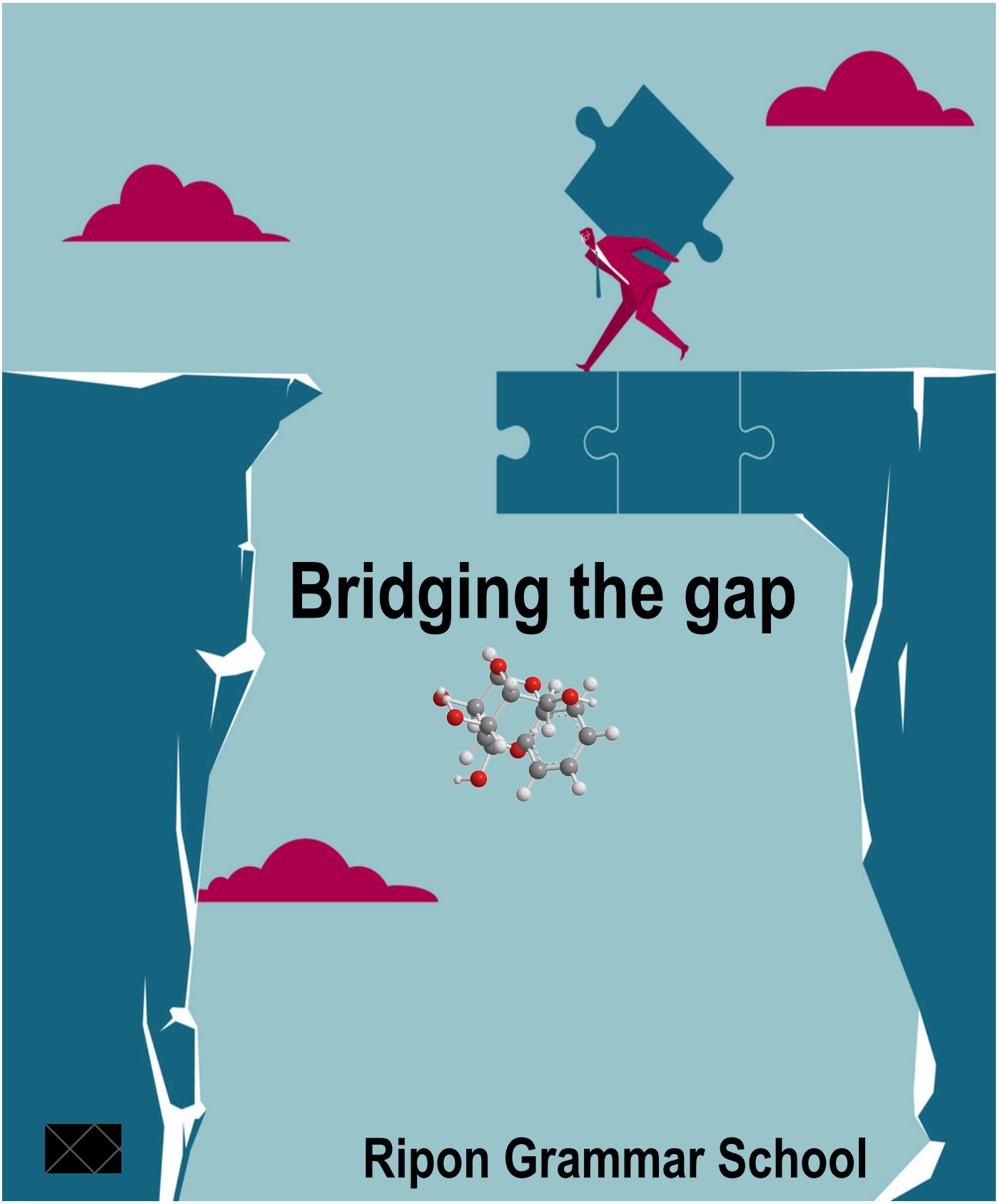
CHEMISTRY



Bridging the gap

Ripon Grammar School

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		**Key**									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	96.0 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La * lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac † actinium 89	[267] Rf rutherfordium 104	[268] Db dubnium 105	[271] Sg seaborgium 106	[272] Bh bohrium 107	[270] Hs hassium 108	[276] Mt meitnerium 109	[281] Ds darmstadtium 110	[280] Rg roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

140.1 Ce cerium 58	140.9 Pr praseodymium 59	144.2 Nd neodymium 60	[145] Pm promethium 61	150.4 Sm samarium 62	152.0 Eu europium 63	157.3 Gd gadolinium 64	158.9 Tb terbium 65	162.5 Dy dysprosium 66	164.9 Ho holmium 67	167.3 Er erbium 68	168.9 Tm thulium 69	173.1 Yb ytterbium 70	175.0 Lu lutetium 71
232.0 Th thorium 90	231.0 Pa protactinium 91	238.0 U uranium 92	[237] Np neptunium 93	[244] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[247] Bk berkelium 97	[251] Cf californium 98	[252] Es einsteinium 99	[257] Fm fermium 100	[258] Md mendelevium 101	[259] No nobelium 102	[262] Lr lawrencium 103

* **58 – 71** Lanthanides

† **90 – 103** Actinides

Introduction

Advanced level Chemistry is a demanding and exciting course. In order to be prepared for your start in September a number of areas from GCSE chemistry are needed to be 'known' thoroughly. To help you make the transition as smoothly as possible we have put together this series of exercises. When you start in September you will be expected to have completed the exercises within this booklet and know the material within. It is by no means ALL you need to know but the very foundations of the exciting journey you are about to start. If you have difficulties or confusions there are a number of suggested online resources you could try. There will be opportunities to discuss concerns with staff at the beginning of the year but you should have made significant headway independently.

This booklet contains some notes to act as a reminder. If you struggle with a particular area you should investigate the suggested support resources including your GCSE notes. There are exercises for you to complete, the answers are at the end.

Contents

Writing formulae

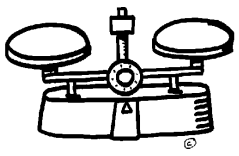
Objectives:

- Know the common ions
- Be able to construct formulae for common ionic substances
- Know the formulae of some common covalent substances

Common Ions (you need to know these):

Positive ions		Negative ions	
Name	Formula	Name	Formula
Hydrogen	H^+	Chloride	Cl^-
Sodium	Na^+	Bromide	Br^-
Silver	Ag^+	Fluoride	F^-
Potassium	K^+	Iodide	I^-
Lithium	Li^+	Hydroxide	OH^-
Ammonium	NH_4^+	Nitrate	NO_3^-
Barium	Ba^{2+}	Oxide	O^{2-}
Calcium	Ca^{2+}	Sulfide	S^{2-}
Copper(II)	Cu^{2+}	Sulfate	SO_4^{2-}
Magnesium	Mg^{2+}	Carbonate	CO_3^{2-}
Zinc	Zn^{2+}		
Lead	Pb^{2+}		
Iron(II)	Fe^{2+}		
Iron(III)	Fe^{3+}		
Aluminium	Al^{3+}		

Putting together an ionic formula:



The charges must balance.
Molecular ions will need to be contained in brackets.

Potassium Oxide

Potassium ion K^+ Oxide ion O^{2-}

There is 1+ and 2-

So we need:

K^+ K^+ to balance the O^{2-}

Giving the formula

K_2O

Aluminium Hydroxide

Aluminium ion Al^{3+} Hydroxide ion OH^-

There is 3+ and 1-

So we need:

OH^- OH^- OH^- to balance the Al^{3+}

Giving the formula

$Al(OH)_3$

Exercise WF 1
Writing formulae from names:

1. Sodium chloride_____
2. Sodium hydroxide_____
3. Sodium carbonate_____
4. Sodium sulfate_____
5. Magnesium chloride_____
6. Magnesium nitrate_____
7. Magnesium hydroxide_____
8. Aluminium chloride_____
9. Aluminium sulfate_____
10. Copper(II) Sulfate_____
11. Copper(I) oxide_____
12. Zinc(II) nitrate_____
13. Silver bromide_____
14. Iron(II) oxide_____
15. Iron(III) oxide_____
16. Ammonium nitrate_____
17. Ammonium sulfate_____
18. Silver(I) sulfide_____
19. Aluminium oxide_____
20. Zinc(II) iodide_____

Some common substances you should know the formulae of:

Carbon Dioxide	CO_2	Carbon Monoxide	CO
Nitrogen monoxide	NO	Nitrogen dioxide	NO_2
Sulfur dioxide	SO_2	Sulfur trioxide	SO_3
Ammonia	NH_3	Methane	CH_4
Hydrogen sulphide	H_2S	Hydrogen peroxide	H_2O_2
Hydrochloric acid	HCl	Sulfuric Acid	H_2SO_4
Nitric Acid	HNO_3		

General rules for naming compounds:

If there are two elements present the name will end in **–ide**.

eg	Na_2O	Sodium Ox**ide**
	$MgCl_2$	Magnesium Chlor**ide**
	Mg_3N_2	Magnesium Nitr**ide**

If the elements concerned can form more than one ion (transition metals) you will need to give the valency in brackets.

e.g.	$PbCl_2$	Lead **(II)** Chloride
	$PbCl_4$	Lead **(IV)** Chloride

Where a compound contains a metal, anon-metal and oxygen it has a name ending in **–ate**.

e.g.	$MgCO_3$	Magnesium Carbon**ate**
	$FeSO_4$	Iron (II) Sulph**ate**
	$KClO_3$	Potassium Chlor**ate**

Exercise WF 2

Writing names from formulae:

1. H_2O _____
2. CO_2 _____
3. NH_3 _____
4. NaH _____
5. CH_4 _____
6. HNO_3 _____
7. $NaNO_3$ _____
8. $CaCl_2$ _____
9. SO_2 _____
10. Li_2S _____
11. Li_2SO_4 _____
12. $CuSO_4$ _____
13. $AgNO_3$ _____
14. $(NH_4)_2SO_4$ _____
15. NH_4VO_3 _____
16. $KMnO_4$ _____
17. $K_2Cr_2O_7$ _____
18. KI _____
19. $Co(NO_3)_2$ _____
20. KAt _____

Equations

Objectives:

- Be able to write word equations
- Be able to balance symbol equations
- Write balanced symbol equations from descriptions

Word equations:

You will very rarely be asked to write word equations at Advanced Level. This is because you are expected to **always** write balanced symbol equations. However, to be able to write the symbol equations you need to know your word equations first!

Some common reaction equations:

You can write general word equations for some common types of reaction.

Acid and alkali: acid + alkali → salt + water

- An example is:
  hydrochloric acid + sodium hydroxide → sodium chloride + water

Acid and metal oxide: acid + metal oxide → salt + water

- An example is:
  sulfuric acid + copper oxide → copper sulfate + water

Acid and carbonate: acid + carbonate → salt + water + carbon dioxide

- An example is:
  hydrochloric acid + calcium carbonate → calcium chloride + water + carbon dioxide

Acid and metal: acid + metal → salt + hydrogen

- An example is:
  sulfuric acid + zinc → zinc sulfate + hydrogen

Metal and oxygen: metal + oxygen → oxide

- An example is:
  magnesium + oxygen → magnesium oxide

Metal and sulfur: metal + sulfur → sulfide

- An example is:
  iron + sulfur → iron sulfide

Metal and water: metal + water → hydroxide + hydrogen

- An example is:
  calcium + water → calcium hydroxide + hydrogen

Combustion of hydrocarbon: fuel + oxygen → carbon dioxide + water

- An example is:
  methane + oxygen → carbon dioxide + water

Exercise Eqn 1

Write word equations for the following reactions:

1. Aluminium reacting with sulfur

2. Copper burning in oxygen

3. Ethane (C_2H_6) burning completely in oxygen

4. Ethanol (C_2H_5OH) burning completely in oxygen

5. Lithium reacting with water

6. Magnesium reacting in nitric acid

7. Potassium oxidising in the air

8. The reaction of calcium hydroxide with hydrochloric acid

9. The reaction of sodium oxide with sulphuric acid

10. Zinc carbonate reacting with hydrochloric acid

Balancing equations

In a chemical reaction atoms are rearranged. They can't disappear or appear from nowhere. You must have the same number of each type of atom on each side of the equation. For clarification see:

http://www.sciencepass.com/2011/02/balancing-chemical-equations.html

Exercise Eqn 2

Write balanced equations for the above reactions

Exercise Eqn 3
Write balanced equations for the following reactions (including state symbols):

Remember:

(s) solid (l) liquid (g) gas (aq) aqueous (dissolved in water)

1. Zinc metal reacts with copper(II) sulphate solution to produce solid copper metal and zinc(II) sulphate solution

2. Solid calcium hydroxide reacts with solid ammonium chloride on heating to produce solid calcium chloride, steam and ammonia gas.

3. When lead(II) nitrate is heated in a dry tube lead(II) oxide, nitrogen dioxide gas and oxygen are produced.

4. Silicon tetrachloride reacts with water to produce solid silicon dioxide and hydrogen chloride gas.

5. When octane (C_8H_{18}) vapour is burnt with excess air in a car engine carbon dioxide and water vapour are produced through a complete combustion reaction.

6. All the halogens apart from fluorine react with concentrated sodium hydroxide solution to produce a solution of the sodium halide (NaX) and the sodium halite ($NaXO_3$) and water.

7. The elements of group 1 of the periodic table all react with water to produce a solution of the hydroxide of the metal and hydrogen gas

8. Tin(II) chloride solution reacts with mercury(II) chloride solution to produce a precipitate of mercury(I) chloride and a solution of tin(IV) chloride. This precipitate of mercury(I) chloride then reacts with a further tin(II) chloride solution to produce liquid mercury and more tin(IV) chloride.

9. Concentrated sulfuric acid reacts with solid potassium iodide to produce solid potassium hydrogen sulfate, iodine vapour, water and hydrogen sulphide gas.

Moles

Objectives:

- Define Mr
- Be able to calculate Mr
- Calculate reacting masses in reactions involving solids
- Know what concentration is
- Be able to calculate concentrations and volumes of solutions

M_r is the sum of the A_r's of a substance. Therefore, if you know the formula of a substance you can calculate (using your Periodic Table) the Mr.

e.g. water has the formula H_2O, H has an A_r of 1.0 and O has an A_r of 16.0.
Therefore the M_r = 1.0 + 1.0 + 16.0 = 18.0

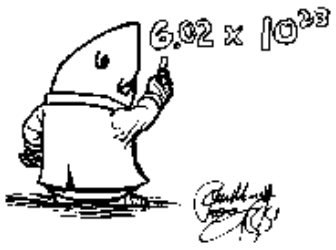
Exercise M 1 Calculate the Mr of the following substances

1. Barium Chloride
2. Ammonium Nitrate
3. Calcium Sulphate
4. Barium Nitrate
5. Silver Oxide
6. Aluminium Sulphate
7. Fluorine
8. Sulphur Dioxide
9. Iron (II) Sulphate
10. Sodium Carbonate
11. Sodium Hydride
12. Zinc Hydroxide
13. Potassium Oxide
14. Zinc
15. Carbon Dioxide
16. Hydrogen
17. Sulphur trioxide
18. Beryllium Hydroxide
19. Vanadium (V) Oxide
20. Copper (I) Oxide

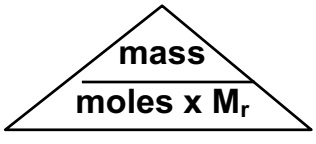
Calculating the number of moles in a substance

A mole is the measurement of a given number of particles. It has the value : 6.02×10^{23}
e.g.

1 mole of hydrogen molecules is 6.02×10^{23} H_2 Molecules
2 moles of electrons, 12.04×10^{23} electrons
10 moles of lead(II) ions, 6.02×10^{24} Pb^{2+}
0.1 moles of zinc atoms, 6.02×10^{22} Zn atoms



To calculate the number of moles in a given mass:
Moles = Mass / M_r
e.g. how many moles are there in 320g of oxygen gas
moles = 320/32= 10 moles of O_2 molecules



Further help

http://www.knockhardy.org.uk/ppoints_htm_files/molespps.pps#256,1,Slide 1

Exercise M 2 Calculate the number of moles in the following:

1. 9.00 g of H_2O
2. 88.0 g of CO_2
3. 1.70 g of NH_3
4. 230 g of C_2H_5OH
5. 560 g of C_2H_4
6. 0.640 g of SO_2
7. 80.0 g of SO_3
8. 18.0 g of HBr
9. 0.0960 g of H_2SO_4
10. 3.15 g of HNO_3
11. 19.3 g of NaCl
12. 21.25 g of $NaNO_3$
13. 2.25 g of Na_2CO_3
14. 0.800 g of NaOH
15. 17.75 g of Na_2SO_4
16. 3.16 g of $KMnO_4$
17. 32.33 g of K_2CrO_4
18. 100 g of $KHCO_3$
19. 7.63 g of potassium iodide
20. 3.90 g of caesium nitrate

Exercise M 3 Calculate the mass of the following:

1. 2 moles of H_2O
2. 3 moles of CO_2
3. 8 moles of NH_3
4. 0.50 moles of C_2H_5OH
5. 1.2 moles of C_2H_4
6. 0.64 moles of SO_2
7. 3 moles of SO_3
8. 1 mole of HBr
9. 0.012 moles of H_2SO_4
10. 0.15 moles of HNO_3
11. 0.45 moles of NaCl
12. 0.70 moles of $NaNO_3$
13. 0.11 moles of Na_2CO_3
14. 2.0 moles of NaOH
15. 0.90 moles of Na_2SO_4
16. 0.050 moles of $KMnO_4$
17. 0.18 moles of K_2CrO_4
18. 0.90 moles of $KHCO_3$
19. 1.5 moles of KI
20. 0.12 moles of $CsNO_3$

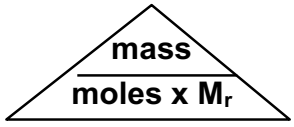
Reacting mass calculations and solution calculations:

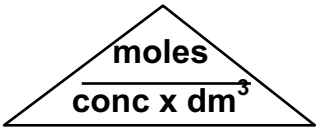
- Write a balanced chemical equation for the reaction (you are usually given this).
- Write out the information given in the question under the equation beneath the appropriate chemical.
- You are **always** given enough information to work out how many moles there are of one reactant, so work it out.
- Using the chemical equation, find out how many moles of the other reactant this quantity reacts with.
- Use this to then find whatever quantity the question asked you to.

You will need to **know** the following key equations:

$$\text{moles} = \frac{\text{mass}}{M_r}$$

$$\text{concentration (mol/dm}^3\text{)} = \frac{\text{moles}}{\text{volume (dm}^3\text{)}}$$





Worked example:

1) What mass of sulphur trioxide is formed from 96 g of sulphur dioxide?

$2\ SO_2$	$\rightarrow$	$2\ SO_3$	$+\ O_2$
✓ 96g		**?**	

Moles of SO_2 = mass/M_r
= 96/64.1
= 1.497…(keep this value in your calculator)

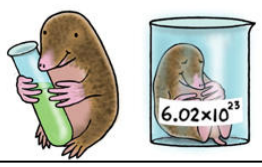
Moles of SO_3 use the ratio of molecules in the equation (2:2)
= 1.497…

Mass of SO_3 = M_r x moles
= 80.1 x 1.497….
= 120g (to 3 sig fig)

A little more help….

http://www.knockhardy.org.uk/ppoints_htm_files/molespps.pps#357,21,Slide 21

Remember concentration is a measurement of how much is dissolved in a dm^3 (a litre)
This may be measure in mol dm^{-3} (number of moles dissolved in a dm^3) or
g dm^{-3} (number of grams dissolved in a dm^3)



Exercise M 4:

1) What mass of potassium oxide is formed when 9.75 g of potassium is burned in oxygen?

$$4\ K + O_2 \rightarrow 2\ K_2O$$

2) What mass of hydrogen is formed when 0.2 g of calcium reacts with hydrochloric acid?

$$Ca + 2\ HCl \rightarrow CaCl_2 + H_2$$

3) What mass of sodium is needed to reduce 1 kg of titanium chloride?

$$TiCl_4 + 4\ Na \rightarrow Ti + 4\ NaCl$$

4) What mass of carbon monoxide is needed to reduce 1 kg of iron oxide to iron?

$$Fe_2O_3 + 3\ CO \rightarrow 2\ Fe + 3\ CO_2$$

5) What mass of oxygen is needed to burn 110 g of propane (C_3H_8)?

$$C_3H_8 + 5\ O_2 \rightarrow 3\ CO_2 + 5\ H_2O$$

6) What mass of iron reacts with 14.2 g of chlorine?

$$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$$

7) 4.17 g of hydrated barium bromide crystals ($BaBr_2.nH_2O$) gave 3.72 g of anhydrous barium bromide on heating to constant mass. Work out the relative molecular mass (M_r) of the hydrated barium bromide and the value of *n*.

$$BaBr_2.nH_2O \rightarrow BaBr_2 + n\ H_2O$$

Solution worked example

Question 1

1) 25.0 cm^3 of a solution of sodium hydroxide solution required 21.50 cm^3 of 0.100 mol/dm^3 sulphuric acid for neutralisation. Find the concentration of the sodium hydroxide solution.

$$H_2SO_4(aq) + 2\ NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\ H_2O(l)$$

21.5cm^3 25 cm^3

0.100 mol/dm^3 ?

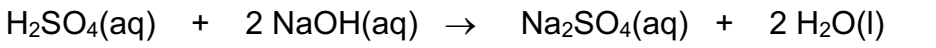
Moles of sulphuric acid = conc x vol/1000
= 0.100 x 21.5/1000
= 2.15 x 10^{-3} mol

Moles of sodium hydroxide = 4.30 x 10^{-3} mol **(from the equation 2:1 ratio of NaOH to H_2SO_4)**

Concentration of sodium hydroxide = mol/vol
= 4.30 x 10^{-3} / (25/1000)
= 0.172 mol/dm^3

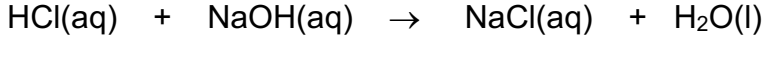
Exercise M 5

1) 25.0 cm^3 of a solution of sodium hydroxide solution required 21.50 cm^3 of 0.100 mol/dm^3 sulphuric acid for neutralisation. Find the concentration of the sodium hydroxide solution.



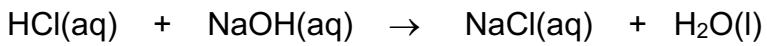
$H_2SO_4(aq) + 2\,NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(l)$

2) Find the volume of 1.0 mol/dm^3 hydrochloric acid that reacts with 25.00 cm^3 of 1.50 mol/dm^3 sodium hydroxide.



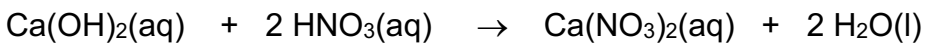
$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

3) 25.0 cm^3 of 0.100 mol/dm^3 sodium hydroxide neutralises 19.0 cm^3 of hydrochloric acid. Find the concentration of the acid.



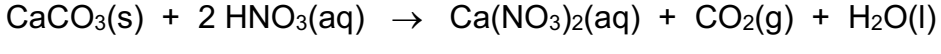
$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

4) What volume of 0.040 mol/dm^3 calcium hydroxide solution just neutralises 25.0 cm^3 of 0.100 mol/l nitric acid?



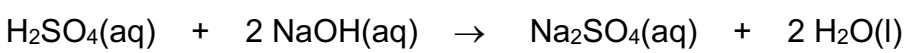
$Ca(OH)_2(aq) + 2\,HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + 2\,H_2O(l)$

5) Find the mass of $CaCO_3$ that is required to neutralise 2 dm^3 of 2 mol/dm^3 nitric acid.



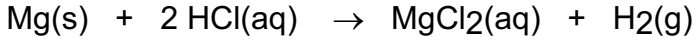
$CaCO_3(s) + 2\,HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$

6) 25.0 cm^3 of 1.00 mol/dm^3 sodium hydroxide neutralises 21.2 cm^3 of sulphuric acid. Find the concentration of the acid.



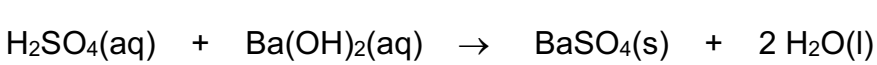
$H_2SO_4(aq) + 2\,NaOH(aq) \rightarrow Na_2SO_4(aq) + 2\,H_2O(l)$

7) What mass of magnesium metal just reacts with 100.0 cm^3 of 2.00 M hydrochloric acid?



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

8) 25.0 cm^3 of 0.020 M sulphuric acid neutralises 18.6 cm^3 of barium hydroxide solution. Find the concentration of the barium hydroxide solution.



$H_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2\,H_2O(l)$

9) Calculate the concentration of the following solutions in mol/litre.

a) 3 moles of H_2SO_4 in 12 dm^3 of water,
b) 36.5 mg of HCl in 10 cm^3 of water,
c) 120 g of sodium hydroxide in 6 litres of water.

10) Calculate the number of moles of solute in:

a) 2500 cm^3 of 0.1 mol/dm^3 nitric acid,
b) 2 dm^3 of 0.05 mol/dm^3 potassium hydroxide.

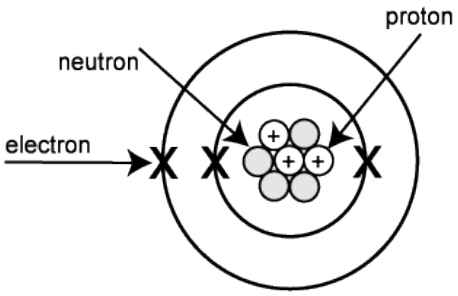
Atomic Structure (GCSE level)

Objectives:

- Identify the position, relative mass and relative charge of the three sub-atomic particles
  Give the number of any of the sub-particles for a given element (atom or ion)
- Define Atomic Number (Z)
- Define Mass Number (A)
- Give the simple electron arrangement for the first 38 elements on the periodic table
- Know how the periodic table is arranged
- Know the links between electronic structure and periodic table arrangement
- Know how ions are formed

GCSE Atomic Structure

The model of atomic structure you have been working with at GCSE will be developed further at Advanced Level. This does not mean the GCSE model is no longer of use. A thorough understanding and familiarity with this model is essential for you to be able to develop a number of Advanced Level concepts. But be warned, it will be developed, it is a model, it is not wrong, it just has limitations.



The atom is made up of three types of fundamental particles: protons, neutrons and electrons.

sub-atomic particle	relative mass	relative charge
proton	1	+1
neutron	1	0
electron	1/1840	-1

The atom is mostly empty space. It consists of a nucleus of protons and neutrons surrounded by electrons in orbitals/shells. Information about the number of particles in each atom can be found using the atomic number and mass number. What makes an atom individual is it's atomic number and therefore it's number of protons.

Atomic Number: Number of protons

Mass Number: Number of protons + Number of neutrons

Atoms can be represented as follows:

$^{\text{mass number}}_{\text{atomic number}}\text{Symbol}$ e.g. $^{19}_{9}\text{F}$ protons = …9.. neutrons = …10.. electrons = 9…..

In a neutral atom the number of electrons will be the same as the number of protons. In an ion there are an altered number of electrons from the original number in the atom. For example Al^{3+} has lost 3 electrons so has 13 protons and 10 electrons, O^{2-} has gained 2 electrons so has 8 protons and 10 electrons.

WARNING: YOUR PERIODIC TABLE DOES NOT TELL YOU THE MASS NUMBER.

Exercise AS 1

Atom / ion	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{19}_{9}F$					
$^{19}_{9}F^{-}$					
$^{27}_{13}Al$					
$^{27}_{13}Al^{3+}$					
	15	31			15
			5	6	5
			8	8	10
		23	11		10
	18			22	18
	12	24			10

To see how the model of the atom has been developed and where you are heading if you can watch the following video clips:
The Atom – Clash of the Titans BBC Four with Professor Jim Al-Khalili
http://video.google.com/videoplay?docid=-4974977412862654856

Brian (oh so smiley) Cox on why atoms are full of space (hitting the physics-only for the very interested)
http://www.bbc.co.uk/news/science-environment-16200089

Electron arrangement:

The electrons are arranged in shells/energy levels/orbitals.
The first shell holds a maximum of 2 electrons, the second shell holds a maximum of 8 electrons. The third shell initially holds a maximum of 8 electrons, you then add 2 electrons to the fourth shell, then come back and add a further 10 electrons to the 3rd shell.

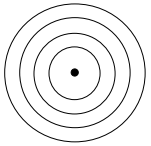
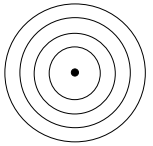
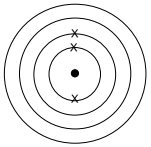
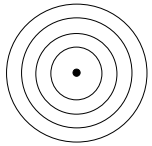
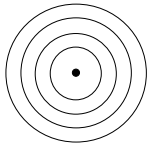
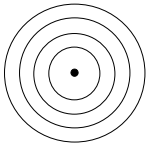
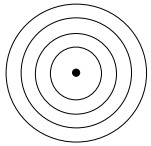
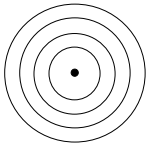
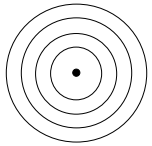
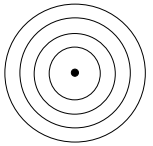
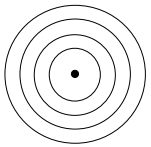
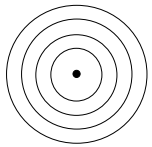
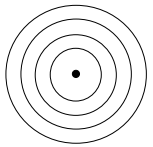
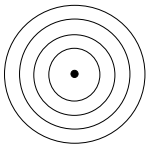
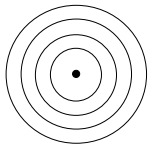
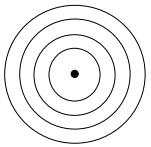
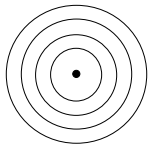
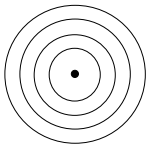
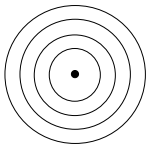
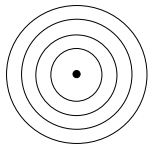
For example:

Sodium	2,8,1
Chlorine	2,8,7
Calcium	2,8,8,2
Scandium	2,8,9,2
Iron	2,8,14,2

On the periodic table:

The group number tells us how many electrons are in the outer shell.
The period number tells us how many shells there are.

ELECTRONIC STRUCTURE Exercise AS 2

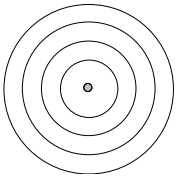
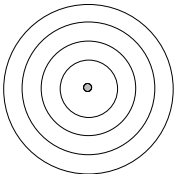
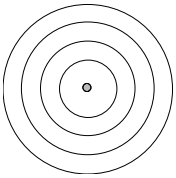
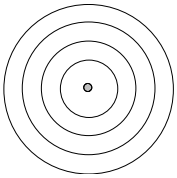
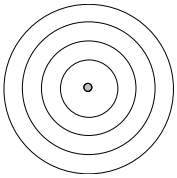
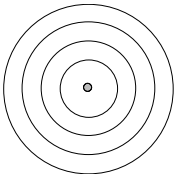
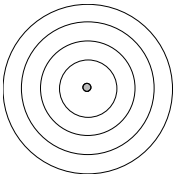
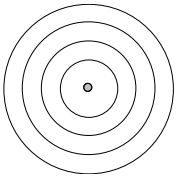
Group 1	Group 2		Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
		hydrogen H Atomic number = **1**  structure = ……						**helium He** Atomic number = **2**  structure = ……
lithium Li Atomic number = **3**  structure = **2,1**	**beryllium Be** Atomic number = ……..  structure = ……		**boron B** Atomic number = ……..  structure = ……	**carbon C** Atomic number = ……..  structure = ……	**nitrogen N** Atomic number = ……..  structure = ……	**oxygen O** Atomic number = ……..  structure = ……	**fluorine F** Atomic number = ……..  structure = ……	**neon Ne** Atomic number = ……..  structure = ……
sodium Na Atomic number = ……..  structure = ……	**magnesium Mg** Atomic number = ……..  structure = ……		**aluminium Al** Atomic number = ……..  structure = ……	**silicon Si** Atomic number = ……..  structure = ……	**phosphorus P** Atomic number = ……..  structure = ……	**sulfur S** Atomic number = ……..  structure = ……	**chlorine Cl** Atomic number = ……..  structure = ……	**argon Ar** Atomic number = ……..  structure = ……
potassium K Atomic number = ……..  structure = ……	**calcium Ca** Atomic number = ……..  structure = ……							

1) The first 20 elements in the Periodic Table are shown below. The elements are arranged in order of increasing atomic number. Fill in the atomic number for each element. The first three have been done for you.

2) Complete the boxes to show the electronic structure of the first 20 elements. The box for lithium has been done for you.

Exercise AS 3

For each of the following, (a) draw the electrons in their shells and (b) state the electronic structure.

1 Na  structure:	2 Na^+  structure:	3 Al  structure:	4 Al^{3+}  structure:
5 F  structure:	6 F^-  structure:	7 O  structure:	8 O^{2-}  structure:

For each of the following particles, state what the particle is. The first one has been done for you.

9 protons = 8 neutrons = 8 electrons = 10 particle = O^{2-}	10 protons = 16 neutrons = 16 electrons = 16 particle =	11 protons = 16 neutrons = 16 electrons = 18 particle =	12 protons = 17 neutrons = 18 electrons = 17 particle =
13 protons = 17 neutrons = 20 electrons = 17 particle =	14 protons = 17 neutrons = 20 electrons = 18 particle =	15 protons = 12 neutrons = 12 electrons = 10 particle =	16 protons = 9 neutrons = 10 electrons = 10 particle =
17 protons = 26 neutrons = 30 electrons = 24 particle =	18 protons = 82 neutrons = 126 electrons = 82 particle =	19 protons = 7 neutrons = 7 electrons = 10 particle =	20 protons = 53 neutrons = 74 electrons = 54 particle =

Complete the table below:

Question	Particle	Atomic number	Mass number	Protons	Neutrons	Electrons	Electron structure
21			31	15		15	
22		20			20	18	
23		6			8	6	

Identifying structure and bonding types (GCSE)

Objectives:

- Identify the most likely type of bonding in a substance
- Identify the most likely structure type of a substance from a) formulae, b) properties

At GCSE level we are introduced to the concept that non-metals are held together (usually) by covalent bonds and that metal and non-metals are (usually) held together by ionic bonds. This will be developed further at advanced level. But let's get the GCSE sorted first!

Exercise SB 1

Substance	Type of elements within substance	Most likely bonding type
H_2O	Non-metal and Non-metal	Covalent
Hydrogen fluoride	Non-metal and Metal	Ionic
K_2O		
CH_4		
Magnesium Oxide		
Carbon Dioxide		
Fe_2O_3		

We can identify the most likely structure type (crystal structure) of a substance from its properties or its formula. If you are rusty on structure types:

Essential:

http://www.chemsheets.co.uk/GCSEStructure11.doc

Helpful:

http://www.knockhardy.org.uk/gcse_htm_files/gbandspps.pps#366,1,Slide 1

Exercise SB 2

What is the most likely structure type of these substances:

Substance	Melting point (°C)	Boiling point (°C)	Electrical conductivity as			Type of structure
			solid	liquid	solution (aq)	
A	963	1560	does not conduct	conducts	conducts	
B	1063	2967	conducts	conducts	insoluble	
C	123	187	does not conduct	does not conduct	insoluble	
D	-7	59	does not conduct	does not conduct	does not conduct	
E	3527	4027	does not conduct	does not conduct	insoluble	
F	30	2397	conducts	conducts	insoluble	
G	1713	2230	does not conduct	does not conduct	insoluble	
H	-138	0	does not conduct	does not conduct	insoluble	

ANSWERS TO EXERCISES

Answers WF 1

Writing formulae from names:

1.	Sodium Chloride	NaCl	11.	Copper (I) Oxide	Cu_2O
2.	Sodium Hydroxide	NaOH	12.	Zinc Nitrate	$Zn(NO_3)_2$
3.	Sodium Carbonate	Na_2CO_3	13.	Silver Bromide	AgBr
4.	Sodium Sulphate	Na_2SO_4	14.	Iron (II) Oxide	FeO
5.	Magnesium Chloride	$MgCl_2$	15.	Iron (III) Oxide	Fe_2O_3
6.	Magnesium Nitrate	$Mg(NO_3)_2$	16.	Ammonium Nitrate	NH_4NO_3
7.	Magnesium Hydroxide	$Mg(OH)_2$	17.	Ammonium Sulphate	$(NH_4)_2SO_4$
8.	Aluminium Clhoride	$AlCl_3$	18.	Silver Sulfide	Ag_2S
9.	Aluminium Sulphate	$Al_2(SO_4)_3$	19.	Aluminium Oxide	Al_2O_3
10.	Copper (II) Sulphate	$CuSO_4$	**20.**	Zinc Iodide	ZnI_2

Answers WF 2

Writing names from formulae:

1.	H_2O	Water	11.	Li_2SO_4	Lithium Sulfate
2.	CO_2	Carbon Dioxide	12.	$CuSO_4$	Copper Sulfate
3.	NH_3	Ammonia	13.	$AgNO_3$	Silver nitrate
4.	NaH	Sodium Hydride	14.	$(NH_4)_2SO_4$	Ammonium sulphate
5.	CH_4	Methane	15.	NH_4VO_3	Ammonium vanadate
6.	HNO_3	Nitric Acid	16.	$KMnO_4$	Potassium Manganate
7.	$NaNO_3$	Sodium Nitrate	17.	K_2CrO_4	Potassium Chromate
8.	$CaCl_2$	Calcium chloride	18.	KI	Potassium Iodide
9.	SO_2	Sulphur Dioxide	19.	$Co(NO_3)_2$	Cobalt Nitrate
10.	Li_2S	Lithium Sulfide	20.	Kat	Potassium Astatide

Answers Eqn 1 and 2

Aluminium + Sulfur → Aluminium Sulfide	$2Al + 3S \rightarrow Al_2S_3$
Copper + Oxygen → Copper (II) Oxide	$Cu + ½\ O_2 \rightarrow CuO$
Ethane + Oxygen → Carbon dioxide + Water	$C_2H_6 + 3½O_2 \rightarrow 2CO_2 + 3H_2O$
Ethanol + Oxygen → Carbon dioxide + Water	$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
Lithium + Water → Lithium hydroxide + Hydrogen	$Li + H_2O \rightarrow LiOH + ½\ H_2$
Magnesium + Nitric acid → Magnesium nitrate + Hydrogen	$Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$
Potassium + Oxygen → Potassium Oxide	$2K + ½\ O_2 \rightarrow K_2O$
Calcium Hydroxide + Hydrochloric acid → Calcium chloride + Water	$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + H_2O$
Sodium Oxide + Sulphuric acid → Sodium Sulphate + Water	$Na_2O + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$
Zinc Carbonate + Hydrochloric acid → Zinc chloride + Carbon dioxide + Water	$ZnCO_3 + 2HCl \rightarrow ZnCl_2 + CO_2 + H_2O$

Answers Eqn 3

1. $Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$
2. $Ca(OH)_2(s) + 2NH_4Cl \rightarrow CaCl_2(s) + 2H_2O(g) + 2NH_3(g)$
3. $Pb(NO_3)_2(s) \rightarrow PbO(s) + 2NO_2(g) + O_2(g)$
4. $SiCl_4(l) + 2H_2O(l) \rightarrow SiO_2(s) + 4HCl(g)$
5. $C_8H_{18}(g) + 12½O_2(g) \rightarrow 8CO_2(g) + 9H_2O(g)$
6. $3X_2 + 6NaOH(aq) \rightarrow 5NaX(aq) + NaXO_3(aq) + 3H_2O(l)$
   Where X represents a halogen, no state symbol I given for X as it varies down the group.
7. $2M(s) + 2H_2O(l) \rightarrow 2MOH(aq) + H_2(g)$ Where M represents a Group 1 metal.
8. STAGE 1: $SnCl_2(aq) + 2HgCl_2(aq) \rightarrow 2HgCl(s) + SnCl_4(aq)$

   STAGE 2: $2HgCl(s) + SnCl_2(aq) \rightarrow 2Hg(l) + SnCl_4(aq)$

   OVERALL: $SnCl_2(aq) + HgCl_2(aq) \rightarrow Hg(l) + SnCl_4(aq)$
9. $3H_2SO_4(aq) + 2KI(S) \rightarrow 2KHSO_4(s) + I_2(g) + H_2O(l) + H_2S(g)$

Exercise M 1

1.	Barium Chloride	208.3	11.	Sodium Hydride	24.0
2.	Ammonium Nitrate	80.0	12.	Zinc Hydroxide	99.4
3.	Calcium Sulphate	136.2	13.	Potassium Oxide	94.2
4.	Barium Nitrate	261.3	14.	Zinc	65.4
5.	Silver Oxide	231.8	15.	Carbon Dioxide	44.0
6.	Aluminium Sulphate	342.3	16.	Hydrogen	2.0
7.	Fluorine	38.0	17.	Sulphur trioxide	80.1
8.	Sulphur Dioxide	64.1	18.	Beryllium Hydroxide	43.0
9.	Iron (II) Sulphate	151.9	19.	Vanadium (V) Oxide	181.8
10.	Sodium Carbonate	106.0	20.	Copper (I) Oxide	143.0

Answer M2

1 0.50
2 2.0
3 0.10
4 5.0
5 20
6 0.010
7 1.0
8 0.22
9 0.0010
10 0.050
11 0.33
12 0.25
13 0.021
14 0.020
15 0.125
16 0.020
17 0.167
18 1.0
19 0.046
20 0.020
21 0.0010
22 0.25
23 0.02
24 0.0025
25 0.20
26 0.10

Answers M3

1 36 g
2 132 g
3 47.6 g
4 23 g
5 33.6 g
6 40.96 g
7 240 g
8 81 g
9 1.152 g
10 9.45 g
11 26.3 g
12 59.5 g
13 11.66 g
14 80.0 g
15 127.8 g
16 7.9 g
17 34.92 g
18 90 g
19 249 g
20 23.4 g
21 12.2 g
22 672.4 g
23 0.296 g
24 13.6 g
25 43.68 g
26 14.95 g

Answers M4 (Answers 1 to 6 to 3 sig fig)

1. 11.7g
2. 9.98×10^{-3}g
3. 484g
4. 526g
5. 400g
6. 7.44g
7. n=2

Answers M5

Exercise AS 1

Atom / ion	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons
$^{19}_{9}F$	9	19	9	10	9
$^{19}_{9}F^{-}$	9	19	9	10	10
$^{27}_{13}Al$	13	27	13	14	13
$^{27}_{13}Al^{3+}$	13	27	13	14	10
$^{31}_{15}P$	15	31	15	16	15
$^{11}_{5}B$	5	11	5	6	5
$^{16}_{8}O^{2-}$	8	16	8	8	10
$^{23}_{11}Na^{+}$	11	23	11	12	10
$^{40}_{18}Ar$	18	40	18	22	18
$^{24}_{12}Mg^{2+}$	12	24	12	12	10

Answers AS 3

1. 2,8,1
2. 2,8
3. 2,8,3
4. 2,8
5. 2,7
6. 2,8
7. 2,6
8. 2,8
9. O^{2-}
10. S
11. S^{2-}
12. Cl
13. Cl
14. Cl^{-}
15. Mg^{2+}
16. F^{-}
17. Fe^{2+}
18. Pb
19. N^{3-}
20. I^{-}

Question	Particle	Atomic number	Mass number	Protons	Neutrons	Electrons	Electron structure
21	$^{31}_{15}P$	15	31	15	16	15	2,8,5
22	$^{40}_{20}Ca^{2+}$	20	40	20	20	18	2,8,8
23	$^{14}_{6}C$	6	14	6	8	6	2,4

Answers SB 1

Substance	Type of elements within substance	Most likely bonding type
H_2O	Non-metal and Non-metal	Covalent
Hydrogen fluoride	Non-metal and Metal	Ionic
K_2O	**Metal and Non-metal**	**Ionic**
CH_4	**Non-metal and Non-metal**	**Covalent**
Magnesium Oxide	**Metal and Non-metal**	**Ionic**
Carbon Dioxide	**Non-metal and Non-metal**	**Covalent**
Fe_2O_3	**Metal and Non-metal**	**Ionic**

Answers SB 2

Substance	Melting point (°C)	Boiling point (°C)	Electrical conductivity as			Type of structure
			solid	liquid	solution (aq)	
A	963	1560	does not conduct	conducts	conducts	**IONIC**
B	1063	2967	conducts	conducts	insoluble	**METALLIC**
C	123	187	does not conduct	does not conduct	insoluble	**SIMPLE MOLECULAR**
D	-7	59	does not conduct	does not conduct	does not conduct	**SIMPLE MOLECULAR**
E	3527	4027	does not conduct	does not conduct	insoluble	**GIANT COVALENT**
F	30	2397	conducts	conducts	insoluble	**METALLIC**
G	1713	2230	does not conduct	does not conduct	insoluble	**GIANT COVALENT**
H	-138	0	does not conduct	does not conduct	insoluble	**SIMPLE MOLECULAR**