (2 x atomic mass of oxygen) = (2 x 16) = **32** (no units)

Example: Calculate the molecular weight of acetic acid (CH_3COOH)

$M_r(CH_3COOH)$ = (2 x atomic mass of C) + (2 x atomic mass of O) + (4 x atomic mass of H)
= (2 x 12.01) + (2 x 16) + (4 x 1.008) = **60.232** (no units)

Formula mass (Relative Formula Mass, Formula weight): M_r

This is the mass of a 'formula unit' compared with one-twelfth the mass of an atom of carbon-12.
Note: A formula unit usually refers to ionic substances such as sodium chloride (NaCl).
These are calculated in exactly the same way as molecular masses.

Example: Calculate the formula mass of ammonium sulfate – $(NH_4)_2SO_4$

M_r:$(NH_4)_2SO_4$
= (2 x atomic mass of N) + (8 x atomic mass of H) + (Atomic mass of S) + (4 x atomic mass of O)
= (2 x 14.01) + (8 x 1.008) + (32.1) + (4 x 16) = **132.184** (no units)

Mole: Is Avogadro's number of particles (6.02×10^{23})

Example: 1 mol of CH_3COOH contains $1 \times 6.02 \times 10^{23}$ molecules of CH_3COOH.
Therefore:
1 mol of CH_3COOH contains $2 \times 6.02 \times 10^{23}$ atoms of C i.e. 2 mol of carbon.
1 mol of CH_3COOH contains $2 \times 6.02 \times 10^{23}$ atoms of O i.e. 2 mol of oxygen.
1 mol of CH_3COOH contains $4 \times 6.02 \times 10^{23}$ atoms of H i.e. 4 mol of hydrogen.
8 mol of CH_3COOH contains $8 \times (4 \times 6.02 \times 10^{23})$ atoms of H i.e. 32 mol of hydrogen.

Molar Mass: Is the mass of one mole of a substance. It is calculated in exactly the same way as relative molecular and formula masses except it has grams (g) for units. The symbol for Molar Mass is **M.**

Example: Calculate the Molar Mass of ammonium sulfate – $(NH_4)_2SO_4$

M:$(NH_4)_2SO_4$
= (2 x atomic mass of N) + (8 x atomic mass of H) + (Atomic mass of S) + (4 x atomic mass of O)
= (2 x 14.01) + (8 x 1.008) + (32.1) + (4 x 16) = **132.184 g**

TYPE EXAMPLES: (REFER TO THE METHOD OF ATTACK GUIDESHEET)

?　　　　　　　　　　　　✓

EXAMPLE 1: How many moles of CO_2 contain 1.8×10^{24} molecules of CO_2?

Always start off by finding the moles of the given or known substance. You might have to use a formula.

$$n = \frac{\text{Number of particles}}{6.02 \times 10^{23}} = \frac{1.8 \times 10^{24}}{6.02 \times 10^{23}} = 2.99 \text{ mol } CO_2$$

?　　　　　　✓

EXAMPLE 2: Find the number of atoms of carbon in 4 mol carbon.

1. Always start off by finding the moles of the given or known substance. You do not have to use a formula because you are given the moles of carbon already.

   n (C) = 4 mol

2. Find moles of the unknown substance. In this case the known substance and the unknown substance are the same therefore the moles of carbon = 4 mol.

3. Work out the answer by using a formula that has moles (n) and number of particles in it.

   $n = \frac{\text{Number of particles}}{6.02 \times 10^{23}}$ therefore Number of atoms = n x 6.02×10^{23}

   Number of atoms C = 4 x 6.02×10^{23} = **2.41×10^{24} atoms C**

?　　　　　　✓

EXAMPLE 3: Find the number of moles of hydrogen in 0.2 mol ammonia (NH_3).

1. Find the number of moles of the known or given substance.

   n (NH_3) = 0.2 mol

2. Find the number of moles of the unknown substance (i.e. what you have to find out)

   n (unknown) = n (known) x number of atoms of the unknown in the formula of the known substance
   n (H) = 0.2 x 3 (because there are 3 atoms of H in NH_3)
   n (H) = 0.6 mol H

   <u>There is no need to go any further because you have obtained the answer already</u>.

? ✓

EXAMPLE 4: Find the number of atoms of hydrogen in 0.5 mol of ammonium carbonate.

1. Find the number of moles of the given or known substance. You have been given this already.

   $n\,[(NH_4)_2CO_3] = 0.5$ mol

2. Find the number of moles of the unknown substance.

   n (unknown) = n (known) x number of atoms of the unknown in the formula of the known substance
   n (H) = 0.5 x 8 because there are 8 atoms of H in $(NH_4)_2CO_3$
   n (H) = 4.0 mol H

3. Work out the answer by using a formula that number of particles in it.

   $n = \frac{\text{Number of particles}}{6.02 \times 10^{23}}$ therefore Number of atoms = n x 6.02×10^{23}
   Number of atoms H = 4 x 6.02×10^{23} = **2.41×10^{24} atoms H**

? ✓

EXAMPLE 5: How many moles of $MgCO_3$ in 33.6 g magnesium carbonate.

1. Find the number of moles of the given or known substance.

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

where:
n = number of moles
m = mass in grams
M = Molar Mass in grams

$$n(MgCO_3) = \frac{33.6}{84} = 0.4\,\text{mol}$$

Molar Mass: $MgCO_3$
1 x Mg = 1 x 24 = 24
1 x C = 1 x 12 = 12
3 x O = 3 x 16 = 48
84 g

There is no need to go any further because you have obtained the answer already.

n ($MgCO_3$) = 0.4 mol

? ✓

EXAMPLE 6: Find the mass of 3 moles of ammonium sulfide.

1. Find the number of moles of the given or known substance.

   $n\,[(NH_4)_2S] = 3$ mol (already given in the data)

2. Find the number of moles of the unknown substance.

   $n\,[(NH_4)_2S] = 3$ mol (known and unknown are the same substance)

3. Work out answer by selecting a formula that has mass in it.

$$n = \frac{m}{M}$$ therefore: $m = n \times M$

Molar Mass: $(NH_4)_2S$

2 x N	=	2 x 14	=	28
8 x H	=	8 x 1	=	8
1 x S	=	1 x 32	=	<u>32</u>
				68

m $(NH_4)_2S$ = 3 x 68 = 204 g

? ✓

EXAMPLE 7: Calculate the mass of carbon in 90 g of propane gas (C_3H_8).

1. Find the number of moles of the given or known substance.

$$n = \frac{m}{M} \qquad n\,[C_3H_8] = \frac{90}{44} = 2.045\ \text{mol}$$

Molar Mass: C_3H_8

3 x C	=	3 x 12	=	36
8 x H	=	8 x 1	=	<u>8</u>
				<u>44</u> g

2. Find moles of unknown substance.

   n (unknown) = n (known) x number of atoms of the unknown in the formula of the known substance
   n (C) = 2.045 x 3 (because there are 3 carbon atoms in every molecule of C_3H_8)

   n (C) = 6.135 mol

3. Find the answer by using a formula that has mass in it.

$$n = \frac{m}{M}$$ therefore: **m (C)** = n x M = 6.135 x 12 **= 73.62 g**

? ✓

EXAMPLE 8: Calculate the moles of nitrate ions in 60 g of copper(II) nitrate.

1. Find the number of moles of the given or known substance.

$n = \frac{m}{M}$ $n\,[Cu(NO_3)_2 = \frac{60}{187.5} = 0.32\ mol$

Molar Mass: $Cu(NO_3)_2$				
1 x Cu	=	1 x 63.5	=	63.5
2 x N	=	2 x 14	=	28
6 x O	=	6 x 16	=	96
				187.5 g

2. Find moles of unknown substance.

n (unknown) = n (known) x number of atoms of the unknown in the formula of the known substance

$n\ (NO_3^-)$ = 0.32 x 2 because there are 2 nitrate ions in every particle of $Cu(NO_3)_2$

$n\ (NO_3^-)$ = 0.64 mol (There is no need to go further because you already have the answer)

? ✓

EXAMPLE 9: Calculate the mass of sodium sulfate that contains 284 g sodium ions.

1. Find the number of moles of the given or known substance.

$n = \frac{m}{M}$ $n\,[Na^+] = \frac{284}{23} = 12.35\ mol$

2. Find moles of unknown substance.

n (unknown) = n (known) ÷ number of atoms of the known in the formula of the unknown substance

$n\ (Na_2SO_4)$ = 12.35 ÷ 2 because there are 2 sodium ions in every particle of Na_2SO_4

= 6.175 mol

3. Find the answer by using a formula that has mass in it.

Molar Mass: Na_2SO_4				
2 x Na	=	2 x 23	=	46
1 x S	=	1 x 32	=	32
4 x O	=	4 x 16	=	64
				142 g

$n = \frac{m}{M}$ therefore: **$m\ (Na_2SO_4)$** = n x M = 6.175 x 142

= **877 g**

EXAMPLE 10: Calculate the Molar Mass (molecular weight, formula mass etc) of a

? ✓

substance if 0.1 mol of it has a mass of 3.0 g.

1. Find moles of known. n (X) = 0.1 mol
2. Find moles of unknown n (X) = 0.1 mol (because known and unknown are the same substance)
3. Work out the answer using a formula that has Molar Mass (M) in it.

$n = \frac{m}{M}$ therefore: **M** $= \frac{m}{n} = \frac{3.0}{0.1} = 30\ g\ mol^{-1}$

? ✓

EXAMPLE 11: Calculate the moles of methane gas that occupies 1.12 litres at S.T.P.
(S.T.P. stands for Standard Temperature and Pressure – 0^0C and 101.3 kPa pressure)

1. Find moles of known. Use a formula that has volume of a gas in it.

$$n\,(\text{methane}) = \frac{V}{22.4} = \frac{1.12}{22.4} = 0.05\ \text{mol}$$

where:
n = number of moles
V = volume of the gas in litres
22.4 = number of litres occupied by 1 mole of any gas at S.T.P.

There is no need to go any further because you already have the answer.

? ✓

EXAMPLE 12: Determine the volume occupied by 48.4 g carbon dioxide at S.T.P.

1. Find the moles of known. You are not given the moles so use a formula that has mass in it.

$$n = \frac{m}{M} \qquad n\,[CO_2] = \frac{48.4}{44} = 1.1\ \text{mol}$$

Molar Mass: CO_2
1 x C = 1 x 12 = 12
2 x O = 2 x 16 = 32
44 g

2. Find moles of unknown. Known and unknown are the same substance.

$n\,[CO_2]$ = 1.1 mol

3. Find the answer by using a formula that has volume of a gas in it.

$$n\,[CO_2] = \frac{V}{22.4} \text{ therefore } V = n \times 22.4 = 1.1 \times 22.4 = 24.6\ \text{L}$$

V [CO_2] = 24.6 L

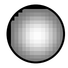
METHANE GAS EXPLOSION ON VARANUS ISLAND

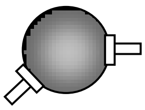
WHAT'S IN A MOLE? - A SIMULATION ACTIVITY

BACKGROUND: The ***mole*** is a quantity used in ***counting*** atoms and molecules much like the dozen is useful in counting eggs and oranges.

WHAT TO DO: Use the molecular model kit and an electronic balance and complete the following table.
Do not fill in the shaded boxes.
Always make your predictions before making the measurements.
Record your results as you go.

Quantity	Predicted weight	Measured weight
one dozen (12) hydrogen (H) atoms		
one dozen (12) oxygen (O) atoms		
one dozen (12) oxygen molecules (O_2)		
one dozen (12) water molecules (H_2O)		
one dozen (12) hydrogen peroxide molecules (H_2O_2)		


Hydrogen


Oxygen

Questions

1. What would 5.5 dozen water molecules weigh?

2. A container has 125 g of hydrogen peroxide molecules in it, how many dozen hydrogen peroxide molecules does it contain?

3. Calculate the mass of 1dozen hydrogen molecules (H_2).

4. How much would 6.2 dozen hydrogen molecules (H_2) weigh?

5. Calculated the number of dozen water molecules in a container that holds 62 g of it.

6. Calculated the number of dozen water molecules in a container that holds 62 g of it.

7. How could you use your balance to measure out (without counting !!!!) 16 dozen (192) hydrogen atoms?

MOLES WORKSHEET 1

Table 1 Relating moles, mass and numbers of atoms in molecular compounds. (abbreviation for moles is mol)

SUBSTANCE	MOLES OF SUBSTANCE	MOLAR MASS	MASS OF SUBSTANCE
Zn	1 mol		
Cu	1.5 mol		
P	0.1 mol		
O_2	1 mol		
O_2	4 mol		
O_2	0.2 mol		
NH_3	1 mol		
NH_3			48g
H_3PO_4			15g

Table 2 Relating moles, mass and numbers of ions in ionic compounds.

SUBSTANCE	MOLES OF SUBSTANCE	MOLAR MASS	MASS OF SUBSTANCE
NaOH			142g
$Ca(OH)_2$	6 mol		
$Ca(OH)_2$			8.5g
$Al_2(SO_4)_3$			
$Al_2(SO_4)_3$			
$Pb(NO_3)_2$	0.15 mol		
$(NH_4)_2Fe(SO_4)_2$	0.25 mol		
$(NH_4)_2Fe(SO_4)_2$			

MOLES WORKSHEET 2

USE THE *METHOD OF ATTACK GUIDESHEET* – TO FILL IN THE MISSING SPACES BELOW:

(A) Mass	**Moles of Atoms**	**Number of Atoms**
130g Zn		
32.5 g Zn		
18.0 g C		
4.0 g C		
21.0 g N_2		

(note: abbreviation for moles is **mol**)

(B) Mass	**Moles of Molecules**	**Number of Molecules**	**Moles of H Atoms**	**Number of H Atoms**
18 g H_2O				
27 g H_2O				
4.5 g H_2O				
12 g CH_4				
51 g NH_3				

(C) Mass	**Moles of Substance**	**Number of "formula units" of substance**	**Moles of :**		**Number of :**	
117 g NaCl			Cl^- ions		Cl^- ions	
55 g $CaCl_2$			Cl^- ions		Cl^- ions	
28 g Al_2O_3			O^{2-} ions		O^{2-} ions	
16.4 g Na_3PO_4			Na^+ ions		Na^+ ions	
55 g Li_2SO_4			SO_4^{2-} ions		SO_4^{2-} ions	

(D) Calculate the mass in grams represented by the given number of moles:

1.0 mol oxygen atoms		1.0 mol oxygen molecules	
0.5 mol H_2SO_4		1.5 mol H_2SO_4	
1.0 mol Fe_2O_3		0.5 mol Mg^{2+} ions	
0.25 mol $CuSO_4$		2.0 mol OH^- ions	
2.5 mol H_2O		0.1 mol $Ca_3(PO_4)_2$	

PERCENTAGE COMPOSITION: A SPECIAL TYPE OF CALCULATION THAT USES A DIFFERENT METHOD

EXAMPLE 1: Find the percentage of iron in Fe_3O_4.

How would you work out the % of girls in the class. If you can do that then finding the % Fe in Fe_3O_4 will be easy – no sweat!!

This means finding the percentage of elements or ions in a compound.

Actually it is finding the mass of an element in 100 g of a compound.

A formula for working it out is:

$$\%\,[\text{element}] = \frac{\text{mass of element in the compound}}{\text{mass of the compound}} \times \frac{100}{1}$$

You are not given any masses to work with so you can work with relative atomic masses and molar masses to obtain an answer. Fe_3O_4 has 3 atoms of Fe so we can adjust the above formula to read:

$$\%\,[\text{Fe}] = \frac{3 \times \text{atomic mass Fe}}{\text{Molar Mass of } Fe_3O_4} \times \frac{100}{1}$$

<u>Molar Mass</u>: Fe_3O_4
3 x Fe = 3 x 56 = 168
4 x O = 4 x 16 = <u>64</u>
<u>232</u> g

$$\%\,[\text{Fe}] = \frac{3 \times 56}{232} \times \frac{100}{1} = 72.4\%$$

EXAMPLE 2: Find the percentage of water in hydrated copper sulfate crystals, $CuSO_4.5H_2O$.

<u>Molar Mass</u>: H_2O
2 x H = 2 x 1 = 2
1 x O = 1 x 16 = <u>16</u>
<u>18</u>

$$\%\,[H_2O] = \frac{5 \times \text{Molar Mass}[H_2O]}{\text{Molar Mass of } CuSO_4.5H_2O} \times \frac{100}{1} = \frac{5 \times 18}{250} \times \frac{100}{1} = 36\%$$

<u>Molar Mass</u>: $CuSO_4.5H_2O$
1 x Cu = 1 x 64 = 64
1 x S = 1 x 32 = 32
4 x O = 4 x 16 = 64
10 x H = 10 x 1 = 10
5 x O = 5 x 16 = <u>80</u>
<u>250</u> g

% $[H_2O]$ = 36%

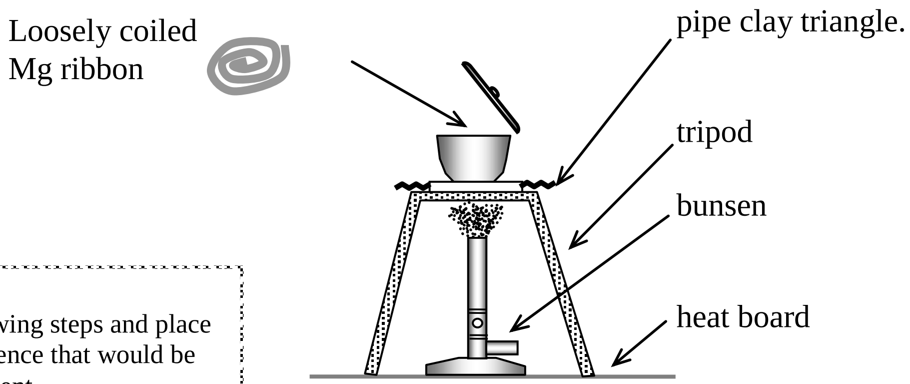
ACTIVITY 9: PERCENTAGE COMPOSITION OF MAGNESIUM OXIDE

AIM: To experimentally determine the composition of magnesium oxide.

BACKGROUND: A compound can be described as "***consisting of two or more different elements that are chemically combined in a definite ratio***". In this experiment you will make a the compound magnesium oxide and determine its composition. The composition can be described as the mass of each element in 100 g of the compound. This is known as the percentage composition of the compound.

EQUIPMENT: balance (± 0.001 g), crucible and lid, bunsen, magnesium ribbon (~0.2 g ie ~20 cm), crucible tongs, pipe clay triangle, tripod, heat mat, matches

PROCEDURE: **Safety Note** Take care when burning magnesium ribbon. Do not touch the hot crucible or tripod with your hands. Always use crucible tongs. Before commencing heating practice handling the crucible lid with tongs.



PLEASE NOTE:
Carefully read the following steps and place them into a logical sequence that would be suitable for this experiment.

- Replace the crucible lid and allow the crucible and contents to cool.
- Coil the magnesium ribbon so that it will fit into the crucible.
- When all the magnesium has reacted, remove the lid and heat strongly for a further 5 minutes.
- Accurately weigh the crucible and lid on a balance and record the mass in the table.
- Obtain a clean, dry crucible and lid, and heat them for 5 minutes over a bunsen flame. Allow them to cool
- Carefully heat the crucible and its contents with the lid off until the magnesium begins to glow. Immediately replace the lid and heat the crucible strongly.
- Reweigh the crucible with its content and lid.
- Place the magnesium ribbon into the crucible, replace the lid and reweigh.
- Carefully heat the crucible for about 10 minutes, occasionally lifting the lid with tongs to provide oxygen for the reaction. Try to avoid the loss of any magnesium oxide smoke when the lid is lifted.
- Draw up a table for your results as shown below.

Mass of crucible + lid	.... *g*
Mass of crucible + lid + magnesium	.... *g*
Mass of crucible + lid + magnesium oxide	.... *g*

Calculations and Questions:

(show all working where a calculation is involved)

1. With reference to your results table, calculate
   a) the mass of magnesium which was used.

   b) the mass of oxygen combined with the magnesium

2. Calculate the % by mass of the element oxygen (O) in the compound.

3. Calculate the % by mass of the element magnesium (Mg) in the compound.

4. Assuming the formula of magnesium oxide is MgO, calculate the % by mass of the element magnesium (Mg) and % by mass of the element oxygen (O) in the compound.

5. Compare your experimental value for the percentage composition of magnesium oxide with that obtained from its known formula of MgO. Are your results in reasonable agreement with the theoretical expectations? You need to justify your answer.

6. Describe one change you could make to this experiment that would improve the reliability of your result. Justify your answer.

ACTIVITY 10: WATER OF CRYSTALLIZATION

AIM: To measure the mass of water contained in a sample of crystalline copper sulfate and use this to determine the hydrated formula of copper sulfate.

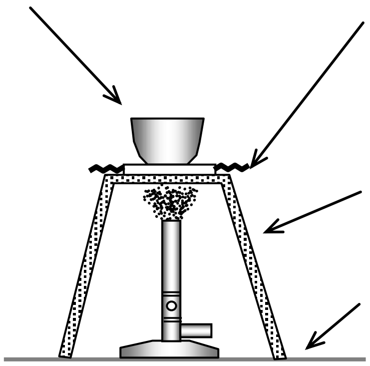
EQUIPMENT: Crucible, 3 to 5 g hydrated copper sulfate, pipeclay triangle, tripod, bunsen, heat board, matches, electronic balance to ± 0.01 g.

PROCEDURE:

1. Accurately weigh (two decimal places) a clean crucible and record this weight.
2. Add 3 to 5 g (your teacher will give each group a different weight) of crystalline copper sulfate to your crucible then reweigh and record your result.
3. Assemble the apparatus as shown below.
4. Heat your sample for 6 minutes.

SAFETY FIRST

Wear safety glasses and take care not to touch hot equipment such as the crucible or tripod.



5. Allow the crucible to cool then reweigh and record this weight to 2 decimal places.

EXTRA: Try this! Add a few drops of water to your dried (anhydrous) $CuSO_4$ sample. What happens?

CALCULATIONS AND QUESTIONS:

1. From your measurement what is the mass of water (H_2O) and copper sulfate ($CuSO_4$) contained in your sample.
2. Calculate the moles of water and copper sulfate contained in your example.
3. For your sample calculate the ratio $\frac{nH_2O}{nCuSO_4}$ Round this off to a whole number
4. Use your result from Question 3 to write a formula for Copper Sulfate crystals i.e. $CuSO_4$. ? H_2O.
5. From what you observed in your experiment, describe two effects of removing the water of crystallisation from your copper sulfate crystals.
6. Use your measurements to work out what percentage (by mass) of your copper sulfate crystals was water.

HOW TO DO CALCULATIONS INVOLVING CHEMICAL EQUATIONS

1. WRITE DOWN THE BALANCED CHEMICAL EQUATION.

2. IDENTIFY THE UNKNOWN SUBSTANCE WITH A QUESTION MARK (?)
AND THE KNOWN SUBSTANCE WITH A TICK (✓)

3. FIND THE MOLES OF THE KNOWN SUBSTANCE.

You will either be given the moles already **OR** you will have to calculate the moles by using one of the formulas below:

$n = \frac{m}{M}$ (Use when given **the mass** of the known substance)

$n = \frac{\text{Number of particles}}{6.02 \times 10^{23}}$ (Use when given the **number of particles** i.e. atoms, ions, molecules)

$n = \frac{V}{22.4}$ (Use when given the **volume of a gas at STP**)

$n = cV$ (Use when given **the concentration in mol L^{-1} and volume in litres of a solution**)

4. FIND THE MOLES OF THE UNKNOWN SUBSTANCE

$$n\ (\text{unknown}) = \frac{\text{unknown coefficient in balanced equation}}{\text{known coefficient in balanced equation}} \times n\ (\text{known})$$

5. WORK OUT THE ANSWER BY RE-ARRANGING THE FORMULAS BELOW.
(if you have not already obtained the answer)

If you have to find **mass** re-arrange: $n = \frac{m}{M}$ to give $m = n \times M$

If you have to find **N° of particles** re-arrange: $n = \frac{\text{Number of particles}}{6.02 \times 10^{23}}$ to give $\text{No.of.particles} = n \times 6.02 \times 10^{23}$

If you have to find **volume of a gas at STP** re-arrange: $n = \frac{V}{22.4}$ to give $V = n \times 22.4$

If you have to find **concentration** or **volume of a solution** rearrange: $n = cV$ to give $c = \frac{n}{V}$ or $V = \frac{n}{c}$

CALCULATIONS INVOLVING CHEMICAL EQUATIONS
TYPE EXAMPLES

EXAMPLE 1: *320 g of sulfur dioxide gas are burnt in oxygen to produce sulfur trioxide gas. Calculate the mass of oxygen gas required to produce the sulfur trioxide.*

This is obviously a calculation involving a chemical equation so we follow the steps:

1. WRITE DOWN THE BALANCED CHEMICAL EQUATION.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

2. IDENTIFY THE UNKNOWN SUBSTANCE WITH A QUESTION MARK (?) AND THE KNOWN SUBSTANCE WITH A TICK (✓)

$$\overset{\checkmark}{2SO_2(g)} + \overset{?}{O_2(g)} \rightarrow 2SO_3(g)$$

3. FIND THE MOLES OF THE KNOWN SUBSTANCE.

You are given a mass, therefore use the formula:

$$\mathbf{n\ (SO_2)} = \frac{m}{M} = \frac{320}{64.06} = \mathbf{5.00\ mol}$$

Mass is ALWAYS expressed in grams in chemistry

MOLAR MASS of SO_2
= Atomic mass of S + 2 x Atomic mass of O
= 32.06 + (2 x 16)
= 64.06 g

4. FIND THE MOLES OF THE UNKNOWN SUBSTANCE

$$\text{n (unknown)} = \frac{\text{unknown coefficient in balanced equation}}{\text{known coefficient in balanced equation}} \times \text{n (known)}$$

$$\mathbf{n\ (O_2)} = \frac{1}{2} \times n\ (SO_2) = \frac{1}{2} \times 5.00 = \mathbf{2.50\ mol}$$

We have not yet obtained the answer so we need to go to step 5.

5. WORK OUT THE ANSWER BY RE-ARRANGING THE CORRECT FORMULA.

You have to find ***mass*** *so re-arrange:* $n = \frac{m}{M}$ to give $\mathbf{m = n \times M}$

$$\mathbf{m(O_2) = n(O_2)} \times \mathbf{M(O_2)} = 2.50 \times 32 = 80.0\ g$$

MOLAR MASS of oxygen (O_2)
= 2 x atomic mass of oxygen
= 2 x 16
= 32 g

<u>ANSWER</u>: mass of $O_2(g)$ = 80.0 g

CALCULATIONS INVOLVING CHEMICAL EQUATIONS
TYPE EXAMPLES

EXAMPLE 2: *540 g of aluminium powder are reacted with hydrochloric acid to give aluminium chloride and hydrogen gas. Calculate the volume of hydrogen gas produced at standard temperature and pressure.*

This is obviously a calculation involving a chemical equation so we follow the steps:

1. WRITE DOWN THE BALANCED CHEMICAL EQUATION.

$$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

2. IDENTIFY THE UNKNOWN SUBSTANCE WITH A QUESTION MARK (?)
AND THE KNOWN SUBSTANCE WITH A TICK (✓)

$$\overset{\checkmark}{2Al(s)} + 6HCl(aq) \rightarrow 2AlCl_3(aq) + \overset{?}{3H_2(g)}$$

3. FIND THE MOLES OF THE KNOWN SUBSTANCE.

You are given a mass, therefore use the formula:

$$\mathbf{n\ (Al)} = \frac{m}{M} = \frac{540}{27} = \mathbf{20.0\ mol}$$

Mass is ALWAYS expressed in grams in chemistry

MOLAR MASS of Al
= Atomic mass of Al
= 27.0 g

4. FIND THE MOLES OF THE UNKNOWN SUBSTANCE

$$\text{n (unknown)} = \frac{\text{unknown coefficient in balanced equation}}{\text{known coefficient in balanced equation}} \times \text{n (known)}$$

$$\mathbf{n\ (H_2)} = \frac{3}{2} \times \text{n (Al)} = \frac{3}{2} \times 20.0 = \mathbf{30.0\ mol}$$

We have not yet obtained the answer so we need to go to step 5.

5. WORK OUT THE ANSWER BY RE-ARRANGING THE CORRECT FORMULA.

You have to find **volume of a gas at STP** so re-arrange: $n = \frac{V}{22.4}$ to give $\mathbf{V = n \times 22.4}$

$$\mathbf{V(H_2)} = n \times 22.4 = 30.0 \times 22.4 = \mathbf{672\ L}$$

VOLUME of a gas is always expressed in litres – symbol **L**

<u>ANSWER</u>: volume of $H_2(g)$ = 672 L

CALCULATIONS INVOLVING CHEMICAL EQUATIONS
TYPE EXAMPLES

EXAMPLE 3: *540 g of aluminium powder are reacted with hydrochloric acid to give aluminium chloride and hydrogen gas. Calculate the volume of 6.00 mol L^{-1} hydrochloric acid required to completely react with the aluminium.*

This is obviously a calculation involving a chemical equation so we follow the steps:

1. WRITE DOWN THE BALANCED CHEMICAL EQUATION.

$$2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

2. IDENTIFY THE UNKNOWN SUBSTANCE WITH A QUESTION MARK (?)
AND THE KNOWN SUBSTANCE WITH A TICK (✓)

$$\overset{✓}{2Al(s)} + \overset{?}{6HCl(aq)} \rightarrow 2AlCl_3(aq) + 3H_2(g)$$

3. FIND THE MOLES OF THE KNOWN SUBSTANCE.

You are given a mass, therefore use the formula:

$$\textbf{n (Al)} = \frac{m}{M} = \frac{540}{27} = \textbf{20.0 mol}$$

Mass is ALWAYS expressed in grams in chemistry

MOLAR MASS of Al
= Atomic mass of Al
= 27.0 g

4. FIND THE MOLES OF THE UNKNOWN SUBSTANCE

$$\text{n (unknown)} = \frac{\text{unknown coefficient in balanced equation}}{\text{known coefficient in balanced equation}} \times \text{n (known)}$$

$$\textbf{n (HCl)} = \frac{6}{2} \times \text{n (Al)} = \frac{6}{2} \times 20.0 = \textbf{60.0 mol}$$

We have not yet obtained the answer so we need to go to step 5.

5. WORK OUT THE ANSWER BY RE-ARRANGING THE CORRECT FORMULA.

You have to find **volume of a solution** so re-arrange: $n = cV$ to give $\mathbf{V = \frac{n}{c}}$

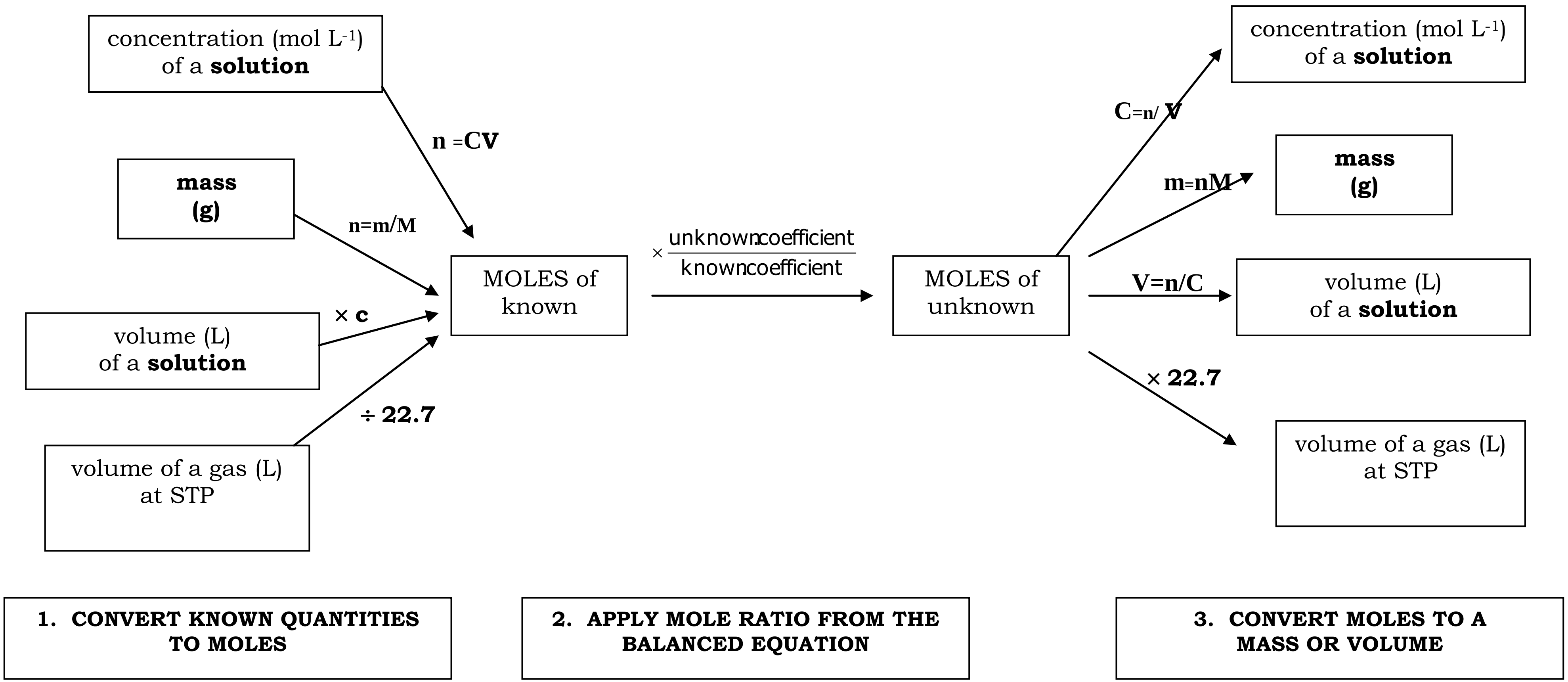
$$\textbf{V(HCl)} = \frac{\mathbf{n}}{\mathbf{c}} = \frac{60.0}{6.0} = \textbf{10.0 L}$$

VOLUME of a solution is always expressed in litres – symbol **L**

CONCENTRATION of a solution is always expressed in MOLES PER LITRE – symbol **mol L^{-1}**

<u>ANSWER</u>: volume of HCl(aq) = 10.0 L

CALCULATIONS FROM EQUATIONS FLOWCHART
[AN ALTERNATIVE METHOD]



ACTIVITY 11:
DECOMPOSITION OF SODIUM HYDROGENCARBONATE

AIM: To examine the mole relationship between, $NaHCO_3$, and Na_2CO_3, for the decomposition of $NaHCO_3$.

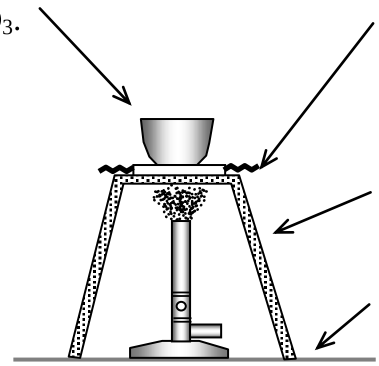
BACKGROUND: When you heat $NaHCO_3(s)$ it decomposes to $Na_2CO_{3(s)}$ and other gaseous products.

EQUIPMENT: Electronic balance (measuring to ± 0.001 g), anhydrous $NaHCO_3$, crucible, bunsen, tripod, pipe clay triangle, heat board and matches.

PROCEDURE:

1. Obtain a clean dry crucible. (You may wish to strongly heat your empty crucible for about 5 min prior to using. This will ensure any volatile material is removed from it before use)
2. Record the mass of the empty crucible (to nearest 0.001g).
3. Add about 1.5g – 4.5g (as directed by your teacher) of $NaHCO_3$ to your crucible.
4. Reweigh your crucible and $NaHCO_3$, record this.
5. Assemble the apparatus as shown below. Heat your sample gently at first then strongly for about 5 minutes.

SAFETY FIRST
Take Care!!
WEAR
SAFETY GLASSES



6. Allow the crucible to cool then reweigh and record your result.

CALCULATIONS & QUESTIONS: **(Show your working for any calculations)**

1. Use your results determine the mass of $NaHCO_3$ and Na_2CO_3 involved in the reaction.
2. Calculate the number of moles of $NaHCO_3$ and Na_2CO_3 involved in the reaction.
3. From your experimental results what is the mole ratio of $\frac{n(NaHCO_3)}{n(Na_2CO_3)}$ for your experiment?
4. Write an equation for the decomposition of $NaHCO_3$. What should the mole ratio be according to the equation? Is your experimental result (from question 3) in agreement? Explain.
5. Does the mole ratio change when different amounts of $NaHCO_3$ used? Explain.

SUMMARY OF CLASS RESULTS- (THERMAL DECOMPOSITION OF $NaHCO_3$)

GROUP	Mass of $NaHCO_3$	Mass of Na_2CO_3	Moles of $NaHCO_3$	Moles of Na_2CO_3	Ratio of moles of $NaHCO_3$ used to moles of Na_2CO_3 formed.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					

ACTIVITY 12:
MOLE RELATIONSHIP BETWEEN COPPER AND IRON

YOUR MISSION: Design then carry out an experiment that allows you to find out the mole relationship (ratio) between n[Cu*(s)*] formed and n[Fe*(s)*] used for the displacement reaction between Iron and copper sulfate solution.

BACKGROUND:

The metal iron has a reaction known as a displacement reaction when added to various salt solutions. In this example a piece of solid iron ***dissolves*** as the reaction progresses. At the same time solid copper is formed as a rather powdery brown insoluble solid.

This reaction involves iron atoms, Fe*(s)* (from the piece of iron) becoming oxidised as each atom loses one or more electrons to form a positive iron ion. The resulting iron ions are soluble in water so the metal appears to dissolve. At the same time the metal ions from the salt solution, in this case Cu^{2+}*(aq)* ions, become reduced as they gain two electrons each to form Cu atoms. As copper is insoluble it forms a brown powdery deposit of particles copper(Cu).

TECHNICAL ISSUES:

How will you collect your copper residue. When weighing your copper residue you will need to ensure it is quite dry and free of any salts. You should consider how to ensure there is no trace of solution adhering to your copper residue. Depending upon the quantities used there may be some iron left over when the reaction is complete. You should consult your teacher regarding this. As the reaction is rather slow it could take several hours to reach completion.

EQUIPMENT: As well as various lab glassware and equipment as stored in all labs you will have access to: Iron, (approximately 1-2g in the form of nail, filings or steel wool - fine or coarse), 50 mL of approximately 1.0 mol L^{-1} $CuSO_4$*(aq)*, Electronic balance (measuring to ± 0.001 g), labels, an oven

PROCEDURE: Determine your procedure for doing the experiment. Pay attention to equipment, sequence of steps and measurements to be made along the way.

CALCULATIONS & QUESTIONS: (Show your working for any calculations)

1. Use your results determine the moles of Fe*(s)* used and moles of Cu*(s)* produced in the reaction.

4. From your experimental results what is the mole ratio of $\frac{n(Fe)}{n(Cu)}$ for your experiment?

4. Determine the average value for your class results.

5. Try to write an equation for the reaction of Fe*(aq)* with $CuSO_4$*(aq)* that is consistent with the mole ratio you found.

6. What were the problems you encountered in conducting this experiment? In particular what situations might have limited the reliability of your final result? Suggest a practical way of overcoming two of the problems you have identified.

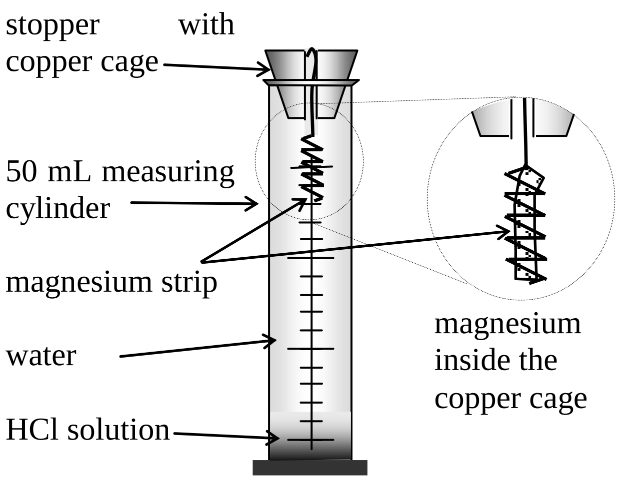
ACTIVITY 13:
MOLAR VOLUME OF HYDROGEN GAS AT ROOM CONDITIONS

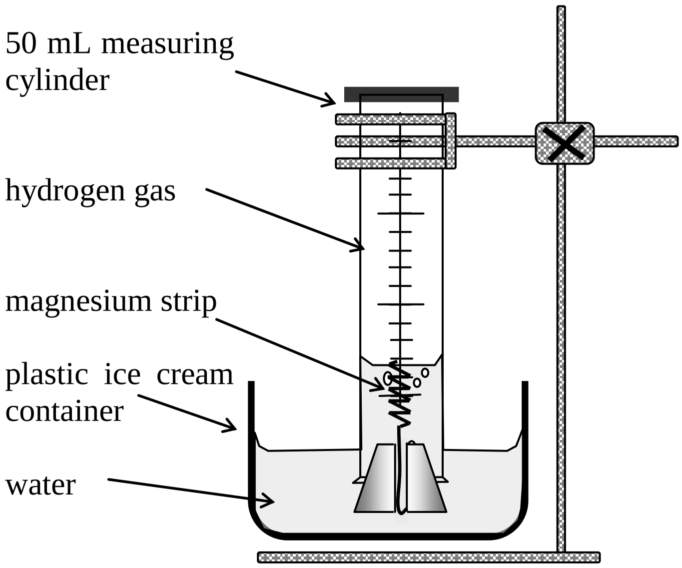
AIM: To experimentally find the volume of one mole of hydrogen gas at room conditions.

BACKGROUND: In this experiment the volume of hydrogen gas which is produced when a small piece of magnesium reacts with hydrochloric acid is measured. By also measuring the mass of magnesium used it is possible to determine the number of moles of hydrogen gas that would be produced. Since the volume of hydrogen gas will be measured it is then be possible to work out what volume one mole of hydrogen gas would occupy. This gives the molar volume of hydrogen gas at room conditions.

EQUIPMENT: One holed rubber stopper with coil of copper wire (to fit the measuring cylinder), 15 ml of 3 mol L^{-1} hydrochloric acid, 50 mL measuring cylinder, magnesium ribbon (about 4 cm), stand and clamp, cotton thread (20 cm), barometer, plastic ice cream container.

APPARATUS SET UP:





PROCEDURE:

1. Collect a length of clean Mg ribbon (2.0 to 3.0 cm max) and measure it to ± 0.05 cm. Your teacher will give you the mass of 100.0cm of clean ribbon so that you can calculate the mass of your magnesium. Record both pieces of data.
2. Fold the magnesium ribbon in half and slide it into the copper cage as shown in sketch above. Loosely wrap cotton thread around the Mg and copper cage.
3. Set up a retort stand and clamp to hold the measuring cylinder (or it may be easier to hold the cylinder upright).
4. Pour 15 mL of 0.3 mol L^{-1} hydrochloric acid into the measuring cylinder. Optional, for a colourful effect !!!!???? add a few drops of universal indicator to your acid…..
5. Now very carefully fill the measuring cylinder to overflowing with tap water. Do this carefully so that mixing of the acid is minimised. It is best to angle the cylinder and pour slowly. Some mixing is OK..
6. Insert the magnesium, copper coil and stopper assembly into the measuring cylinder. Do this with a **gentle twist** and push action, there should be no air bubbles in your tube.
   DANGER – don't excessively push on the stopper.

7. With a finger covering the hole in your stopper invert the measuring cylinder into the plastic trough as shown above. Gently clamp or hold the tube in place. The acid, being denser than water, will move down through the water and start to react with the magnesium. Hopefully the magnesium will stay in its copper cage.
8. When the reaction is complete tap the cylinder gently to dislodge any gas bubbles that are still attached to the coil or to the sides of the gas measuring tube.
9. Keep the mouth of the cylinder under water and carefully raise or lower it so that the water level inside the cylinder matches the water in the plastic trough. Now record the volume of gas in the cylinder to within ± 0.1 mL.
10. Record the room temperature and barometric pressure.

Processing Of Results and Questions:

1. From your length of magnesium ribbon and the know mass of 100.0 cm of magnesium ribbon, determine the mass of magnesium used in the reaction.
2. Write an equation showing the reaction that occurs between Mg(s) and HCl(aq) producing H_2(g) and $MgCl_2$(aq).
3. Using your answers to question 1 and 2, calculate the moles of hydrogen gas that should have been produced.
4. From your measured volume of hydrogen gas and your answer to question 3, regarding the moles of hydrogen expected, determine the volume of one mole of hydrogen gas (molar volume at room conditions). Quote your answer in litres per mole at the measured temperature and pressure.

   (Hint: molar volume (H_2) = $\frac{volume}{moles}$)

5. How would your answer for the molar volume of hydrogen have been different if the following changes were made? Answer higher, lower, no change, can't tell and give a short explanation.
   (a) the room temperature had been higher
   (b) the room pressure had been higher
   (c) a bigger piece of magnesium had been used.

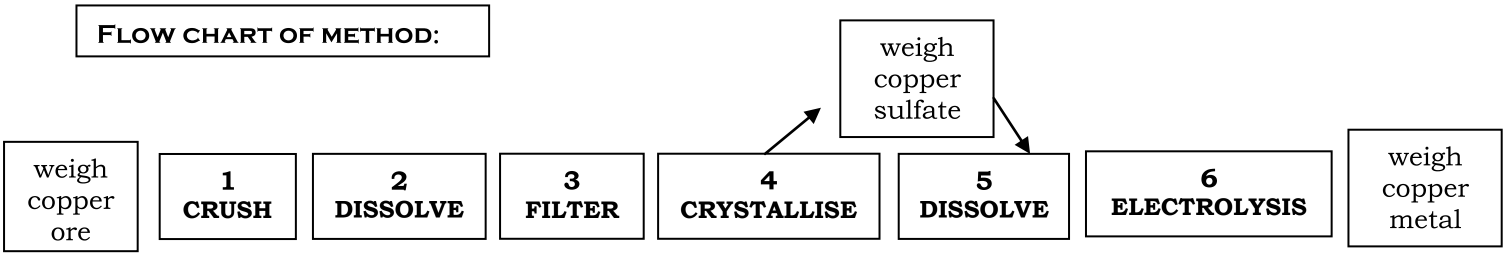
6. How does your experimental result for the molar volume of hydrogen gas compare with the accepted value of 22.4 litres at 0 ^{0}C and 101.3 kPa (or 24.5 L at 25 ^{0}C and 101.3 kPa). Do you think your result is acceptable given the techniques used? Justify your ideas.

ACTIVITY 14: EXTRACTION OF A METAL FROM ITS ORE

AIM: To extract copper sulfate and copper metal from a copper containing ore.

APPARATUS: The copper ore is made by mixing copper sulfate, sand and plaster of Paris, adding water and allowing to set. (This will be done for you); balance; mortar and pestle; 2 beakers; filter funnel and stand; filter paper; burner, tripod and gauze mat; watch glass; hand lens; spatula; sodium chloride; stirring rod; power pack; strips of copper and lead;
2 connecting leads; steel wool.

FLOW CHART OF METHOD:



METHOD: TAKE CARE !!! USE SAFETY GLASSES

1. Find the **mass** of the ore.
2. **Crush** the ore in a mortar using the pestle, until it is a powder.
3. Put the crushed ore in a beaker and add enough water to **dissolve** the ore and heat it for five minutes.
4. Let the mixture cool while any solid settles then **filter**. Keep as much solid in the beaker as possible so that it does not clog the filter paper.
5. Rinse the solid left in the beaker with about 10 mL of water and pour the rinse water through the filter paper as well.
6. Boil the filtrate until only a few mL remain then turn off the burner and leave the **crystals** to dry out completely.
7. Scrape the dry crystals that have formed onto a watch glass and **weigh** them.
8. CALCULATE the percentage yield of crystals in the ore.
9. Dissolve the crystals in water so that they completely **dissolve**.
10. Add a spatula of sodium chloride to help the solution conduct electricity.
11. Clean the lead and copper strips with steel wool.
12. **Weigh** the copper strip.
13. With the power pack on 4 V DC, pass an **electric** current through the solution with the lead strip connected to the positive and copper connected to the negative.
14. When the solution is clear or after 15 minutes turn the current off.
15. Take out the copper strip, wash it gently, leave it to dry then **weigh** it again.
16. CALCULATE the mass of copper deposited.
17. CALCULATE the percentage of copper in the copper ore you originally started with.

RESULTS:

Mass of copper ore	
Description of the crystals in the watch glass	
Mass of crystals in the watch glass	
Percentage yield of crystals in the ore	
What is the chemical name of the crystals?	
Mass of copper strip	
Mass of copper strip after electrolysis	
Mass of copper deposited on the copper strip	
Percentage of copper in the original copper ore sample	

QUESTIONS:

1. Why was the ore crushed before any processing was done?
2. What steps in the processing required an input of energy?
3. Calculate the percentage of copper in a sample of copper ore using the following information:
   mass of copper ore = 54.1 g; mass of crystals in watch glass = 50.6 g; mass of copper strip = 24.8 g;
   mass of copper strip after electrolysis = 43.2 g.

ACTIVITY 15: SMELTING A LEAD ORE

AIM: To extract lead from lead oxide by carbon reduction.

BACKGROUND:

Some metals like lead and iron can be extracted from their ores by carbon reduction. This involves mixing the ore with carbon in the form of coking coal or graphite and heating the mixture vigorously. This heating process is known as **smelting**.

The lead ions in the ore gain two electrons and form lead atoms. We say the lead ore has been reduced because electrons have been gained by a substance.

TECHNICAL ISSUES:

Lead oxide, lead and their vapours are poisonous. Avoid skin contact, and wash your hands after using lead or any lead compound. Avoid breathing any fumes.

EQUIPMENT:

Yellow lead oxide; piece of white paper; Bunsen burner, matches.

PROCEDURE:

1. Adjust the burner so you have a small flame.
2. Light a match and let one third of it burn. The black charred end is mainly charcoal (Carbon)
3. Dip the charred end into water, then into some lead oxide.
4. Hold the end of the match in the burner flame and watch for the formation of tiny metallic blobs of molten material.
5. Allow the match to cool. Then place it on a piece of white paper and see if you can see any lead. If no lead has been formed, repeat steps 2 to 5. Maybe a popstick could be used instead of a match.

QUESTIONS:

1. Why was the match dipped into water?

2. How do you know that a chemical reaction has taken place?

3. Where did the carbon needed for the reaction come from?

4. Write a balanced chemical equation for the smelting of lead oxide by carbon reduction.

ASSIGNMENT ON MINERALS AND MINING IN WA

Western Australia is well known for its vast mineral wealth. In fact mineral exploration mining and mineral processing provide the major platform for Western Australia's prosperity. In this assignment you are to research some aspects of this industry.

1. On a map of Western Australia, and using a key system identify where the following ores and minerals are mined, include the mine / town name. e.g ♦ could be gold.

IRON ORE (three locations)
SALT (three locations)
NICKEL (two locations)
MINERAL SANDS (two locations)
COAL (two locations)
BAUXITE (one location)
GOLD (three locations)

2. Complete a table similar to the one below, indicating the names, formula and metals contained in the various minerals

MINERAL NAME	FORMULA OF MINERAL	USE OR ECONOMIC IMPORTANCE
MAGNETITE		**(Iron Ore)**
HAEMATITE		
ZIRCON		
TANTALITE		
RUTILE		**(Mineral Sands)**
ILMENITE		
SALT		
PENTLANDITE		
BAUXITE		

3. Give a **short** description of each of the following methods of mining; a simple two dimensional LABELLED sketch would be essential.
In particular, state the **advantages** of each type of mining.

OPEN PIT
STRIP
DREDGING
VERTICAL SHAFT
DECLINE

4. Consider the following techniques used in mineral exploration and write a short description of the scientific principle on how each of these works.

Aeromagnetic surveys **Seismic surveys** **Satellite imagery** **Surface Sampling**

Costeans (trenching) **Diamond drilling** **Rotary Percussion drilling**

5. Once an ore body has been mined the material is crushed to a suitable size. The valuable minerals within the crushed ore must then be concentrated. Concentration of the mineral from an ore involves physical processes. Use **nickel** and **mineral sands** mining to explain the process of mineral concentration. Consider any **two** of the following methods.

Froth Flotation **Gravity Separation**
Magnetic Separation **Electrostatic Separation**

6. Metals such as iron and aluminium are extracted from their ores by oxidation-reduction chemical processes like carbon reduction or electrolysis.

(i) Define the processes of reduction and oxidation in terms of gain/loss of electrons.

(ii) Using **aluminium** or **iron** as an example describe the chemical processes that occur during either **electrolysis** or **carbon reduction**. What substances are oxidised and what substances are reduced?

MINING POSTER

- *You must SELECT ONE MINING COMPANY operating in W.A. and use it to demonstrate an awareness of the mining activities in which it is engaged.*
- *For example you could cover: location, exploration methods, mining methods, concentrating and processing methods, other activities of the company (including the current share price) etc. BUT THE FOCUS OF THE POSTER IS ON THE CONCENTRATING AND PROCESSING METHODS (include equations for any chemical processing steps – even if they take place out of WA)*
- *You can have a go at designing your own poster with the aid of a computer package.*
- *The internet is a useful source of information.*

THE TOPIC FOR THE POSTER IS:
MINING AND CHEMISTRY INVOLVED IN MINERAL PROCESSING

THE SIZE OF THE POSTER IS TO BE A-3 SIZE.
THAT IS TWO A-4 SHEETS JOINED TOGETHER.