Haberdashers' Adams

Y12 INDUCTION

A LEVEL CHEMICAL LANGUAGE (1)

WRITING BALNCED SYMBOL EQUATIONS WITHOUT MISTAKES UNDER TEST CONDITIONS

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Department of Chemistry

Improving Chemistry GCSE skills for A Level : Repetition followed by Repetition followed by Repetition followed by R...

To make a success of A Level all the basic GCSE language skills (types of bonding a substance has, knowing whether a substance is a molecule, element, compound, writing balance symbol, ionic and ion-electron equations) have to be perfect. Some GCSE courses concentrate more of these skills than others so it is important to check for any gaps before you start the A Level. Can you write balance symbol equations quickly without mistake under test conditions?? Only when you can do the Questions on pg 29 without mistake, under test conditions, have you mastered GCSE level, this can take many months – start now to be ready for September

An example : Aluminium(s) + nitric acid(aq) → Aluminium nitrate(aq) + hydrogen (g)

The steps involved are

(1) **The most important thing to remember is** when you are first starting writing equations is that you have to work out the formula of each substance **separately**, ie do not try to work out the formulae of any of the products by looking back at the formulae of the reactants, in the example above you need to work out the four individual formula, and only then link them together by putting balancing numbers in front of the formulae, and ONLY in front - **DO NOT CHANGE THE FORMULAE**.

(2) Are the substances ionic (or contains ions), covalent or metallic, and when starting out it helps to write I, C or M above the name.

a) IF metallic – just write the substance symbol from the Periodic Table DO NOT WRITE A CHARGE, metals elements are neutral

b) If covalent (at GCSE this was if Non-Metal + Non-Metal, can be the same or different Non-Metals eg O_2, NH_3)

- for common covalent substances and acids (if (aq) actually contain ions) – you usually just have to remember their formula (see tables on page 9 of notes - and also page 2 for knowing which elements go around in pairs)
- others you have to work out form their name (see page 22 in the questions section)

c) If ionic, (at GCSE this was if Metal + Non-Metal eg NaCl, Na_2O)

- if it is a binary ionic compound (ie just containing a two types of 'elements' such as aluminium oxide) then you can work out the charges on the aluminium ion and oxide ion directly from the period table (see page 6 and then write its formula (page 11&12 of notes and pages 18-20 for practice questions)
- if it contains a compound ion eg aluminium nitrate, then you have to remember the compound ion formula (pg 9) , including charge, then write its formula (method page 11&12, practice questions pages 18-20) ['hate the –ates', you have to learn them; be 'idle for the -ides' you use the Periodic Table (exception, learn the hydroxide ion: OH^-), though once you have learnt the –ates, there is less work to do!!]
- For both i) and ii) in the early stages of getting good at symbol equations, for ionic formulae, write the ions and the number of each needed to ensure the total +ve charge = total –ve charge above the word of the ionic compound, to help you get the correct formula of the compound – the first practice page on full equations is set out so that you can do this.

(3) Only balance after 1 and 2 (notes page 10 – make sure you read the hints including the short cuts so you can get faster) , just balancing practice questions pages 15 &16) REMEMBER DO NOT CHANGE THE FORMULAE – you can ONLY put big numbers in front

Worked example

Step 1 I (I as aq) I C

Aluminium(s) + nitric acid(aq) → Aluminium nitrate(aq) + hydrogen (g)

Step 2 a Al

Step 2 b HNO_3 H_2 (NOTE, H_2 not H see page2)

Step 2 c Al^{3+} + 3 NO_3^-

Aluminium(s) + nitric acid(aq) → Aluminium nitrate(aq) + hydrogen (g)

Step 2 a/b Al + HNO_3 → $Al(NO_3)_3$ H_2

Step 2 c

Step 3, using handy hints one and three, write 3 in front of HNO_3 as you must have 3 x '(NO_3)'

Using handy hint two, leave diatomics to last and use halves if you can, 3H's on left, therefore 1½ H_2

Al + 3 HNO_3 → $Al(NO_3)_3$

You could have also written 2Al + 6 HNO_3 → 2$Al(NO_3)_3$ + 3H_2 but this involves more work and time. The worked example is much easier than most equations asked in the final exam after two years, but by then you will have had two years doing harder examples than asked at GCSE, the important thing is that you know your GCSE level balanced symbol equations very well before the start of the A Level. The other GCSE equation skills (ionic and ion –electron) are relatively easy***, once*** you have mastered balanced symbol equations. The sensible students try to recall the formula that are needed to be learnt for the course most days over the summer, they also do a bit of practice on equations/ equations skills most days**.**

***remember* DO NOT WRITE THE ANSWERS IN THIS BOOKLET, SO YOU ARE ABLE TO REDO THE QUESTIONS AGAIN**, put a * by the ones you get wrong the first time and redo after a week or so.

CHEMICAL LANGUAGE

Substance A general term, could be an atom, element, compound, mixture, etc The term 'species' is also used by chemists

Atoms The tiny particles that all substances are made from. **It is the smallest stable particle of an element that can exist**

Elements **Substances that are made up of just one type of atom**. eg Ne, Cl_2 , Fe.
Every atom of the same element has the same number of protons

Compounds **two or more different types of atoms chemically bonded together in a fixed ratio**. eg NaCl, CO_2,
Chemical bond could be ionic or covalent. ionic compounds- made up of metal ions and non metal ions bonded together
Covalent bonded compounds made up (usually) of non-metal atoms sharing pairs of electrons

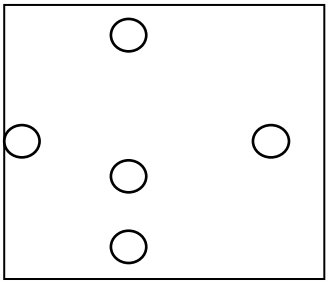
Molecules **Made up of 2 or more atoms covalently bonded** eg N_2, Cl_2, CO_2
Molecules often have no overall charge, though molecular compound ions are common eg SO_4^{2-}]
Most metal containing compounds have ionic bonding and therefore are not molecules

Mixtures Two or more **substances that are not chemically bonded together**. Eg Air is a mixture of gases, salt solution is a mixture of salt/water.

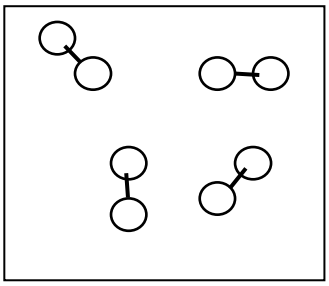
Ions Atoms (can be compounds) that have a charge as they have gained or lost electrons eg Na^+, Cl^- , S^{2-}

Compound Ions Compounds that have a charge eg MnO_4^- , can be molecular compound ions eg SO_4^{2-} ,

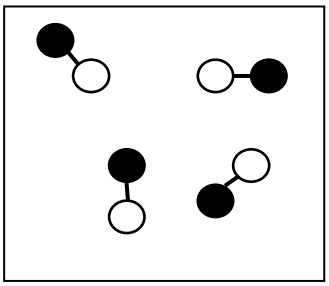
HFBrONIClAt REMEMBER is used to remember which elements are diatomic (ie X_2) when present just as the elements by themselves
HF BrONIClAt does NOT apply to the ions of the element or compounds containing these elements, eg H^+, NO_3^-



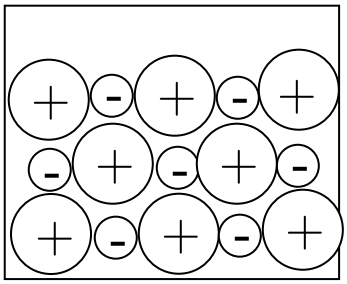
ATOM
& ELEMENT
(gas)



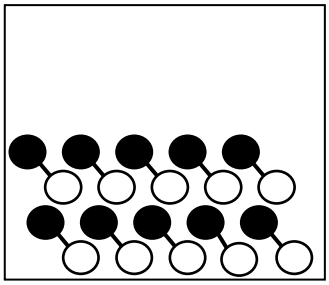
MOLECULE
& ELEMENT
(gas)



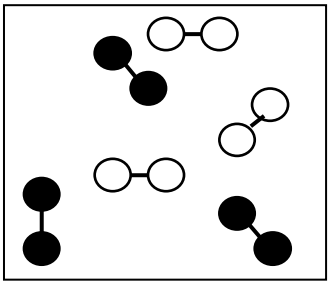
MOLECULE
& COMPOUND
(gas)



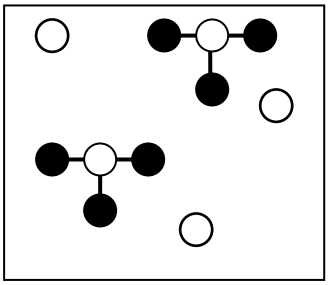
IONIC
COMPOUND
(solid)



PURE MOLECULE
& COMPOUND
(solid)



MIXTURE of two
molecules (elements)
(gas)



MIXTURE of molecules
(compound) and atoms (element)
(gas)

CHEMICAL PROPERTIES How a substance reacts with another chemical

Metals Definition Element that usually reacts by losing electron(s) to form positive ions
Metals react to form ionic compounds

Non-metals Definition Element that usually react by gaining electron(s) to form negative ions or share electrons
Non-metals react forming Ionic compounds or covalent substances (can be elements or compounds)

Metalloid Element that shows characteristics of metal and non-metals

PHYSICAL PROPERTIES Property a substance has that doesnt involve another chemical

Metals shiny (lustrous) Good conductor of heat / electricity, malleable and ductile, sonorous, usually high melting points and high densities and hard (exceptions : alkali metals – soft , needs to be freshly cut to see it shine .

Non-metals **typically** Do not conduct electricity / poor conductor of heat (except graphite), brittle, not ductile, dull (exceptions eg graphite, Iodine), not sonorous

Exam Technique. only state property that relates to that substance eg Gp1 untypical metals – don't say high melting point. Metalloids can have different chemical / physical properties that are between metal and non-metals eg usually amphoteric oxides

Allotropes Different structural forms of the same element
eg oxygen (O_2) and ozone (O_3) molecules are allotropes of oxygen

Ionic compound (Not molecules) Contains ions [Ionic bond is the electrostatic attraction of oppositely charge ions]
Formed when elements react by transferring electrons from one atom to another
Consist of a metal and a non-metal in a compound eg NaCl

Covalent substance (molecules) Contain atoms covalently bonded together (covalent bond = shared pair of electrons)
Usually formed between two or more non-metals
Can be an element (eg H_2) or a compound (CO_2)

Acid **PROTON DONOR** [forms H^+ ions when dissolved in water, $H^+(aq)$ ions make solutions acidic, pH < 7].
$H^+(aq)$ **This is actually H_3O^+ (aq) - the hydronium ion** (aka hydroxonium ion)

Base **PROTON ACCEPTOR** [neutralises an acid to form a salt]

Alkali **Soluble base forms/releases OH^- ions when dissolved in water** [$OH^-(aq)$ions make solutions alkaline pH > 7]
(all alkalis are bases, only soluble bases are alkalis)

Salt Substance that can be formed when a metal ion or an ammonium ion replaces a hydrogen ion in an acid
[a salt can be formed by another method, its a salt as long as it can be formed by replacing a hydrogen ion of an acid]

Amphoteric Will react with both an (strong) acid AND with a (strong) alkali

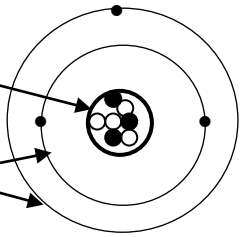
Solvent	*liquid that does the dissolving*	*water, ethanol, tetrachloromethane*
Solute	*substance that is dissolved by the solvent*	*sodium chloride, sugar, gases,*
Solution	*mixture of solute dissolved in the solvent*	*brine*
Solubility	*amount that a substance will dissolve*	
Precipitate	*a solid produced from the reaction of two solutions .*	

State symbols (s) = solid ; (l) = liquid (g) = gas (aq) = dissolved in water [does not mean soluble or aqueous]

ATOMIC STUCTURE AND THE PERIODIC TABLE

protons and neutrons in nucleus
The nucleus is positively charge

electrons in shells* (around nucleus)
The electrons are negatively charged



particle	Relative charge	Relative mass
● proton (**p**)	+1	1
○ neutron (**n**)	0	1
• electron (**e**$^-$)	-1	1/2000

The –ve electrons are held in place by the +ve protons in the nucleus [opposite charges attract]

atoms are neutral (**no electrical charge**) because: the no. of protons (1+ charge) = no. of electrons (1-)

*The different shells have different amounts of energy. Therefore electrons can be stated to be in energy levels rather than shells. The further away the electron is form the nucleus, the higher its energy. Therefore outer energy levels are of higher energy than inner energy levels. At GCSE either the terms shells or energy levels can be used.

Symbols for the elements The symbols can be a capital letter or a capital and a lower case letter Eg K, Na. Every new capital letter represents a new element, CO = 2 elements as 2 capitals. **On the IGCSE exam Periodic Table** the elements are shown with atomic numbers (bottom left) and with relative atomic mass numbers above the symbol

35.5 — 35.5 is the relative atomic mass (see last topic in Chemistry Unit 2)
Cl — **Every atom with an atomic number of 17 is a chlorine atom.**
17 — 17 is the **atomic** no. = no. of protons = no. of **electrons** (for an atom!)

Arrangement of electrons – SHELLS (or energy levels) : ONLY NEEDED for first 20 elements (up to Ca)
The electrons in an atom occupy the lowest available energy level. Therefore the innermost shell (the 1st shell - maximum of two electrons) is fully filled before an electron will occupy the second shell (maximum of 8 electrons). The arrangement of electrons determines an element's position in the periodic table and how the element reacts.

1st shell = up to **2** electrons
2nd shell = up to **8** electrons
3rd shell (treat as only 8 up to Ca)

As Li has 3 electrons, its electron arrangement is 2,1
As Na has 11 electrons, its electron arrangement is 2,8,1
As K has 19 electrons, its electron arrangement is 2,8,8,1

Li, Na, & K are all in group 1 as they all have 1 electron in their outer shell

Elements in the same group in the periodic table have the same number of electrons in the outer shell.

hence **The group number of an element = the number of electrons in the outer shell**

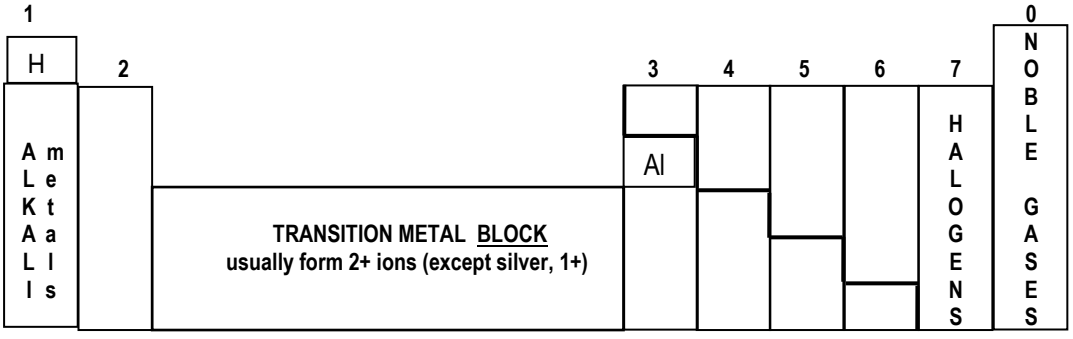
elements in the same group have similar chemical reactivity , as electrons are transferred/shared in chemical reactions

PERIODIC TABLE: arranged **in order of increasing atomic number** shows known elements

Periods → : show repeating trends (of period above) in physical and chemical properties **(periodicity)**
period number = number of shells containing electrons

Groups ↓ : **have similar chemical properties as have same number of electrons in outer shell**
group number =

Hydrogen is a non metal
It's unusual as it can lose, gain or share electrons!
Often it's not placed in a group

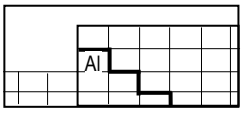


By looking at the RAMs of Ar (40) and K(39) it shows that the periodic table is in order of increasing proton number and not RAM.
Ar comes before K, though Ar has a larger RAM (40)
Ar atomic number is 18,
K atomic number is 19

The Periodic Table is also divided into metals and non metals (step over Aluminium). Elements that have some properties of both metals and non-metals can be called METALLOIDS. These are situated near the dividing line eg Si, Ge.

How to work out what type of bonding a substance has

just **METALS**



Eg Na, Mg, Fe, alloys

METALLIC BONDING

METAL and NON METAL

NaCl, MgO, $CaCO_3$

IONIC BONDING

just **NON-METALS** **(except noble gases)**

C, H_2 ,O_2, CO_2, NH_3, HCl*

COVALENT BONDING

* Some covalent molecules ionise in solution eg **ACIDS** HCl(g/l) = cov. HCl(aq) = ionic , H_2SO_4(g/l) = cov; H_2SO_4(aq) = ionic
Also compounds containing molecular ions are ionic, eg ammonium nitrate contains NH_4^+ and NO_3^- ions

How to work out what type of STRUCTURE a substance has

just **METALS**

GIANT[1] Metallic

or

Eg Na, Mg, Fe, alloys

METAL and NON METAL

GIANT[1] Ionic

NaCl, MgO, $CaCO_3$

just **NON-METALS** **(except noble gases)**

If HIGH melting point (> about 1000^oC[2])

GIANT[1] Covalent

AKA MACROMOLECULES
The only common examples are diamond, graphite, SiO_2 , BN

If LOW melting point (> about 1000^oC[2])

SIMPLE MOLECULAR

Most covalent substances
C_{60}, H_2O, Cl_2, O_2, N_2, NH_3
C_8H_{18}, C_2H_5OH, $C_6H_{12}O_6$

[1] Giant structures can therefore have metallic, ionic or covalent bonding. The type of bonding the giant structure has can be worked out by its electrical conduction properties.
Metallic: conducts when liquid & solid (without decomposition) due to delocalised outer shell electrons that can move through the structure. **Ionic**: do not conduct when solid but conducts with decomposition when liquid (molten) or in solution due to mobile ions that are attracted to the electrodes
,
Covalent: (giant and simple molecular) do not conduct electricity (except graphite) as outer electrons involved in bonding and are not free to move through the structure and simple molecules have no overall electric charge.

The giant structures only apply when the substances are liquids or solids (not when gaseous). A **Giant *covalent*** structure is destroyed when it boils eg diamonds just become C atoms when it boils. If the gas formed was condensed, you would just get soot. A **Simple molecular structure** - remain as molecules (just separated) when it boils. When condensed the same simple molecular structure would reform (eg $H_2O(l) \rightleftharpoons H_2O(g)$)

[2] the mpt used to distinguish between simple molecular and giant covalent is approximate and only applies to substances with covalent bonding. Giant metallic substances can have quite low mpt eg sodium, 98^oC) Ionic compounds vary but normally above 500^oC. ALL Giant covalent structures are insoluble

FORMATION OF IONS: An ion was an atom that now has a charge as it gained or lost electron(s) (no longer an atom…).

Positive ions are called CATIONS eg K^+, Negative ions are called ANIONS eg Cl^-

The number of charges an ion has is always written before the symbol for a charge eg Mg^{2+} is correct, Mg^{+2} is wrong. Atom's gain or lose electrons to form empty/full outer shells. A full/empty outer shell electron arrangement is can be more stable* Noble gases (Gp 0) have full outer shells and are very unreactive. They do not want to gain or lose e^-. The noble gases are the only elements that exist as atoms.

Metals *lose* electrons to form +ve ions (size of charge = group number = no. of e- they need to lose to get to 0 outer e^-). **[NOTE if (ROMAN NUMERAL) then Roman Numeral = size of +ve charge)**

The metal ions are +ve because they now have less protons than e^-s. The no. of neutrons and protons has not changed

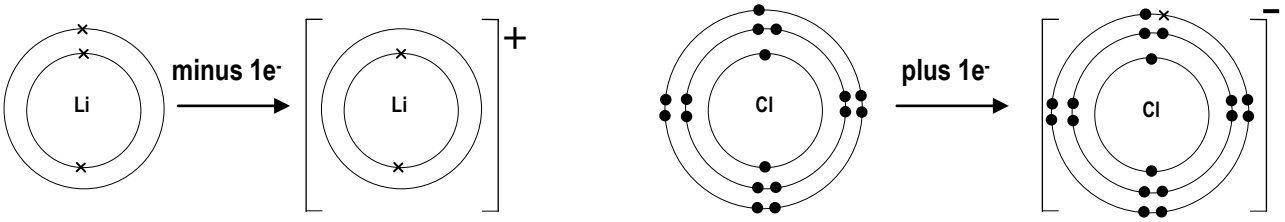
Non-metals usually *gain* electrons to form –ve ions (size of charge = no of e^- they need to get to 8 outer electrons)

The non-metal ions are -ve because they now have more e^-s than protons. The no. of n and p has not changed. [Hydrogen can form +ve or –ve ions. H^+ is called a hydrogen ion (it is also called a proton as that's all it consists of) H^- is called a hydride ion]

Non-metals in Gp 4 tend not to form ions,)

Examples:	**METAL**			**Metal ions**	**NON-METALS**			**Non-Metal ions**
	Li	gp 1	loses 1 electron	to form a Li^+ ion	Cl	gp 7	gains 1 electron	to form a Cl^- ion
	Mg	gp 2	loses 2 electrons	to form a Mg^{2+} ion	O	gp 6	gains 2 electrons	to form a O^{2-} ion
	Al	gp 3	loses 3 electrons	to form a Al^{3+} ion	N	gp 5	gains 3 electrons	to form a N^{3-} ion
				(0 e^- in outer shell)				**(8 e^- in outer shell)**
Naming of ions:	**metal ions** The name is the same as the metal element Sodium metal forms sodium ions Magnesium metal forms magnesium ions				**non-metal ions** the ending of the word is change to –ide eg oxygen atoms form oxide ions chlorine atoms form chloride ions			

The formation of ions can also be shown by diagrams and by a change in electronic arrangement.



lithium **atom** (3p, **3e**) 2,1

lithium **ion** (3p, **2e**) [2]+ same electron configuration as He (but one more p)

chlorine **atom** (17p, **17e**) 2,8,7

chlor**ide ion** (17p, **18e**) [2,8,8]- same *e. c.* as Ar (but 1 less p)

NOTE: (1) dots and crosses must be used when atoms have gained electrons, to show this (2) electrons should usually be drawn in pairs where possible (3) The electron arrangement diagrams usually just show outer shells electrons only. (4) Metal ions can be shown with full or empty outer shells. The *e. c.* diagrams can be shown without the actual circle representing the shell.

Transition metal ions

Transition metals form +ve ions as they are metals. Usually 2+ ions. One exception is **silver which always forms 1+** ions Ag^+. An A property of most transition metals is that the size of the ion can vary. At GCSE they usually only ask about iron, which can be either 2+ or 3+. Therefore for iron roman numerals must be used in the name to show which charge the iron ion has eg Iron(II)oxide is FeO, (containing Fe^{2+} ions) whilst iron(III)oxide is Fe_2O_3 (containing Fe^{3+} ions)

NOTE: Roman numerals are never used in Gp1/Gp2 compounds as Gp1 always form 1+ ions and Gp2, 2+ ions.

How do alkali metals react? They have 1 electron in their outer shell and all react by transferring their one outer shell electrons to non-metals, resulting in the formation of 1+ ions. **Alkali metals have similar chemical properties.**

sodium + chlorine → sodium chloride , $2Na + Cl_2 \rightarrow 2NaCl$, lithium + bromine → lithium bromide

The halogens will all react with Gp 1 metals to form ionic compounds containing halide ions which have a single negative charge eg (F^- fluoride ion, Cl^- , chloride ion, Br^-, bromide ion, I^-, iodide ion (Halide ion = -ve ions of the halogens). The electron has been gained from the outer shell of the alkali metal. **Halogens have similar chemical properties**

STABLE OCTECT: Eight electrons in the outer shell – considered a stable electron arrangement, NOTE, Li^+, only has two electrons in its outer shell. If an ion has a Full outer shell of electrons : its electron configuration will be the same as a noble gas

CHEMICAL BONDING

Chemical **bonds form when atoms react by TRANFERRING or SHARING**
(Valence) outer shell electrons (ie highest occupied energy levels of atoms)

all chemical bonds involve the electrostatic attraction of opposite charges
Types of bonds: ionic, covalent, metallic

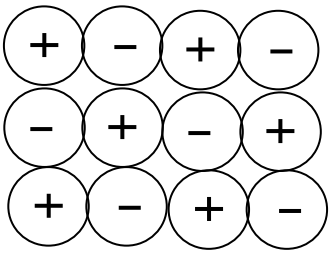
Atoms, Electron configuration & Bonding Only atoms of Group O are stable substances by themselves. A full outer shell of electrons is therefore said to be a stable electron configuration. All other atoms in the periodic table transfer/gain/share electrons resulting in the formation of bonds to become more stable. In the process of forming bonds most atoms achieve a full outer shell electron configuration. It is not necessarily the full outer shell configuration that leads to stability, rather it is the formation of bonds. For most atoms, a full outer shell is eight electrons, For H and He, (period 1) a full outer shell = 2 electrons.

METALS *lose* electrons [to form positive ions (size of charge = group number)] to a non metal to form ions which bond together
NON-METALS EITHER *gain* electrons [to form –ve ions (size of charge = gp. no. – 8)] from form ions which bond together
OR *share* electrons with other non metals to form covalent substances.

IONIC BONDING **–** Defn**: electrostatic attraction between oppositely charged ions**

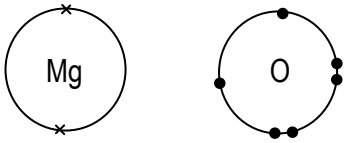
[**STRONG]** **The ionic bond extends in all directions throughout an ionic lattice** (see structure topic)

- **Ionic bonding occurs AFTER ions have been formed**
- extends throughout the structure, **it is not just 2 ions bonded together**
- eg between metal and nonmetal ions eg NaCl, MgO, K_2S
- eg between ions/ compound ions eg $CaCO_3$, $MgSO_4$, NH_4NO_3
- Ions are formed when (usually) metal atoms **transfer** outer shell electron(s) to a non-metal so that a negative and positive ions have formed.

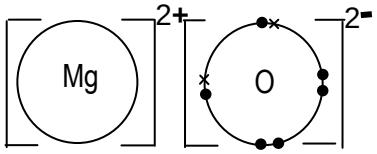


Formation of ions Ionic bonding occurs **AFTER** a metal atom has **transferred** its OUTER SHELL electron(s) to a non-metals OUTER SHELL so that ions are formed which attract each other and therefore form the ionic bond.

Eg **(1) *Formation of ions in* magnesium oxide** Magnesium reacts with oxygen by transferring its **2 outer** shell electrons to oxygen's outer shell. Mg atoms become Mg^{2+} ions (empty outer shell), O atoms become oxide, O^{2-} , ions with eight outer electrons (a full outer shell). Both Mg^{2+} and O^{2-} ions formed have the same electronic configuration as Neon (2,8). They are not the same as Ne because they still have their original number of protons. Usually only show the valence electrons, as the inner electrons are not involved in bonding



outer main shells only
must use
dots and crosses
to show where the electrons come from

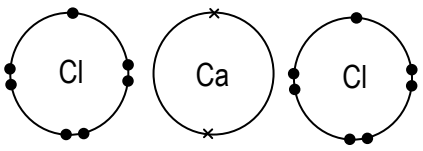


or Mg: *[2,8,2]* O: *[2,6]*
magnesium atom oxygen atom

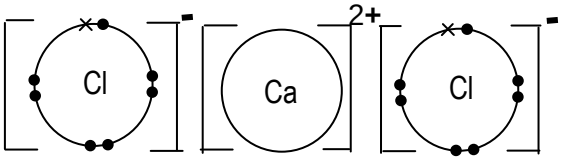
Mg^{2+} *[2,8,]*$^{2+}$ O^{2-} *[2,8,]*$^{2-}$
magnesium oxide (ionic compound)

note: Mg forms a **2**$^{+}$ ions, because it loses **2** electrons, oxygen atoms forms a **2-** oxide ion as it gains **2** electrons. Electrons are negative. The charges on the ions (Mg^{2+} and O^{2-}) are not written in the formula of Magnesium oxide, MgO. It is assumed that a chemist would know that it is likely to be an ionic compound (as it contains a metal and a non metal). It is also assumed that a chemist could work out the size of the charges on the ions either by the diagram above, or from their knowledge that group 2 elements from 2+ ions, and group 6 elements form 2^{-} ions.

Eg **(2) Calcium Chloride** Calcium is in group 2, therefore will lose its 2 outer electrons. Chlorine is in group 7 and will gain 1 electron. In order for both atoms to achieve a full/empty outer shell calcium transfers one outer electron to one chlorine and its other outer electron to a another chlorine atom so two chloride ions (Cl^{-})are formed. **$CaCl_2$**



outer shells only



2,8,7 2,8,8,2 2,8,7 $[2,8,8]^{-}$ $[2,8,8]^{2+}$ $[2,8,8]^{-}$

COVALENT BONDING: DEFN: A **shared pair** of electrons between atoms
[**STRONG]** NOTE: the electrostatic attraction is between the shared negative electrons and both positive nuclei

Covalent bonding: Usually occurs between non-metals

Single covalent bond: One shared pair of e^- (2e overall) with one e^- coming from each atom, represented by a line like this H—F
Both electrons in a shared electron pair can originate from one of the atom (dative covalent)

Double covalent bond: Two shared pairs (4e shared overall), represented by 2 lines eg O=O The two bonds are not identical

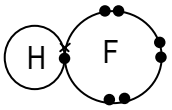
Triple covalent bond: Three shared pairs (6e shared overall), represented by 3 lines eg N≡N

LONE PAIRS Non-bonding outer shell electrons -should usually be shown in pairs in the '**after' bonding** diagram

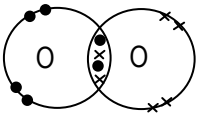
Displayed formula : This is the representation of the molecule by showing the covalent bonds as lines

Examples Eg HF, a Hydrogen atom has 1 (outer) electron, and fluorine has 7 outer electrons, the atoms share one each. The hydrogen now has a share in 2 electrons, and fluorine has a share in eight electrons and a covalent bond has been formed.

only outer shells shown ● and × must be used to show where the electrons have come from



H—F



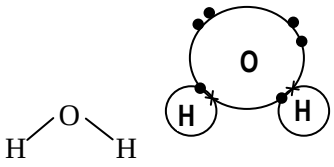
O═O

the shells don't need to be drawn

Electron pairs in the outer shell that are not used in the bonding are called lone pairs of electrons. each O atom in O_2 has 2 lone pairs. Each Cl atom in Cl_2 has three lone pairs of electrons.

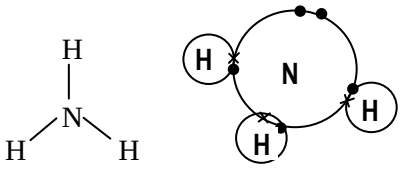
H_2O, water

O + H, O group 6, needs 2 electrons,
Therefore bonds with two hydrogens



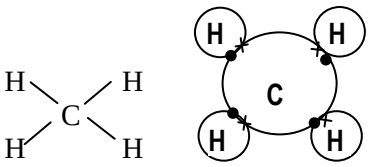
NH_3, ammonia

N + H, N group 5, needs 3 electrons,
Therefore bonds with three hydrogens



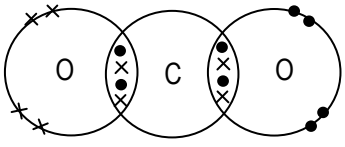
CH_4, methane

C + H C group 4, needs 4e,
Therefore bonds with four hydrogens

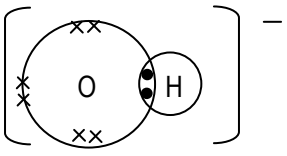


Displayed formula : this is the representation of the molecule by showing the covalent bonds as lines

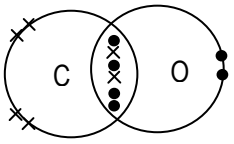
CO_2, carbon dioxide O═ C═ O



OH^- hydroxide ion



Carbon Monoxide C ⇌ O



Note (1): For the usual covalent bond the electrons must be shown as alternate (vertical) ● and x
Note (2): When doing a ● x diagram for a molecular ion, an electron is added for each negative charge, whilst an electron is removed for each positive charge.

MAKE SURE YOU DRAW IT LARGE ENOUGH TO FIT ALL THE SHARED ELECTRONS WITH IN THE OVERLAP AREA

In Giant covalent structures *networks* of atoms are covalently bonded to each other eg diamond, silicon dioxide

Naming Substances (1) **USING JUST THE PERIODIC TABLE**

Name of **FORMULA WITH JUST ONE TYPE OF ATOM** **(AND NO CHARGE)** eg K

- As stated on the periodic table (PT) K = potassium, Cl_2 = chlorine P_4 = phosphorus

Name of **FORMULA of an ION** eg K^+ and Cl^-

- If it is a metal ion name is as stated on the PT with the word ion on the end eg Na^+ = sodium ion, Mg^{2+} = magnesium ion
- If it is a non metal ion CHANGE THE ENDING TO –IDE and add the word ion eg Cl^- = chloride ion, S^{2-} = sulphide ion

Name of a compound with **ONE type of METAL AND ONE type of NON METAL** (and no overall charge) eg LiCl

- Give the name of the metal first as printed on the periodic table
- Give the name of the non metal second BUT CHANGE ITS ENDING to –IDE

eg LiCl = lithium chlor**ide**
MgF_2 = magnesium fluor**ide**

Name of a compound with **two types of NON METALS** (and no overall charge) eg CO

- Give the name of the first non metal as given on the periodic table
- Give the name of the non metal second BUT CHANGE ITS ENDING to –IDE
- If there is more than one of the second type, use mono for 1, di for 2, tri for 3 and tetra for 4
- Some Exceptions – common molecules such as H_2O (water), NH_3 (ammonia) , acids

eg CO = carbon monoxide
NO_2 = nitrogen dioxide

Naming substances (2) **FORMULAE THAT NEED TO BE REMEMBERED**

COMMON MOLECULES					
H_2O	**water**	**CH_4**	**Methane**	**H_2O_2**	**hydrogen peroxide**
CO_2	**carbon dioxide**	**CO**	**carbon monoxide**	**C_2H_5OH**	**ethanol**
SO_2	**sulphur dioxide**	**NO**	**nitrogen monoxide**	$C_6H_{12}O_6$	Glucose
SO_3	**Sulphur trioxide**	**NO_2**	**Nitrogen dioxide**	HCOOH	Methanoic acid
NH_3	**ammonia**	**C_2H_4**	**Ethene**	**CH_3COOH**	**Ethanoic acid**
(sometimes the number of the second atom is given from mono =1, di = 2, tri = 3).					

IN BOLD - THE FORMULAE/NAME YOU MUST WRITE OUT EVERY DAY OVER THE SUMMER UNTIL YOU CAN REMEMBER THEM ALL < THEN >

GRADUALLY INCREASE THE LENGTH OF TIME BETWEEN WRITING THEM OUT SO YOU NEVER FORGET THEM

ACIDS		**COMPOUND IONS**			
H^+ ion	**Hydrogen ion** or Proton	**OH^-**	**hydroxide ion**	**NH_4^+**	**ammonium ion**
H_2CO_3	carbonic acid*	**HCO_3^-**	**hydrogencarbonate ion**		
CH_3COOH	**ethanoic acid**	**CH_3COO^-**	**Ethanoate ion**		
HNO_3	**nitric acid** [nitric(V) acid]	**NO_3^-**	**Nitrate ion** [Nitrate(V) ion]		
HNO_2	nitric(III) acid (Nitrous acid)	NO_2^-	Nitrate(III) ion (nitrite ion)	MnO_4^-	Manganate(VII)ion
H_2SO_4	**sulphuric acid** [sulphuric(VI) acid]	**SO_4^{2-}**	**Sulphate ion** [sulphate(VI) ion]		
H_2SO_3	sulphuric(IV) acid (Sulphurous acid)	SO_3^{2-}	sulphate(IV) ion (sulphite ion)		
HCl	**hydrochloric acid**	**CO_3^{2-}**	**Carbonate ion**		
$HClO_3$	Chloric acid [chloric(V) acid]	ClO_3^-	Chlorate(V) ion		
HClO	Chloric(I) acid	ClO^-	Chlorate(I) ion		
H_3PO_4	phosphoric acid (phosphoric(V) acid	PO_4^{3-}	Phosphate ion (Phosphate(V) ion]		
H_3PO_3	phosphoric(III) acid (phosphorous acid)	PO_3^{3-}	phosphate(III) ion phosphite ion		

*forms when CO_2 gas dissolves in water $CO_2 + H_2O \rightleftharpoons H_2CO_3$), equilibrium lies to the left ; carbonic acid will ionise weakly in water $H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$

** H_2SO_3(aq) may not exist, in solution the following occurs $SO_2 + H_2O \rightleftharpoons H^+ + HSO_3^-$ forming the hydrogensulphate(IV) ion [equilibrium lies to the left]

note compound ions with oxygen end with –ate ion OR –ate(oxidation number) ion

BALANCING EQUATIONS

Chemists often write chemical equations using symbols instead of words. For example, the reaction of magnesium with oxygen to form magnesium oxide can be written as: Magnesium + oxygen → magnesium oxide or $Mg + O_2 \rightarrow MgO$ however……this symbol equation is not complete. The equation needs to be balanced.

$Mg + O_2 \rightarrow MgO$ $\quad$ $2Mg + O_2 \rightarrow 2MgO$

Left hand side	Right hand side	Left hand side	Right hand side
1 Mg	**1 Mg**	**2 Mg**	**2 Mg**
2 O	1 O	2 O	2 O
not balanced		balanced	

- In a balanced equation there has to be the **same number of each particular atom on both sides of the arrow**.
- To balance an equation, numbers CAN ONLY be put in front of the formulae.

Remember

- A chemical formula represents two or more elements chemically combined.
- Symbols for elements are either a single capital letter (eg O), or a capital letter and a small case letter (Na). So NO, as it is two capital letters, must represent the elements N **and** O, not a mysterious new element!

NOTE:

Subscript numbers cannot be changed. eg O_2 cannot be changed into O_3

Subscript numbers only apply to the element immediately before the subscript unless the subscript is after a bracket.

eg In ZnO_2 the subscript 2 means there are two O, It **does not mean** there are 2 O and 2 Zn.
In $AgNO_3$ there are 3 O, 1 N and 1 Ag
In $Ag(NO_3)_2$ there are 6 O, 2 N and 1 Ag

Putting the balancing number in front of a formula, multiplies all the elements in the formula by that number.

eg 2 CuO means there are 2 Cu and 2 O , 3 $Mg(NO_3)_2$ = 18 O (see handy hints)

Handy Hints to speed up your balancing

1) Look at the equation and first put in the minimum numbers required by the formulae

eg $Zn + HCl \rightarrow ZnCl_2 + H_2$: The left hand side of this equation requires at least 2 HCl to provide the two Cl required by the formula $ZnCl_2$. In this example, this has led straight away to a balanced equation.

2) If the equation contains a diatomic element <u>by itself</u> eg O_2 Br_2 leave the balancing of the O_2 / Br_2 to the end and then use ½'s if needed. ½ O_2 (ie 1 O) or a multiple of a ½ O_2 eg 3.5 O_2 (= 7 O) are usually allowed

NOTE: This can usually ***only be done for Diatomic elements***, as you cannot have an equation with ½ an atom eg ½ H_2O is wrong, as you cannot have ½ an O atom, ½ O_2 is accepted as it give 1 whole O atom.

eg $NO + O_2 \rightarrow NO_2$ The equation would balance if you used ½ O_2. => $NO + ½\ O_2 \rightarrow NO_2$

The equation $NO + ½\ O_2 \rightarrow NO_2$ can be multiplied by 2 to give whole numbers => $2NO + O_2 \rightarrow 2NO_2$

3) ***Count the Compound ions***, rather than the atoms that make up the compound ions, ***<u>if</u> the compound ion stays together***

eg $Mg(OH)_2 + HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$;

Rather than trying to count all the oxygens, note that on the left hand side there are 2 nitrate ions (NO_3^-) in $Mg(NO_3)_2$, and one nitrate ion on the right (in HNO_3) therefore put a 2 in front of nitric acid (HNO_3), and then you only have to count the oxygen in $Mg(OH)_2$ and H_2O. ie get to $Mg(OH)_2 + \mathbf{2}HNO_3 \rightarrow Mg(NO_3)_2 + H_2O$ then count the remaining O => 2O and 4H's on the left so 2 H_2O will lead to a balanced equation. $Mg(OH)_2 + \mathbf{2}HNO_3 \rightarrow Mg(NO_3)_2 + \mathbf{2}H_2O$. To use this method you need to know what the compound ions are! (see page 4).

4) ***When a carbonate/hydrogencarbonate compound*** reacts to form CO_2 and H_2O, normally ***the same number of CO_2 and H_2O are needed*** in the balancing eg $Mg(HCO_3)_2 + HCl \rightarrow MgCl_2 + CO_2 + H_2O$

- Using hint 1 => $Mg(HCO_3)_2 + \mathbf{2}HCl \rightarrow MgCl_2 + CO_2 + H_2O$
- There are 2 C in $Mg(HCO_3)_2$ therefore 2 CO_2
- Using hint 4 try 2 H_2O => $Mg(HCO_3)_2 + \mathbf{2}HCl \rightarrow MgCl_2 + \mathbf{2}CO_2 + \mathbf{2}H_2O$ equation is balanced

5) Balancing redox equations using oxidation numbers: see page 22

WRITING SYMBOL EQUATIONS from word equations

Symbol for **Metal Elements**
If the word equation contains a metal element (ie a metal by itself) **just write the symbol of the metal from the periodic table**. Do not change the symbol AT ALL. Eg magnesium Mg not Mg_2 or Mg^{2+}

Symbol/formulae for **Non - Metal Elements**
If the word equation contains a non- metal element (ie a non-metal by itself) just write the symbol of the non-metal from the periodic table UNLESS the element is H,F,Br,O,N,I,Cl, At in which case write it as a diatomic molecule ie H_2, F_2 Br_2 O_2 N_2 I_2 At_2 Cl_2 I_2. These can be remembered by (Mr) HF. BrONIClAt has a twin brother.

Formulae of **Non- Metal Compounds**
A. Some formulae you can work out from the name, if you remember that mono = 1, di = 2, tri = 3, tetra = 4

B. Some formulae need to be remembered - see table on previous page

WRITING Formulae of **IONIC compounds (Metal + Non metal)**

To work out the formula you first NEED TO KNOW THE CHARGE ON THE ION. First Always check whether it is an ion that needs to be remembered or whether it is an ion whose charge can be worked out from the periodic table

CHARGES OF METAL IONS (+ve)

For GROUPS	Charge = Group no.	eg all Gp 2 have 2+ charge This is equal to the no of e- that have to be lost for a full outer shell
For TRANSITION METALS	Charge usually = 2+	(Except for Ag^+ and for some, Roman numerals show the size of the eg Iron(III)chloride contains Fe^{3+} ions, Iron(II)chloride , Fe^{2+} ions

.

CHARGES OF NON-METAL IONS (-ve)

Charge = Group number minus 8.	eg oxide = O, Gp 6 charge = 6 – 8 = - 2) This is equal to the no of e- that have to be GAINED for a full shell

Once the charge is known, the formula can be worked by either of the following methods

Method (1) [this avoids writing Pb_2O_4 formula (incorrect) instead of correct PbO_2 for lead(IV)oxide]

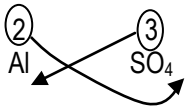
- **Ionic compounds have no overall charge** as the +ve charges are cancelled out by an equal number of –ve charges
- The subscript numbers in the formula are the number needed of each ion to get the +ve/-ve charges to balance.

(1) Use the periodic table to work out the charges on the ions (or if a –ate or –ite compound ion, you have to remember the ion)
Eg Magnesium Chloride , contains Mg^{2+} and Cl^- ions ; Magnesium nitrate, Mg^{2+} and nitrate ions, NO_3^-

(2) Work out the number of each ion so that the total charge of the compound is zero. Here ***TWO*** Cl^- ions are needed to make the make 2 – ve charges (Cl^- has 1 –ve charge) to balance out the 2+ charge of the Mg^{2+} ion- => ANSWER = $MgCl_2$
NOTE: Brackets are used if more than one compound ion is needed eg Magnesium nitrate, made up of magnesium ions Mg^{2+} and nitrate ions, NO_3^- => Answer = $Mg(NO_3)_2$

Method (2) Quick method, but need to cancel down crossing over size of charge eg Worked example : Aluminium sulphate
Step 1: write out ions Al^{3+} SO_4^{2-} NOTE: if ions are of the same size then STOP, The formula is done! eg Mg^{2+} O^{2-} → MgO

Step 2: write out with size of ion above symbol(s), *in a different colour.* 3 Al 2 SO_4

Step 3: cross over diagonally 

Al_2 $SO_4{}_3$

step 4: if needed cancel down to smallest whole number (eg Pb^{4+} + O^{2-} → Pb_2O_4 → PbO_2)
step 5: if needed cross out any 1's
step 6: put brackets around compound ions if there is more than one **$Al_2(SO_4)_3$**

Method 3 – using Valency

Valence electrons – the electrons in the outer shell of an atom
VALENCY : the combining power of an atom

Group	I	II	III	IV	V	VI	VII	0
Typical valency (non-metals)	-	-	3	4	3	2	1	0
maximum (non-metals)			(5)	4	5	6	7	8!
Typical Valency (metals)	1	2	3	2 & 4	3 & 5	4 & 6	-	-
Transition metals	Valency can vary eg Fe 2 & 3 ; Mn 2 to 7 ; Ag 1 only							

Typical valencys when metals react to forming IONIC compounds

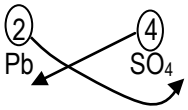
- Gp II elements have a valency of 2 as they lose the two outer shell electrons when combining with another atom to form an empty outer energy level [noble gas electronic structure]
- Gp IV metals can have a valency of 2 or 4 as they can lose two or four electrons when combining
- Transition metals – varies

Typical valencys when Non- metals form IONIC or COVALENT compounds

- Gp VI elements has a valency of 2 as they need two electrons to complete its highest energy level / outer shell (either by gaining two outer shell electrons from other atom(s) when combining / or sharing two electrons from other atom(s)
- Boron valency usually 3!!
- Can range widely

Writing formula using valency - use cross over method : Example for Lead(IV)sulphate

Step1: write out with valency above symbol(s), *in a different colour.* ^{4}Pb $^{2}SO_4$

Step 2: cross over diagonally 

Pb_2 $SO_{4\,4}$

step 3: put brackets around compound ions if there is more than one $Pb_2(SO_4)_4$

step 4: if needed cancel down to smallest whole number $Pb(SO_4)_2$

step 5: if needed cross out any 1's **$Pb(SO_4)_2$** Lead(IV)sulphate

NOTE::::::::::::::::: DONT NEED TO REMEBER THE FOLLOWING for IGCSE::::::::::::::::::::

Examples of wide ranging valencys of elements

(1) Nitrogen can be 1 to 5 (N_2O , NO , N_2O_3, NO_2, N_2O_5)
(2) Some Transition metals can vary widely and also can form covalent compounds, usually if they contain a high proportion of oxygen eg Chromium trioxide

	Ionic or Covalent	Valency	Name	Basic, amphoteric or acidic oxide?
CrO	Ionic	1	Chromium(II)oxide	**Basic**
Cr_2O_3	Ionic	3	Chromium(III)oxide	**Amphoteric**
CrO_2		4	Chromium(IV)oxide	**Amphoteric**
CrO_3	Covalent	6	Chromium(VI)oxide	**Acidic**

Chromium(VI)oxide may react with water in the same way as the covalent sulphur trioxide, forming chromic acid

$SO_3 + H_2O \rightarrow H_2SO_4$; $SO_3 + H_2SO_4 \rightarrow H_2S_2O_7$
$CrO_3 + H_2O \rightarrow H_2CrO_4$; $CrO_3 + H_2CrO_4 \rightarrow H_2Cr_2O_7$

Sulphuric acid reacts with sulphur trioxide forming 'oleum' aka disulphuric acid; Chromic acid would react with chromium(VI)oxide to form dichromic acid. The $Cr_2O_7^{2-}$ ion, 'dichromate(IV)ion is a common chemical in A Level chemistry.

DEFINITIONS / REACTIONS of ACIDS / BASES To LEARN

ACID – Defns PROTON DONOR (or forms H^+ ions when dissolved in water) **BASE – Defn PROTON ACCEPTOR**

ALKALI - Defn soluble base that forms OH^- ions when dissolved in water

SALT: Substance form when a metal ion or an ammonium ion replaces a hydrogen ion in an acid

State symbols s = solid, l = liquid, g = gas, aq = dissolved in water

REDOX **Metal + Acid → metal Salt + Hydrogen** **[for 'mazit' metals]**

BASE + ACID

NEUTRALISATION **Ammonia + Acid → Ammonium Salt**

NEUTRALISATION **metal Oxide + Acid → metal Salt + Water**

NEUTRALISATION **metal Hydroxide + Acid → metal Salt + Water**

NEUTRALISATION **metal* Carbonate + Acid → metal Salt + Water + carbon dioxide**

NEUTRALISATION **metal* Hydrogencarbonate + Acid → metal Salt + Water + carbon dioxide**

- Ammonium carbonate / hydrogencarbonate will react in the same way, but form ammonium salts of the acid

General eqn for Neutralisation

For most bases that contain oxygen

for carbonates / hydrogencarbonates

Base / Alkali + Acid → SALT [+ water (+ carbon dioxide)]

WRITING WORD EQUATIONS for the PRODUCTS of Reactions of acids : names of metal salts

Acid + other reactant → metal salt + **other product(s)**

first part (+ve ion) ***named from metal***

calcium hydroxide gives	calcium…….
aluminium oxide	aluminium……
sodium carbonate	sodium…….
Ammonium carbonate	Ammonium…..
Ammonia	Ammonium…..

second part (-ve ion) ***named from the acid***

Hydrochloric acid gives	
Sulphuric acid	……..sulphate
Nitric acid	……..nitrate
''Carbonic acid''	……..carbonate
Nitrous acid	……..nitrite

Other product(s) – depends on non-acid reactant eg eg water if the reaction is metal oxide + acid ; water and carbon dioxide from a metal carbonate

eg

Hydrochloric acid + magnesium oxide → magnesium chloride + water

nitric acid + calcium carbonate → calcium nitrate + water + carbon dioxide

sulphuric acid + strontium → strontium sulphate + hydrogen

hydroxxx***ic*** acids lead to…..***ide salts,*** xxxx***ic*** acids …..***ate salts,*** xxxx***ic (Ox.no.)*** acids …..***ate(Ox.no.) salts***

Background information about salts : substance that can be formed when a metal ion or an ammonium ion replaces a hydrogen ion in an acid [a salt can be formed by another method, its a salt as long as it can be formed by replacing a hydrogen ion of an acid]

Salts are ionic compounds – contain a +ve ion (usually a metal or an ammonium ion NH_4^+) and a –ve ion

Salts can be soluble or insoluble; When ionic compounds that are soluble dissolve in water the +ve ions and –ve ions separate

NaCl(aq) means NaCl dissolved in water (not aqueous / soluble!!). The Na^+ ions are separated from the Cl^- ions. NaCl + aq → $Na^+(aq)$ + $Cl^-(aq)$

Only when the water is evaporated do the ions join up together to form a solid Table salt is mainly sodium chloride

EXAMPLES of acids / ions from acids TO LEARN : NOTE Chemists usually write $H^+(aq)$ instead of $H_3O^+(aq)$, and therefore it is acceptable to do this, unless you are asked to show how the acid is reacting with water.

Name	Formula	Ions produced in water for one acid molecule [$H^+(aq) = H_3O^+(aq)$]		Name of negative ion
Strong acids				*H^+ ions are also known as protons*
Hydrochloric acid	HCl	H^+	Cl^-	Chloride ion
Chloric(V) acid	$HClO_3$	H^+	ClO_3^-	Chlorate(V) ion
nitric acid	HNO_3	H^+	NO_3^-	Nitrate ion
sulphuric acid	H_2SO_4	$\mathbf{2}H^+$	SO_4^{2-}	Sulfate ion
Note: the size of charge on the negative ion = number of H^+ ions formed when the molecule ionises in water				
	Di- and triprotic acids can react by losing only some of their protons			
sulphuric acid	H_2SO_4	H^+	HSO_4^-	Hydrogensulfate ion
phosphoric acid	H_3PO_4	H^+	$H_2PO_4^{2-}$	dihydrogenphosphate ion
eg KOH + H_2SO_4 → $KHSO_4$ + H_2O ; $KHSO_4$ is called potassium hydrogensulphate				
Acid salts	potassium hydrogensulphate is an example of an 'acid salt' as it can still donate a proton, and its a salt.			
The HSO_4^- ion is an 'acid ion', not an acid salt (need +ve & -ve ion to be a salt],				

Weak acids		*only about 1 to10 of 1000 molecules split up to form ions, for carbonic acid even fewer*		
phosphoric acid	*H_3PO_4*	*$\mathbf{3}H^{+*}$*	*PO_4^{3-}*	*Phosphate ion*
Nitric(III) acid	*HNO_2*	*H^+*	*NO_2^-*	*Nitrate(III) ion*
carbonic acid	*H_2CO_3*	*H^+*	*HCO_3^-*	*Hydrogencarbonate ion*
ethanoic acid	*CH_3CO_2H*	*H^+*	*$CH_3CO_2^-$*	*Ethanoate ion*
Citric acid	*Not on syllabus $HOOCC(CH_2CO_2H)_2OH$*	*3H+*	*Not on syllabus $C_6H_5O_7^{3-}$*	*Citrate ion*
Ammonium ion	*NH_4^+*	Can act as an acid as it can donate a proton $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$		
***Strong acid**	*Complete ionisation in water (every molecule reacts to form $H^+(aq)$ ions and a –ve ion)*			
***weak acid**	*Partial ionisation in water (only a few molecule react to form H^+ (aq) ions and a –ve ion)*			
*	*when an acid can react to release more than $1H^+$ ion, the other ions usually only partially ionise, like a weak acid*			

NOTE (1) The terms 'Strong' and 'weak' CANNOT be used to imply the overall amount of a substance dissolved in water. **Strong and weak only refer to the amount of ionisation**.

NOTE (2) The terms **concentrated** and **dilute** are used to imply the amount of substance dissolved in a given volume .

Dilute solution of a strong acid: a relatively small amount of HCl dissolved in water
Dilute solution of a weak acid: a relatively small amount of ethanoic acid dissolved in water
Concentrated solution of a strong acid: a relatively large amount of HCl dissolved in water)
Concentrated solution of a weak acid: a relatively large amount of ethanoic acid dissolved in water

NOTE (3) : To compare the pH of a strong acid and a weak acid in a fair way the weak acid and strong acid must be of the same concentration (and both be monoprotic or diprotic acids). If this is the case then the pH of the stronger acid will always be lower

BALANCING EQUATIONS *1*

1 State the number of each type of atom in the following. Where the formula has a balancing number, take the balancing number into account when working out the number of each type of atom.

a	PbO_2	no. of Pb =	no. of O =			(1)
b	$Al(NO_3)_3$	no. of Al =	no. of O =	no. of N =		(1)
c	$Bi_2(SeO_3)_5$	no. of Bi =	no. of O =	no. of Se =		(1)
d	$2\ Li_2S$	no. of Li =	no of S =			(1)
e	$3H_2SO_4$	no. of H =	no. of O =	no. of S =		(1)
f	$2(NH_4)_3AsO_4$	no. of H =	no. of O =	no. of As =	No of H =	(1)

2**. Balance the following equations.**

A	H_2	+	Cl_2	→	HCl					
B	Ba	+	O_2	→	BaO					
C	HCl	+	Mg	→	$MgCl_2$	+	H_2			
D	K	+	H_2O	→	KOH	+	H_2			
E	$Mg(OH)_2$	+	HNO_3	→	$Mg(NO_3)_2$	+	H_2O			
F	H_2SO_4	+	Na	→	Na_2SO_4	+	H_2			
G	In	+	O_2	→	In_2O_3					
H	$PbCO_3$	+	HCl	→	$PbCl_2$	+	CO_2	+	H_2O	
I	$Ca(OH)_2$	+	H_2SeO_4	→	$CaSeO_4$	+	H_2O			
J	Na	+	HCl	→	NaCl	+	H_2			
K	LiOH	+	H_2SO_4	→	Li_2SO_4	+	H_2O			
L	$CaCO_3$	+	HNO_3	→	$Ca(NO_3)_2$	+	CO_2	+	H_2O	
M	NH_4OH	+	H_2SeO_4	→	$(NH_4)_2SeO_4$	+	H_2O			
N	$Ba(HCO_3)_2$	+	HNO_3	→	$Ba(NO_3)_2$	+	CO_2	+	H_2O	
O	Al	+	HNO_3	→	$Al(NO_3)_3$	+	H_2			
P	C_2H_6	+	O_2	→	CO	+	H_2O			
Q	$In_2(CO_3)_3$	+	HCl	→	$InCl_3$	+	H_2O	+	CO_2	
R	Ru_2O_3	+	CO	→	Ru	+	CO_2			
S	Ga_2S_3	+	HNO_3	→	$Ga(NO_3)_3$	+	H_2S			
T	H_3PO_4	+	$Cu(HCO_3)_2$	→	$Cu_3(PO_4)_2$	+	CO_2	+	H_2O	
U	C_4H_{10}	+	O_2	→	CO_2	+	H_2O			
V	RbOH	+	H_2TeO_4	→	Rb_2TeO_4	+	H_2O			
W	CH_3OH	+	O_2	→	CO_2	+	H_2O			
X	NH_3	+	H_3PO_4	→	$(NH_4)_3PO_4$					
Y		$Cu(NO_3)_2$		→	CuO	+	NO_2	+	O_2	
Z	$C_5H_{11}OH$	+	O_2	→	CO_2	+	H_2O			
Extension (1)	$C_{18}H_{38}$	+	O_2	→	CO_2	+	H_2O			
Extension (2)	NH_3	+	O_2	→	NO	+	H_2O			
Extension (3)	HNO_3	+	Cu	→	$Cu(NO_3)_2$	+	NO_2	+	H_2O	

BALANCING EQUATION QUESTIONS 2

1 State the number of each type of atom in the following. Where the formula has a balancing number, take the balancing number into account when working out the number of each type of atom.

a Ga_2O_3 no. of Ga = no. of O =

b HNO_3 no. of H = no of N = no. of O =

c $Al_2(SO_4)_3$ no. of S = no of O = no. of Al =

d $2MgCl_2$ no. of Mg = no of Cl =

e $3Ca(NO_3)_2$ no. of O = no of Ca = no. of N =

2**. Balance the following equations**

A	H_2	+	Br_2	→	HBr					
B	Cu	+	O_2	→	CuO					
C	Na	+	H_2O	→	NaOH	+	H_2			
D	$Mg(OH)_2$	+	HNO_3	→	$Mg(NO_3)_2$	+	H_2O			
E	Li	+	O_2	→	Li_2O					
F	Al	+	O_2	→	Al_2O_3					
G	KOH	+	H_2SO_4	→	K_2SO_4	+	H_2O			
H	$CaCO_3$	+	HCl	→	$CaCl_2$	+	CO_2	+	H_2O	
I	C_2H_6	+	O_2	→	CO_2	+	H_2O			
J		$Cu(NO_3)_2$		→	CuO	+	NO_2	+	O_2	
K	$Ca(HCO_3)_2$	+	HNO_3	→	$Ca(NO_3)_2$	+	CO_2	+	H_2O	
L	C_3H_7OH	+	O_2	→	CO_2	+	H_2O			
M	NH_4OH	+	H_2SO_4	→	$(NH_4)_2SO_4$	+	H_2O			
N	CH_4	+	O_2	→	CO	+	H_2O			
O	Ru_2O_3	+	CO	→	Ru	+	CO_2			
P	Ga_2S_3	+	HNO_3	→	$Ga(NO_3)_3$	+	H_2S			
Q	H_3PO_4	+	$Cu(HCO_3)_2$	→	$Cu_3(PO_4)_2$	+	CO_2	+	H_2O	

Balancing Equations Extension

Extension 1			Br_2	+	KOH	→	$KBrO_3$	+	KBr	+	H_2O			
Extension 2	C_2H_5OH	+	$Na_2Cr_2O_7$	+	H_2SeO_4	→	CH_3COOH	+	$Cr_2(SeO_4)_3$	+	H_2O	+	Na_2SeO_4	
Extension 3	V	+	$HClS_3$	→	V_2S_5	+	ClS_2	+	H_2S					
Extension 4	HNO_3	+	Cu	→	$Cu(NO_3)_2$	+	NO	+	H_2O					

Recognising ATOMS, ELEMENTS, MOLECULES, COMPOUNDS, IONS

1 Define the terms (a) molecule (b) compound

Please note for Q2 , Q3 and Q4

- **state all the formulae that answer the question (ie there could be up to 5/6 answers for each)**
- **If a compound contains a metal then it is unlikely to be a molecule**

2(a). From $MgBr_2$ Br_2 CO CaO O_2 state which represent molecules
(b). From $MgBr_2$ Br_2 CO CaO O_2 state which represent compounds
(c). From $MgBr_2$ Br_2 CO CaO O_2 state which represent elements

3(a) From CO_2 InF_3 I_3 PBr_5 Sb_2S_5 state which *are both* elements and molecules
(b) From CO_2 InF_3 I_3 PBr_5 Sb_2S_5 state which *are both* molecules and compounds
(c) From CO_2 InF_3 I_3 PBr_5 Sb_2S_5 state which are compounds *but not* molecules

4(a) From Mn^{2+} Cl^- Ne CO_2 CO_3^{2-} MnO_4^- state which are ions
(b) From Mn^{2+} Cl^- Ne CO_2 CO_3^{2-} MnO_4^- state which are compounds
(c) From Mn^{2+} Cl^- Ne CO_2 CO_3^{2-} MnO_4^- state which are compound ions
(d) From Mn^{2+} Cl^- Ne CO_2 CO_3^{2-} MnO_4^- state which are molecular ions

<u>Section B Symbols, Formulae and names</u>

1(a) Is O^{2-} called an oxygen ion or an oxide ion?
(b) Is Ca^{2+} called a calcium ion or a calcide ion?
(c) Is Si^{4-} called a silicon ion, a silicide ion or a silicate ion?
(d) Is CO_3^{2-} called a carbon ion, a carbide ion or a carbonate ion?

2(a) What can you tell (in general) when the name of an ion has an –ide ending eg nitride ion?
(b) What can you tell (in general) when the name of an ion has an –ate ending eg nitrate ion?
(c) Give the names and formulas of three common non metal –ate ions

3 Give the names of the following so that the person reading the name can tell them all apart from just the name ***ie use molecule / atom / ion etc after the name*** (a) H (b) H_2 (c) H^+ (d) H^-

4 Give the names of the following so that the person reading the name can tell them all apart from just the name
(a) S^{2-} (b) S (c) SO_2 (d) S_8 e) SO_4^{2-}

5 Give the names of the following so that the person reading the name can tell them all apart from just the name
(a) Fe^{2+} (b) Fe^{3+} (c) MnO (d) MnO_2 (e) MnO_4^-

6 Give the formula of the ions present in the following dissolve **AND ALSO give the numbers of each type of ions present eg $Na_2O = 2Na^+ + O^{2-}$**

a) NaCl b) HCl c $MgBr_2$ d Al_2O_3 e LiOH f H_2SO_4 g $Ca(OH)_2$ h H_3PO_4
i) HClO j) $(NH_4)_2CO_3$ k H_2TeO_3 l $Cf_2(TeO_3)_3$ m CaC_2O_4 n $Sm_2(C_2O_4)_5$ o) Name a-l

1. **Formulae from names** : **using the periodic table write the formula for the following ions**

a oxide ion
b sodium ion
c Aluminium ion
d bromide ion
e nitride ion
f magnesium ion
g sulfide ion
h cobalt ion
i silver ion
j iron(II) ion
k iron(III) ion
l lead(IV) ion
m phosphide ion
n bismuth ion
o selenide ion
p carbide ion
q polonium ion
r hydrogen ion
s hydride ion
t copper(I) ion

2. Write the formula for the following ions

a carbonate ion
b nitrate ion
c ammonium ion
d sulphate ion
e hydroxide ion
f hydrogencarbonate ion

3.Suggest the names of the following ions

a C^{4-}
b CO_3^{2-}
c Si^{4-}
d SiO_3^{2-}
e N^{3-}
f NO_3^-
g P^{3-}
h PO_4^{3-}
i Cl^-
j ClO_3^-
k S^{2-}
l SO_4^{2-}
m Br^-
n BrO_3^-
o Se^{2-}
p SeO_4^{2-}
q I^-
r IO_3^-
s Te^{2-}
t TeO_4^{2-}
u As^{3-}

4.Suggest the names of the following

a Cl_2
b Cl
c Cl^-
d Cl^+
e ClO_3^-
f HCl(g)
g HCl(aq)
h $HClO_3$(aq)

5.Suggest the names of the following

a Br_2
b Br
c Br^-
d Br^+
e BrO_3^-
f HBr(g)
g HBr(aq)
h $HBrO_3$(aq)

5. State the two ions AND <u>The number of each type of ion</u> of the following. Note some can be worked out by knowing just the formula of one ion and by knowing that overall the compound has no charge)

EXAMPLE **answer**

$Ca(OH)_2$ **Ca^{2+} + 2 OH^-**

a NaCl
b Na_2O
c $BaBr_2$
d $Al(OH)_3$
e K_2SO_4
f $Ca(NO_3)_2$
g $MgCO_3$
h $Ga_2(CO_3)_3$
I $Pb(SO_4)_2$
j $CuCl_2$
k Fe_2O_3
l $Mg(NO_3)_2$
m $CaSO_4$
n Li_2CO_3
o NH_4Cl
p KNO_3
q NH_4NO_3
r NH_4OH
s $Mg(HCO_3)_2$
t $NaHCO_3$
u $(NH_4)_2SO_4$
v $FeCO_3$
w $Ca_3(PO_4)_2$
x K_3PO_4
y $MgSiO_3$
z $In(NO_3)_3$

EXTENSION

α $Ca(MnO_3)_2$
β Na_2CrO_4
χ $Sr(ClO_3)_2$
δ $Ga_2(SeO_3)_3$
ε $Cf(NO_3)_3$
ϕ $Au_2(CO_3)_3$
γ $(NH_4)_3PO_4$

Q6 Name 5a to γ (inclusive)

FORMULAE FROM NAMES OF IONIC COMPOUNDS (1) _____

Compound	+ve	-ve ion	FORMULA	Compound	+ve ion	-ve ion	FORMULA
Sodium chloride				Gallium hydrogencarbonate			
Barium oxide				Ammonium hydrogencarbonate			
Magnesium chloride				Potassium hydrogencarbonate			
Potassium oxide				Iron(II)hydrogencarbonate			
Copper(I) oxide				Bismuth(V)hydroxide			
Aluminium Bromide				Gold(III)oxide			
Lead(IV)fluoride				Aluminium sulphate			
Tin(IV)oxide				Silver carbonate			
Aluminium oxide				Chromium(IV)oxide			
Bismuth(V)bromide				Strontium nitrate			
Vanadium(V)oxide				Potassium phosphate			
Polonium(VI)iodide				Tin nitrate			
Polonium(VI)oxide				Ammonium sulphate			
Sodium sulphide				Calcium silicate (guess)			
Sodium sulphate				Titanium(IV) sulphate			
lithium sulphde				Ammonium carbonate			
Magnesium hydroxide				Bismuth(V) Hydrogencarbonate			
Ammonium hydroxide				thallium sulfide			
Lithium hydroxide				silver iodide			
Thallium(III)hydroxide				Iron(III)oxide			
magnesium nitride				calcium fluoride			
calcium nitrate				zinc sulphate			
Barium nitrate				Bismuth(III) astatide			
Lithium phosphide				tin(II)nitrate			
Ammonium phosphate				Antimony(V) selenide			
Aluminium phosphate				Rubidium nitride			
Sodium carbonate				potassium sulphate			
Calcium carbide				sodium ethanoate			
Strontium carbonate				Zirconium(IV) selenate (guess)			

IONIC FORMULAE 2

Compound	+ve	-ve ion	FORMULA	Compound	+ve ion	-ve ion	FORMULA
Barium sulphate				**Gallium hydrogencarbonate**			
Sodium carbonate				**Sodium oxide**			
caesium sulphide				**Lithium sulphate**			
Ammonium sulphate				**Calcium Iodide**			
Copper(I) oxide				**strontium hydroxide**			
Lithium hydrogencarbonate				**Indium oxide**			
Strontium hydroxide				**Platinum(II)chloride**			
Copper(II)carbonate				**Potassium selenide**			
Zinc hydrogen carbonate				**Rubidium sulphate**			
Aluminium nitrate				**Calcium carbonate**			
Ammonium carbonate				**Gallium nitride**			
Silver carbonate				**Aluminium hydroxide**			
Barium nitrate				**Gold nitrate**			
Aluminium fluoride				**Calcium silicate (guess)**			
Potassium sulphate				**Titanium(IV) oxide**			
Francium astatide				**Ammonium nitride**			
Magnesium hydroxide				**Bismuth(V) oxide**			
Ammonium bromide				**Gallium telluride**			
Indium carbonate				**Copper(II)hydroxide**			
Magnesium hydroxide				**Iron(III) hydrogencarbonate**			
Silver sulphate				**Lithium phosphide**			
Nickel(II) Chloride				**Cadmium Nitride**			

EXTENSION FORMULA QUESTIONS: **(1) By looking for patterns in the formulae below,** try to find a link between the: Roman Numerals, number of oxygens, overall charge on the ion and the position of the element in the periodic table for the formulas below. Suggest what the Roman Numerals may represent.

Chlorate(I) ion = ClO^- Chlorate(V) ion = ClO_3^- Bromate(I) ion = BrO^- phosphate(V) ion = PO_4^{3-}
phosphate(III) ion = PO_3^{3-} sulphate(VI) ion = SO_4^{2-} Sulphate(IV) ion = SO_3^{2-} Nitrate(V) ion = NO_3^-
Nitrate(III) ion = NO_2^- Selenate(IV) ion = SeO_3^{2-}

2. Work out the formula of the following

a) ammonium chlorate(I) b) lead(II)phosphate(V) c) tin(IV)phosphate(III)
d) Polonium sulphate(VI) e) Antinomy bromate(I) f) Ruthenium(III)chlorate(V)
g) Iridium phosphate(V) h) Bismuth Tellurate(IV) i) Gallium Iodate(V)

***FORMULAE OF COVALENT MOLECULES:** Give the formula of the following (these have to be remembered)*

Name	Formula	Name	Formula	Name	Formula
Water		Methane		Ethanoic acid	
Ammonia		Ethanol		Carbonic acid	
Glucose				Hydrogen peroxide	

(2) Formula which can be worked out just from the name and knowing number of atoms from the prefixes.....

di =	penta =	mon(o) =	tetra =	tri=	hexa =	deca =	octa =

and the valency / oxidation number : give the common valency(s) for the groups

group	1	2	3	4	5	6	7	8
Valency(s)								

Compound	V 1st	V 2nd	FORMULA	Compound	FORMULA	V 1st	V 2nd	Does the valency agree with the formula?
Hydrogen fluoride				Carbon dioxide				
Selenium bromide				Phosphorus pentachloride				
Tellurium astatide				Nitrogen trichloride				
Hydrogen sulphide				Selenium dichloride				
Boron oxide				Carbon disulphide				
Boron hydride				Arsenic trioxide				
Hydrogen telluride				Oxygen difluoride				
Boron nitride				Diphosphorus pentoxide				
Germanium hydride				Sulphur dioxide				
Germanium(IV) oxide				Diantimony pentasulfide				
Phosphorus(III) oxide				Nitrogen monoxide				
Antimony(III) oxide				Disulphur dibromide				
Silicon(IV) oxide				Dinitrogen tetroxide				
Arsenic(V) sulphide				Sulphur trioxide				
Nitrogen(I) oxide				Tetraphosphorus decaoxide				
Selenium(VI) oxide				Xenon tetroxide				

EXTENSION: By doing the *Extension Question on page 3* you may be able to work out the formulae of the following

a) Phosphoric(V)acid
b) Phosphoric(III)acid
c) Chloric(I)acid
d) Chloric(V)acid
e) selenic(IV)acid
f) Bromate(V)acid
j) nitric(III) acid
k) Astatic(VII) acid
l) Chromic(VI)acid

Section A: Checking basics needed for balanced symbol equations, sheet 1

DATE:

1. Give the formulae of the following **SCORE /15**

hydroxide ion		carbonate ion		nitric acid	
sulphate ion		Nitrate ion		Oxide ion	
Chloride ion		sulphuric acid		Zinc ion	
ammonium ion		Iron(III) ion		hydrochloric acid	
Sulphide ion		Ammonia		Silver ion	

2. State whether the following are I (ionic) C (covalent) M (metallic) Score /3 (all I = 1, all C= 1, all M = 1)

Mg(s)	NaCl(s)	CO_2(g)	Cl_2(g)	HCl(g)	$MgCl_2$(s)	H_2O(l)
Br_2(aq)	NaCl(aq)	CO_2(aq)	Cl_2(aq)	HCl(aq)	$MgCl_2$(aq)	H_2SO_4(aq)

3. A possible area of confusion when writing eqautions is knowing when to use diatomic formula - ONLY when certain elements (H,F,Br,O,N,I,Cl,At) are uncombined and when not to use this list (all other times). For the equations below:

(i) Write above the equation whether the substance is I, C or M,

(ii) Then CIRCLE all the formulae that you need to use HFBrONIClAt with

M C I

a) ~~Calcium~~ + oxygen → ~~calcium oxide~~

b) Sodium + sulphur → sodium sulphide

c) hydrogen + oxygen → water

d) Iodine(aq) + calcium → calcium iodide

e) Magnesium + hydrochloric acid(aq) → magnesium chloride + hydrogen

f) Aluminium bromide(aq) + nitrogen → aluminum nitride + bromine(aq)

g) Strontium carbonate + sulfuric acid (aq) → strontium sulfate + carbon dioxide + water

h) Chlorine + hydrogen → hydrogen chloride

i) Copper(I)oxide + nitric acid(aq) → copper(I)nitrate + water

j) Silver + chlorine → silver chloride

Section A: Checking basics needed for writing balanced symbol equations, sheet 2

DATE:

1. Give the formulae of the following **SCORE /21**

Chloride ion		Ammonia		nitric acid	
sulphate ion		Sulphide ion		Silver ion	
sulphuric acid		Zinc ion		ammonium ion	
Nitrate ion		ethanoate ion		hydrochloric acid	
carbonate ion		ethanoic acid		hydroxide ion	
Iron(III) ion		Strontium ion		Nitride ion	
Selenide ion		Iodide ion		Phosphide ion	

I/C or	Name	**If C or M**	**if Ionic**, work out ions ***then number of each needed***				
M?		formula	no	+ve ion	no	- ve ion	formula
I	Sodium oxide	**----**	**2**	**Na^+**	**1**	**O^{2-}**	**Na_2O**
C	oxygen	**O_2**	**--**	**--**	**--**	**--**	**--**
M	sodium	**Na**	**--**	**--**	**--**	**--**	**--**
I	Calcium hydroxide	**--**	**1**	**Ca^{2+}**	**2**	**OH^-**	**$Ca(OH)_2$**
	Carbon dioxide						
	Magnesium oxide						
	Iron(III) chloride						
	Chlorine						
	Barium chloride						
	Calcium carbonate						
	Sodium carbonate						
	Aluminum carbonate						
	silver sulphate						
	Iron(III) sulphate						
	Lead(IV) nitrate						
	Lead(IV) nitride						

Section A: Checking basics needed for writing balanced symbol equations, SEE PAGE 1 of notes for worked example

Step 1: Work out if *C* , *M* or *an acid* and write their formula below their name. Step 2: ***Above*** any ionic substance write the + and – ions and the number of each ion needed ; Step 3: Below write in the formula of each substance SEPARATELY – DO NOT LOOK AT ANY OTHER SUBSTANCE ; Step 4: Only balance (with big numbers in from of formula) when you have completed step 3, NOTE do not change any of the formula, you are only allowed to balance with big numbers in front

1.					
Aluminium	+ chlorine	→	Aluminium chloride		

2.					
	Calcium carbonate	→	Calcium oxide	+ carbon dioxide	

3.					
	sodium carbonate	→	Sodium oxide	+ carbon dioxide	

4.					
Magnesium	+ hydrochloric acid	→	Magnesium chloride	+ hydrogen	

5.					
Sodium hydroxide	+ nitric acid	→	Sodium nitrate	+ water	

6.					
Calcium hydroxide	+ nitric acid	→	Calcium nitrate	+ water	

7.					
Aluminium hydroxide	+ nitric acid	→	Aluminium nitrate	+ water	

8.					
Lead(IV) hydroxide	+ nitric acid	→	Lead(IV) nitrate	+ water	

9.					
potassium hydroxide	+ sulphuric acid	→	potassium sulphate	+ water	

10.					
Gallium bromide	+ oxygen	→	Gallium oxide	+ bromine	

Reaction of Acids 1 (a) Complete the word equation CHECK YOUR ANSWERS and then (b) Write balanced symbol equations

1. Magnesium + hydrochloric acid →
2. Calcium oxide + sulphuric acid →
3. sodium hydroxide + nitric acid →
4. Magnesium carbonate + hydrochloric acid →
5. sodium hydrogencarbonate + sulphuric acid →
6. silver oxide + hydrochloric acid →
7. Lithium + sulphuric acid →
8. Calcium hydroxide + nitric acid →
9. potassium carbonate + hydrochloric acid →
10. Barium hydrogencarbonate + nitric acid →
11. sulphuric acid + barium oxide →
12. Gallium hydroxide + ethanoic acid →

Reaction of Acids 2 (a) Complete the word equation CHECK YOUR ANSWERS and then (b) Write balanced symbol equations

1a. …….. + …….. → Aluminum sulphate + water
1b. …….. + …….. → Aluminum sulphate + water
2a. …….. + …… → lead(IV)nitrate + carbon dioxide + water
2b. …….. + …… → lead(IV)nitrate + carbon dioxide + water
3. …… + magnesium → magnesium chloride + ……
4. …….. + sulphuric acid → ammonium sulphate + water
5. …… + nitric acid → ammonium nitrate
6. copper(II) hydroxide + hydrobromic acid →
7. calcium hydrogencarbonate + phosphoric acid →
8. Vandium(V)oxide + …… → vanadium(V)iodide + ……
9. ammonia + hydrochloric acid →
10. strontium + …… → strontium nitrate + ……

Reaction of Acids 3 (a) Complete the word equation CHECK YOUR ANSWERS and then (b) Write balanced symbol equations

1. Tin(II) hydroxide + hydrochloric acid →
2. Bismuth + nitric acid →
3. Iron(III)carbonate + sulphuric acid →
4. ammonium hydrogencarbonate + ethanoic acid →
5. Copper(II)oxide + nitric acid →
6. silver carbonate + phosphoric acid→
7. ammonia + sulfuric acid →
8. Calcium hydroxide + sulphuric acid →
9. Caesium carbonate + hydroiodic acid →
10. Polonium(VI) hydrogencarbonate + ethanoic acid →
11 . …….. + …… → Antimony(V)sulphate + hydrogen
12. …… + …….. → Thallium Chlorate + water

Reaction of Acids 4

1.. …… + …….. → Indium nitrite + carbon dioxide + water
2. Rubidium oxide + hydrochloric acid →
3. …… + …….. → ammonium phosphate
4. titanium + sulphuric acid → (assume Ti(IV) ions formed)
5. silver oxide + phosphoric acid →
6. …… + …….. → Aluminium bromide + hydrogen
7. Gallium hydrogencarbonate + nitric acid →
8. Antimony(V)oxide + nitric acid →
9. ammonia + phosphoric acid →
10. …… + …….. → Lead(IV) bromate + water
11. …….. + …… → Antimony(III) sulphate + hydrogen
12. …… + …….. → Polonium(VI) selenate + carbon dioxide + water

WRITE BALANCED SYMBOL EQUATIONS FOR THE FOLLOWING

SECTION A : remember HF BrONIClAt

1 Calcium + oxygen → calcium oxide
2 Sodium + sulphur → sodium sulphide
3 hydrogen + oxygen → water
4 Iodine + calcium → calcium iodide
5 Magnesium + hydrochloric acid → magnesium chloride + hydrogen
6 Aluminium + bromine → aluminum bromide
7 Strontium carbonate + sulfuric acid → strontium sulfate + carbon dioxide + water
8 Chlorine + hydrogen → hydrogen chloride
9 Copper(I)oxide + nitric acid → copper(I)nitrate + water
10 Silver + oxygen → silver oxide
11 Tin + oxygen → Tin(IV) oxide
12 Sodium + water → sodium hydroxide + hydrogen
13 Calcium hydroxide + hydrochloric acid → calcium chloride + water
14 Magnesium + water → magnesium hydroxide + hydrogen
15 Barium nitrate → barium oxide + nitrogen dioxide + oxygen

SECTION B Formation of oxides

a copper + oxygen → copper(II)oxide
b copper + oxygen → copper(I)oxide
c nitrogen + oxygen → nitrogen monoxide
d nitrogen monoxide + oxygen → nitrogen dioxide
e methane + oxygen → carbon monoxide + water
f phopshorus (P_4)+ oxygen → tetraphosphorus hexoxide
g magnesium carbonate → magnesium oxide + carbon dioxide
h calcium hydroxide → calcium oxide + water
I Calcium nitrate → calcium oxide + nitrogen dioxide + oxygen
j aluminium carbonate → aluminium oxide + carbon dioxide
k Lithium nitrate → lithium oxide + nitrogen dioxide + oxygen

SECTION C displacement

a) sodium oxide + potassium → potassium oxide + sodium
b) Lithium + strontium oxide → lithium oxide + strontium
c) Zinc oxide + carbon monoxide → carbon dioxide + zinc
d) Copper(II) sulphate + magnesium → magnesium sulphate + copper
e) Aluminium chloride + lithium → lithium chloride + aluminium
f) copper(II)nitrate + Gallium → Gallium nitrate + copper
g) chlorine + sodium bromide → sodium bromide + chlorine
h) Thallium iodide + bromine → thallium bromide + iodine
i) phosphorus(III) fluoride + nitrogen → phosphorus + nitrogen fluoride

SECTION D: Reaction of Oxides

(a) Lithium oxide + water → lithium hydroxide
(b) Calcium hydroxide + carbon dioxide → calcium carbonate + water
(c) sulphur trioxide + water → sulphuric acid
(d) Sulphuric acid + sodium oxide → sodium sulphate + water
(e) magnesium oxide + Hydrochloric acid → magnesium chloride + water
(f) Sulphur trioxide + Calcium oxide → calcium sulphate
(g) Aluminium oxide + water → Aluminium hydroxide
(h) carbon dioxide + water → carbonic acid
(i) Strontium hydroxide + nitric acid → strontium nitrate + water
(I) Sulphuric acid + Gold(I) oxide → Gold(I) sulphate + water
(m) Potassium hydroxide + carbon dioxide → potassium carbonate + water
(n) Lead(II)oxide + Nitrogen dioxide + oxygen → Lead(II) nitrate
(o) Hydrochloric acid + Aluminium oxide → aluminium chloride + water
(p) Gallium hydroxide + nitric acid → Gallium nitrate + water
EXTENSION (r) Tin(IV)oxide + phosphoric acid → Tin(IV)phosphate + water
EXTENISON (q) Silicon dioxide + Thallium(III) oxide → Thallium(III) silicate

SECTION E Miscellaneous 1

a Aluminium hydroxide → aluminium oxide + water
b Lithium nitrate → lithium oxide + nitrogen dioxide + oxygen
c Potassium nitrate → Potassium nitrite + oxygen **(look up nitrite ion)**
d Propane (C_3H_8) + oxygen → carbon dioxide + water
e Pentanol ($C_5H_{11}OH$) + oxygen → carbon dioxide + water
f Copper(II) nitride + oxygen → Copper(II) oxide + nitrogen monoxide + nitrogen dioxide
g Ammonia + oxygen → nitrogen monoxide + water
h Bismuth(V) oxide + Phopshoric acid → Bismuth(V) phosphate + water **(look up sulphurous acid and sulphite ion)**
I Thallium(III) hydrogencarbonate + sulphurous acid → Thallium(III) sulphite + water + carbon dioxide
j Lead(IV)oxide + sulphurous acid → Lead(IV) sulphite + water
k Polonium hydroxide + ammonium sulfate → polonium sulfate + ammonia + water
l zinc + nitric acid → zinc(II)nitrate + nitrogen dioxide + water
m Iron(III)oxide + carbon monoxide → iron + carbon dioxide
n gallium hydrogencarbonate + chloric acid → gallium chlorate + water + carbo

SECTION F Miscellaneous 2

1 Thallium(III)sulphite + magnesium → thallium + magnesium sulphite (look up sulphite ion)
2 Barium + nitrogen → barium nitride
3 Iron(III)sulphate → Iron(III)oxide + sulphur trioxide
4 Lithium nitrate → lithium oxide + nitrogen dioxide + oxygen
5 alumium oxide + sodium hydroxide → sodium aluminate + water (look up aluminate ion)
6 ammoniumcarbonate + nitrous acid → ammonium nitrite + carbon dioxide + water (look up nitrous acid/nitrite ion)
7 gallium sulphide + hydrobromic acid → gallium bromide + hydrogen sulphide
8 calcium hydroxide + phosphoric acid → calcium phosphate + water
9 gallium hydrogencarbonate + chloric(V) acid → gallium chlorate(V) + water + carbon dioxide
10 Lead(IV)oxide + sulphurous acid → Lead(IV)sulphite + water (look up sulphurous acid and sulphite ion)
11 Bismuth(V)hydroxide + ammonium sulfate → bismuth(V)sulfate + ammonia + water
12 Zinc oxide + Aluminum hydroxide → aluminium zincate + water (look up zincate ion)

SECTION G : From the following, write the word equation and then the full balanced equation

1 aluminium + iodine
2 potassium hydroxide + sulphuric acid
3 lithium + oxygen
4 lead(II) oxide with nitric acid
5 polonium + nitrogen
6 ammonium carbonate + hydrochloric acid
7 water + sodium
8 Iron(II)hydrogencarbonate + phosphoric acid
9 calcium + water
10 Gallium + chloric acid
11 carbon dioxide + sodium hydroxide
12 Thermal decomposition of aluminium nitrate
13 complete combustion of CH_3SH
14 silicon oxide + sodium oxide →
15 gallium + hydroiodic acid
16 carbon dioxide + aluminium oxide → ONE PRODUCT
17. sulphur trioxide + copper oxide → ONE PRODUCT
18 magnesium hydroxide + aluminium oxide → magnesium aluminate + water
19. nitrogen dioxide + oxygen + barium oxide → ONE PRODUCT
20 carbon dioxide + sodium oxide → ONE PRODUCT
21. phosphorous trioxide + calcium oxide + oxygen
22. Incomplete combustion of dodecane
23. Comubstion of ammonia
24. Formation of phosphorus pentachloride from its elements
25. Formation of dichlorine heptaoxide from

ANSWERS

BALANCING EQUATIONS *1*

A	PbO_2	no. of Pb =1	no. of O = 2		
b	$Al(NO_3)_3$	no. of Al =1	no. of O =9	no. of N =3	
c	$Bi_2(SeO_3)_5$	no. of Bi =2	no. of O =15	no. of Se =5	
d	$2\ Li_2S$	no. of Li = 4	no of S = 2		
e	$3H_2SO_4$	no. of H = 6	no. of O = 12	no. of S =3	
f	$2(NH_4)_3AsO_4$	no. of H =24	no. of O =8	no. of As = 2	No of N = 6

2. Balance the following equations. **1/2s are ok for diatomics eg 3.5 O_2 is fine as it leads to a whole number of atoms, cant do 1/2s for eg CO_2 as give ½ a C atom**

A		H_2	+	Cl_2	→	$2HCl$				
B		$2Ba$	+	O_2	→		$2BaO$			
C		$2HCl$	+	Mg	→	$MgCl_2$	+	H_2		
D		$2K$	+	$2H_2O$	→	$2KOH$	+	H_2		
E		$Mg(OH)_2$	+	$2HNO_3$	→	$Mg(NO_3)_2$	+	$2H_2O$		
F		H_2SO_4	+	$2Na$	→	Na_2SO_4	+	H_2		
G		$4In$	+	$3O_2$	→	$2In_2O_3$				
H	$PbCO_3$	+	$2HCl$	→	$PbCl_2$	+	CO_2	+	H_2O	
I		$Ca(OH)_2$	+	H_2SeO_4	→	$CaSeO_4$	+	$2H_2O$		
J		$2Na$	+	$2HCl$	→	$2NaCl$	+	H_2		
K		$2LiOH$	+	H_2SO_4	→	Li_2SO_4	+	$2H_2O$		
L	$CaCO_3$	+	$2HNO_3$	→	$Ca(NO_3)_2$	+	CO_2	+	H_2O	
M		$2NH_4OH$	+	H_2SeO_4	→	$(NH_4)_2SeO_4$	+	$2H_2O$		
N	$Ba(HCO_3)_2$	+ $2HNO_3$	→	$Ba(NO_3)_2$	+	$2CO_2$	+	$2H_2O$		
O		$2Al$	+	$6HNO_3$	→	$2Al(NO_3)_3$	+	$3H_2$		
P		$2C_2H_6$	+	$5O_2$	→	$4CO$	+	$6H_2O$		
Q	$In_2(CO_3)_3$	+ $6HCl$	→	$2InCl_3$	+	$3H_2O$	+	$3CO_2$		
R		Ru_2O_3	+	$3CO$	→	$2Ru$	+	$3CO_2$		
S		Ga_2S_3	+	$6HNO_3$	→	$2Ga(NO_3)_3$	+	$3H_2S$		
T	$2H_3PO_4$ +	$3Cu(HCO_3)_2$	→	$Cu_3(PO_4)_2$	+	$6CO_2$	+	$6H_2O$		
U		$2C_4H_{10}$	+	$13O_2$	→	$8CO_2$	+	$10H_2O$		
V		$2RbOH$	+	H_2TeO_4	→	Rb_2TeO_4	+	$2H_2O$		
W		$2CH_3OH$	+	$3O_2$	→	$2CO_2$	+	$4H_2O$		
X		$3NH_3$	+	H_3PO_4	→		$(NH_4)_3PO_4$			
Y		$2Cu(NO_3)_2$		→	$2CuO$	+	$4NO_2$	+	O_2	
Z		$2C_5H_{11}OH$	+	$15O_2$	→	$10CO_2$	+	$12H_2O$		
(1)		$2C_{18}H_{38}$	+	$55O_2$	→	$36CO_2$	+	$38H_2O$		
(2)		$4NH_3$	+	$5O_2$	→	$4NO$	+	$6H_2O$		
(3)	$4HNO_3$	+ Cu	→	$Cu(NO_3)_2$	+	$2NO_2$	+	$2H2O$		

BALANCING EQUATION QUESTIONS 2

1 State the number of each type of atom in the following. Where the formula has a balancing number, take the balancing number into account when working out the number of each type of atom.

a	Ga_2O_3	no. of Ga = 2	no. of O = 3	
b	HNO_3	no. of H = 1	no of N = 1	no. of O =3
c	$Al_2(SO_4)_3$	no. of S = 3	no of O = 12	no. of Al = 2
d	$2MgCl_2$	no. of Mg = 2	no of Cl = 4	
e	$3Ca(NO_3)_2$	no. of O = 18	no of Ca = 3	no. of N = 6

2. Balance the following equations

A	H_2	+	Br_2	→	**2**HBr					
B	Cu	+	**0.5**O_2	→	CuO					
C	Na	+	H_2O	→	NaOH	+	**0.5**H_2			
D	$Mg(OH)_2$	+	**2**HNO_3	→	$Mg(NO_3)_2$	+	**2**H_2O			
E	**2**Li	+	**0.5**O_2	→	Li_2O					
F	**2**Al	+	**1.5**O_2	→	Al_2O_3					
G	**2**KOH	+	H_2SO_4	→	K_2SO_4	+	**2**H_2O			
H	$CaCO_3$	+	**2**HCl	→	$CaCl_2$	+	CO_2	+	H_2O	
I	C_2H_6	+	**3.5**O_2	→	**2**CO_2	+	**3**H_2O			
J		$Cu(NO_3)_2$		→	CuO	+	**2**NO_2	+	**0.5**O_2	
K	$Ca(HCO_3)_2$	+	**2**HNO_3	→	$Ca(NO_3)_2$	+	**2**CO_2	+	$2H_2O$	
L	C_3H_7OH	+	**4.5**O_2	→	**3**CO_2	+	**4**H_2O			
M	**2**NH_4OH	+	H_2SO_4	→	$(NH_4)_2SO_4$	+	**2**H_2O			
N	CH_4	+	**1.5**O_2	→	CO	+	**2**H_2O			
O	Ru_2O_3	+	**3**CO	→	**2**Ru	+	**3**CO_2			
P	Ga_2S_3	+	**6**HNO_3	→	**2**$Ga(NO_3)_3$	+	**3**H_2S			
Q	**2**H_3PO_4	+	**3**$Cu(HCO_3)_2$	→	$Cu_3(PO_4)_2$	+	**6**CO_2	+	**6**H_2O	

Balancing Equations Extension

Extension 1 **3**Br_2 + **6**KOH → $KBrO_3$ + **5**KBr + **3**H_2O

Extension 2 C_2H_5OH + $Na_2Cr_2O_7$ + H_2SeO_4 → CH_3COOH + $Cr_2(SeO_4)_3$ + H_2O + Na_2SeO_4

Extension 3 V + $HClS_3$ → V_2S_5 + ClS_2 + H_2S

Extension 4 HNO_3 + Cu → $Cu(NO_3)_2$ + NO + H_2O

Recognising atoms, silielements, molecules, compounds, ions – Page 4

1a. Molecule- made up of 2 or more atoms covalently bonded together

b. Compound- substance made up of 2 or more different types of atoms chemically bonded together

2a. Br_2 CO O_2

b. $MgBr_2$ CO CaO

c. Br_2 O_2

3a. I_3

b. CO_2 PBr_5

c. InF_3 Sb_2S_5 [ionic compounds are not, overall, classed as molecules, though can contain molecular ions eg NH_4NO_3]

4a. Mn^{2+} Cl^- CO_3^{2-} MnO_4^-

b. CO_2 CO_3^{2-} MnO_4^-

c. CO_3^{2-} MnO_4^-

d. CO_3^{2-} [+MnO_4^- A level]

Section B Symbols, Formulae and names

1a. oxide ion
b. calcium ion
c. silicide ion
d. carbonate ion

2a. has the general formula X^{n-} where X = non-metal ion (usually exception OH^-)
b. has the general formula XO_y^{n-}
c) It's has positive charge and usual a metal ion
d. e.g. Nitrate ion - NO_3^- , Carbonate ion- CO_3^{2-} , Sulfate ion- SO_4^{2-} [A level Manganate ion MnO_3^-]

3a. hydrogen atom
b. hydrogen molecule
c. hydrogen ion
d. hydride ion

4a. sulfide ion
b. sulfur atom
c. sulfur ion
d. sulfur molecule
e. sulfur dioxide
f. sulfate ion

5a. Iron(II) ion
b. Iron(III) ion
c. Manganese(II)oxide or Manganese oxide
d. Manganese dioxide or Manganese(IV)oxide
e. Manganate ion or Manganate(V) ion

6a. $Na^+ + Cl^-$
b. $H^+ + Cl^-$
c. $Mg^{2+} + 2Br^-$
d. $2Al^{3+} + 3O^{2-}$
e. $Li^+ + OH^-$
f. $2H^+ + SO_4^{2-}$
g. $Ca^{2+} + 2OH^-$
h. $3H^+ + PO_4^{3-}$
i. $H^+ + ClO_3^-$
j. $2NH_4 + CO_3^{2-}$
k. $2H^+ + TeO_4^{2-}$
l. $2Cf^{3+} + 3TeO_4^{2-}$
m. $Ca^{2+} + C_2O_4^{2-}$
n. $2Sm^{5+} + 5C_2O_4^{2-}$
o. a) sodium chloride
b) hydrogen chloride
c) magnesium bromide
d) aluminium oxide
e) lithium hydroxide
f) sulfuric acid
g) calcium hydroxide
h) phosphoric acid
i) chloric acid
j) ammonium carbonate
k) telluric acid
l) californium(III) tellurate

1. **Formulae from names : using the periodic table write the formula for the following ions**

a oxide ion **O^{2-}** b sodium ion **Na^{+}**
c Aluminium ion **Al^{3+}** d bromide ion **Br^{-}**
e nitride ion **N^{3-}** f magnesium ion **Mg^{2+}**
g sulfide ion **S^{2-}** h cobalt ion **Co^{2+}**
i silver ion **Ag^{+}** j iron(II) ion **Fe^{2+}**
k iron(III) ion **Fe^{3+}** l lead(IV) ion **Pb_4^{+}**
m phosphide ion **P^{3-}** n bismuth ion **Bi^{3+}**
o selenide ion **Se^{2-}** p carbide ion **C^{4-}**
q polonium ion **Po^{6+}** r hydrogen ion **H^{+}**
s hydride ion **H^{-}** t copper(I) ion **Cu^{+}**

2. Write the formula for the following ions

a carbonate ion **CO_3^{2-}** b nitrate ion **NO_3^{-}**
c ammonium ion **NH_4^{+}** d sulphate ion **SO_4^{2-}**
e hydroxide ion **OH^{-}**
f hydrogencarbonate ion **HCO_3^{-}**

3.Suggest the names of the following ions

a C^{4-} **Carbide ion** b CO_3^{2-} **Carbonate ion**
c Si^{4-} **Silicide ion** d SiO_3^{2-} **Silicate ion**
e N^{3-} **Nitride ion** f NO_3^{-} **Nitrate ion**
g P^{3-} **Phosphide ion** h PO_4^{3-} **Phosphate ion**
i Cl^{-} **Chloride ion** j ClO_3^{-} **Chlorate ion**
k S^{2-} **Sulfide ion** l SO_4^{2-} **Sulphate ion**
m Br^{-} **Bromide ion** n BrO_3^{-} **Bromate ion**
o Se^{2-} **Selenide ion** p SeO_4^{2-} **Selenate ion**
q I^{-} **Iodide ion** r IO_3^{-} **Iodate ion**
s Te^{2-} **Telluride ion** t TeO_4^{2-} **Tellurate ion**
u As^{3-} **Arsenide ion**

Question 4

a) Chlorine molecule
b) Chlorine atom
c) Chloride ion
d) Chlorine ion
e) Chlorate ion
f) Hydrogen chloride
g) Hydrochloric acid
h) Chloric acid

Question 5

i) Bromine molecule
j) Bromine atom
k) Bromide ion
l) Bromine ion
m) Bromate ion
n) Hydrogen bromide
o) Hydrobromic acid
p) Bromic acid

Question 5

a) $Na^{+} + Cl^{-}$
b) $2Na^{+} + O^{2-}$
c) $Ba^{2+} + 2Br^{-}$
d) $Al^{3+} + 3OH^{-}$
e) $2K^{+} + SO_4^{2-}$
f) $Ca^{2+} + 2NO_3^{-}$
g) $Mg^{2+} + CO_3^{2-}$
h) $2Ga^{3+} + 3CO_3^{2-}$
i) $Pb^{4+} + 2SO_4^{2-}$
j) $Cu^{2+} + 2Cl^{-}$
k) $2Fe^{3+} + 3O^{2-}$
l) $Mg^{2+} + 2NO_3^{-}$
m) $Ca^{2+} + SO_4^{2-}$
n) $2Li^{+} + CO_3^{2-}$
o) $NH_4^{+} + Cl^{-}$
p) $K^{+} + NO_3^{-}$
q) $NH_4^{+} + NO_3^{-}$
r) $NH_4^{+} + OH^{-}$
s) $Mg^{2+} + 2HCO_3^{-}$
t) $Na^{+} + HCO_3^{-}$
u) $2NH_4^{+} + SO_4^{2-}$
v) $Fe^{2+} + CO_3^{2-}$
w) $3Ca^{2+} + 2PO_4^{3-}$
x) $3K^{+} + PO_4^{3-}$
y) $Mg^{2+} + SiO_3^{2-}$
z) $In^{3+} + 3NO_3^{-}$
α) $Ca^{2+} + 2MnO_3^{-}$
β) $2Na^{+} + CrO_4^{2-}$
χ) $Sr^{2+} + 2ClO_3^{-}$
ε) $Cf^{3+} + NO_3^{-}$
φ) $2Au^{3+} + 3CO_3^{2-}$
γ) $3NH_4^{+} + PO_4^{3-}$

Question 6

a) Sodium chloride
b) Sodium oxide
c) Barium bromide
d) Aluminium hydroxide
e) Potassium sulphate
f) Calcium nitrate
g) Magnesium carbonate
h) Gallium carbonate
i) Lead(IV) sulphate
j) Copper(II) chloride
k) Iron (III) oxide
l) Magnesium nitrate
m) Calcium sulphate
n) Lithium carbonate
o) Ammonium chloride
p) Potassium nitrate
q) Ammonium nitrate
r) Ammonium hydroxide
s) Magnesium hydrogen carbonate
t) Sodium hydrogen carbonate
u) Ammonium sulphate
v) Iron(II) carbonate
w) Calcium phosphate
x) Potassium phosphate
y) Magnesium silicate
z) Indium nitrate
α) Calcium manganate
β) Sodium chromate
χ) Strontium chlorate
ε) Californium(III) nitrate
φ) Gold (III) carbonate
γ) Ammonium phosphate

FORMULAE FROM NAMES OF IONIC COMPOUNDS (1)

Compound	+ve	-ve ion	FORMULA	Compound	+ve ion	-ve ion	FORMULA
Sodium chloride	Na^+	Cl^-	$NaCl$	Gallium hydrogencarbonate	Ga^{3+}	$3HCO_3^-$	$Ga(HCO_3)_3$
Barium oxide	Ba^{2+}	O^{2-}	BaO	Ammonium hydrogencarbonate	NH_4^+	HCO_3^-	NH_4HCO_3
Magnesium chloride	Mg^{2+}	$2Cl^-$	$MgCl_2$	Potassium hydrogencarbonate	K^+	HCO_3^-	$KHCO_3$
Potassium oxide	$2K^+$	O^{2-}	K_2O	Iron(II)hydrogencarbonate	Fe^{2+}	$2HCO_3^-$	$Fe(HCO_3)_2$
Copper(I) oxide	$2Cu^+$	O^{2-}	Cu_2O	Bismuth(V)hydroxide	Bi^{5+}	$5OH^-$	$Bi(OH)_5$
Aluminium Bromide	Al^{3+}	$3Br^-$	$AlBr_3$	Gold(III)oxide	$2Au^{3+}$	$3O^{2-}$	Au_2O_3
Lead(IV)fluoride	Pb^{4+}	$4F^-$	PbF_4	Aluminium sulphate	$2Al^{3+}$	$3SO_4^{2-}$	$Al_2(SO_4)_3$
Tin(IV)oxide	Sn^{4+}	$2O^{2-}$	SbO_2	Silver carbonate	$2Ag^+$	CO_3^{2-}	Ag_2CO_3
Aluminium oxide	$2Al^{3+}$	$3O^{2-}$	Al_2O_3	Chromium(IV)oxide	Cr^{4+}	$2O^{2-}$	CrO_2
Bismuth(V)bromide	Bi^{5+}	$5Br^-$	$BiBr_5$	Strontium nitrate	Sr^{2+}	$2NO_3^-$	$Sr(NO_3)_2$
Vanadium(V)oxide	$2V^{5+}$	$5O^{2-}$	V_2O_5	Potassium phosphate	$3K^+$	PO_4^{3-}	K_3PO_4
Polonium(VI)iodide	Po^{6+}	$6I^-$	PoI_6	Tin (II) nitrate	Sn^{2+}	$2NO_3^-$	$Sn(NO_3)_2$
Polonium(VI)oxide	Po^{6+}	$3O^{2-}$	PoO_3	Ammonium sulphate	$2NH_4^+$	SO_4^{2+}	$(NH_4)_2SO_4$
Sodium sulphide	$2Na^+$	S^{2-}	Na_2S	Calcium silicate (guess) *Silicon in same Gp as C*	Ca^{2+}	SiO_3^{2-}	$CaSiO_3$
Sodium sulphate	Na^+	SO_4^{2-}	Na_2SO_4	Titanium(IV) sulphate	Ti^{4+}	$2SO_4^{2-}$	$Ti(SO_4)_2$
lithium sulphide	Li^+	S^{2-}	Li_2S	Ammonium carbonate	NH_4^+	CO_3^{2-}	$(NH_4)_2CO_3$
Magnesium hydroxide	Mg^{2+}	OH^-	$Mg(OH)_2$	Bismuth(V) Hydrogencarbonate	Bi^{5+}	HCO_3^-	$Bi(HCO_3)_5$
Ammonium hydroxide	NH_4^+	OH^-	NH_4OH	thallium sulfide	$2Tl^{3+}$	$3S^{2-}$	Tl_2S_3
Lithium hydroxide	Li^+	OH^-	$LiOH$	silver iodide	Ag^+	I^-	AgI
Thallium(III)hydroxide	Tl^{3+}	$3OH^-$	$Tl(OH)_3$	Iron(III)oxide	$2Fe^{3+}$	$3O^{2-}$	Fe_2O_3
magnesium nitride	Mg^{2+}	$2N^{3-}$	Mg_3N_2	calcium fluoride	Ca^{2+}	$2F^-$	CaF_2
calcium nitrate	Ca^{2+}	$2NO_3^-$	$Ca(NO_3)_2$	zinc sulphate	Zn^{2+}	SO_4^{2-}	$ZnSO_4$
Barium nitrate	Ba^{2+}	$2NO_3^-$	$Ba(NO_3)_2$	Bismuth(III) astatide	Bi^{3+}	$3At^-$	$BiAt_3$
Lithium phosphide	$3Li^+$	P^{3-}	Li_3P	tin(II)nitrate	Sn^{2+}	$2NO_3^-$	$Sn(NO_3)_2$
Ammonium phosphate	$3NH_4^+$	PO_4^{3-}	$(NH_4)_3PO_4$	Antimony(V) selenide	$2Sb^{5+}$	$5Se^{2-}$	Sb_2Se_5
Aluminium phosphate	Al^{3+}	PO_4^{3-}	$AlPO_4$	Rubidium nitride	$3Rb^+$	N^{3-}	Rb_3N
Sodium carbonate	$2Na^+$	CO_3^{2-}	Na_2CO_3	potassium sulphate	$2K^+$	SO_4^{2-}	K_2SO_4
Calcium carbide	$2Ca^{2+}$	C^{4-}	Ca_2C	sodium ethanoate	Na^+	CH_3COO^-	CH_3COONa
Strontium carbonate	Sr^{2+}	CO_3^{2-}	$SrCO_3$	Zirconium(IV) selenate *Se in same group as S*	Zr^{4+}	$2SeO_4^{2-}$	$Zr(SeO_4)_2$

IONIC FORMULAE 2

Compound	+ve	-ve ion	FORMULA	Compound	+ve ion	-ve ion	FORMULA
Barium sulphate	Ba^{2+}	SO_4^{2-}	$BaSO_4$	Gallium hydrogencarbonate	Ga^{3+}	HCO_3^-	$Ga(HCO_3)_3$
Sodium carbonate	Na^+	CO_3^{2-}	Na_2CO_3	Sodium oxide	Na^+	O^{2-}	Na_2O
caesium sulphide	Cs^+	S^{2-}	Cs_2S	Lithium sulphate	Li^+	SO_4^{2-}	Li_2SO_4
Ammonium sulphate	NH_4^+	SO_4^{2-}	$(NH_4)_2SO_4$	Calcium Iodide	Ca^{2+}	I^-	CaI_2
Copper(I) oxide	Cu^+	O^{2-}	Cu_2O	strontium hydroxide	Sr^{2+}	OH^-	$Sr(OH)_2$
Lithium hydrogencarbonate	Li^+	HCO_3^-	$LiHCO_3$	Indium oxide	In^{3+}	O^{2-}	In_2O_3
Strontium hydroxide	Sr^{2+}	OH^-	$Sr(OH)_2$	Platinum(II)chloride	Pt^{2+}	Cl^-	$PtCl_2$
Copper(II)carbonate	Cu^{2+}	CO_3^{2-}	$CuCO_3$	Potassium selenide	K^+	Se^{2-}	K_2Se
Zinc hydrogen carbonate	Zn^{2+}	HCO_3^-	$Zn(HCO_3)_2$	Rubidium sulphate	Rb^+	SO_4^{2-}	Rb_2SO_4
Aluminium nitrate	Al^{3+}	NO_3^-	$Al(NO_3)_3$	Calcium carbonate	Ca^{2+}	CO_3^{2-}	$CaCO_3$
Ammonium carbonate	NH_4^+	CO_3^{2-}	$(NH_4)_2CO_3$	Gallium nitride	Ga^{3+}	N^{3-}	GaN
Silver carbonate	Ag^+	CO_3^{2-}	Ag_2CO_3	Aluminium hydroxide	Al^{3+}	OH^-	$Al(OH)_3$
Barium nitrate	Ba^{2+}	NO_3^-	$Ba(NO_3)_2$	Gold nitrate	Au^+	NO_3^-	$AuNO_3$
Aluminium fluoride	Al^{3+}	F^-	AlF_3	Calcium silicate (guess)	Ca^{2+}	SiO_4^-	$Ca(SiO_4)_2$
Potassium sulphate	K^+	SO_4^{2-}	K_2SO_4	Titanium(IV) oxide	Ti^{4+}	O^{2-}	TiO_2
Francium astatide	Fr^+	At^-	$FrAt$	Ammonium nitride	NH_4^+	N^{3-}	$(NH_4)_3N$
Magnesium hydroxide	Mg^{2+}	OH^-	$Mg(OH)_2$	Bismuth(V) oxide	Bi^{5+}	O^{2-}	Bi_2O_5
Ammonium bromide	NH_4^+	Br^-	NH_4Br	Gallium telluride	Ga^{3+}	Te^{2-}	Ga_2Te_3
Indium carbonate	In^{3+}	CO_3^{2-}	$In_2(CO_3)_3$	Copper(II)hydroxide	Cu^{2+}	OH^-	$Cu(OH)_2$
Magnesium hydroxide	Mg^{2+}	OH^-	$Mg(OH)_2$	Iron(III) hydrogencarbonate	Fe^{3+}	HCO_3^-	$Fe(HCO_3)_3$
Silver sulphate	Ag^+	SO_4^{2-}	Ag_2SO_4	Lithium phosphide	Li^+	P^{3-}	Li_3P
Nickel(II) Chloride	Ni^{2+}	Cl^-	$NiCl_2$	Cadmium Nitride	Cd^{2+}	N^{3-}	Cd_3N_2

1. If you take the O as -2, then the Roman numerals represent as assigned charge of the other element. In compound ions the individual element are not preent as ions, oxidation numbers are used to represent the formal charge, to distinguish oxidation numbers form ions the + or – must be before the number eg SO_4^{2-} : S = +6, each O = -2, +6 +(4 x -2) = charge on the compound ion

a NH_4ClO_3 b. $Pb_3(PO_4)_2$ c. $Sn_3(PO_3)_4$ d. $PoSO_4$
e. $Sb(BrO)_3$ f. $Ru(ClO_3)_3$ g. $Ir_3(PO_4)_4$ h. $Bi_2(TeO_3)_3$ i. $Ga(IO_3)_3$

***FORMULAE OF COVALENT MOLECULES:** Give the formula of the following (these have to be remembered)*

Name	Formula	Name	Formula	Name	Formula
Water	H_2O	Methane	CH_4	Ethanoic acid	CH_3COOH
Ammonia	NH_3	Ethanol	C_2H_5OH	Carbonic acid	H_2CO_3
Glucose	$C_6H_{12}O_6$			Hydrogen peroxide	H_2O_2

(2) Formula which can be worked out just from the name and knowing number of atoms from the prefixes.....

di = 2	penta = 5	mon(o) = 1	tetra = 4	tri= 3	hexa = 6	deca = 10	octa = 8

and the valency / oxidation number : give the common valency(s) for the groups

group	1	2	3	4	5	6	7	8
Valency(s)	**1**	**2**	**3**	**4**	**3**	**2**	**1**	**0**

Compound	V 1st	V 2nd	FORMULA	Compound	FORMULA	V 1st	V 2nd	Does the valency agree with the formula?
Hydrogen fluoride	1	1	HF	Carbon dioxide	CO_2	4	2	Yes
Selenium bromide	2	1	$SeBr_2$	Phosphorus pentachloride	PCl_5	3	1	NO
Tellurium astatide	3	1	$TlAt_3$	Nitrogen trichloride	NCl_3	3	1	Yes
Hydrogen sulphide	1	2	H_2S	Selenium dichloride	$SeCl_2$	2	1	Yes
Boron oxide	3	2	B_2O_3	Carbon disulphide	CS_2	4	2	Yes
Boron hydride	3	1	BH_3	Arsenic trioxide	AsO_3	3	2	No
Hydrogen telluride	1	2	TeH_2	Oxygen difluoride	OF_2	2	1	Yes
Boron nitride	2	3	B_3N_2	Diphosphorus pentoxide	P_2O_5	3	2	No
Germanium hydride	4	1	GeH_4	Sulphur dioxide	SO_2	2	2	No
Germanium(IV) oxide	4	2	GeO_2	Diantimony pentasulfide	Sb_2S_5	3	2	No
Phosphorus(III) oxide	3	2	P_2O_3	Nitrogen monoxide	NO	3	2	No
Antimony(III) oxide	3	2	Sb_2O_3	Disulphur dibromide	S_2Br_2	2	1	No
Silicon(IV) oxide	4	2	SiO_2	Dinitrogen tetroxide	N_2O_3	3	2	Yes
Arsenic(V) sulphide	3	2	As_2S_3	Sulphur trioxide	SO_3	2	2	No
Nitrogen(I) oxide	1	2	N_2O	Tetraphosphorus decaoxide	P_4O_{10}	3	2	No
Selenium(VI) oxide	6	2	$_3SeO_3$	Xenon tetroxide	XeO_4	0	2	No

EXTENSION: By doing the *Extension Question on page 3* you may be able to work out the formulae of the following

a) Phosphoric(V)acid H_3PO_4
b) Phosphoric(III)acid H_3PO_3
c) Chloric(I)acid HClO
d) Chloric(V)acid $HClO_3$
e) selenic(IV)acid H_2SeO_3
f) Bromate(V)acid $HBrO_3$
j) nitric(III) acid HNO_3
k) Astatic(VII) acid $HAtO_3$
l) Chromic(VI)acid H_2CrO_4

Section A: Checking basics needed for balanced symbol equations, sheet 1

1. Give the formulae of the following **SCORE /15**

hydroxide ion	OH^-	carbonate ion	CO_3^{2-}	nitric acid	HNO_3
sulphate ion	SO_4^{2-}	Nitrate ion	NO_3^-	Oxide ion	O^{2-}
Chloride ion	Cl^-	sulphuric acid	H_2SO_4	Zinc ion	Zn^{2+}
ammonium ion	NH_4^+	Iron(III) ion	Fe^{3+}	hydrochloric acid	HCl
Sulphide ion	S^{2-}	Ammonia	NH_3	Silver ion	Ag^+

2. State whether the following are I (contain ions) C (covalent) M (metallic) Score /3 (all I = 1, all C= 1, all M = 1)

Mg(s)	NaCl(s)	$CO_2(g)$	$Cl_2(g)$	HCl(g)	$MgCl_2(s)$	$H_2O(l)$
M	I	C	C	C	I	C
$Br_2(aq)$	NaCl(aq)	$CO_2(aq)$	$Cl_2(aq)$	HCl(aq)	$MgCl_2(aq)$	$H_2SO_4(aq)$
C	I	C	I	I*	I	I*

Acids form ions when dissolved in water

3. Use of HFBrONIClAt, for the equations below (i) Write above the equation whether the substance is I, C or M,

(ii) Then CIRCLE all the formulae that you need to use HFBrONIClAt with

M C I
a) ~~Calcium~~ + oxygen → ~~calcium oxide~~

M C I
b) Sodium + sulphur → sodium sulphide

C C C
c) hydrogen + oxygen → water

C M I
d) Iodine(aq) + calcium → calcium iodide

M I (an (aq) acid) I C
e) Magnesium + hydrochloric acid(aq) → magnesium chloride + hydrogen

I C I C
f) Aluminium bromide(aq) + nitrogen → aluminum nitride + bromine(aq)

I I I C C
g) Strontium carbonate + sulfuric acid (aq) → strontium sulfate + carbon dioxide + water

C C C
h) Chlorine + hydrogen → hydrogen chloride

I I I C
i) Copper(I)oxide + nitric acid(aq) → copper(I)nitrate + water

M C I
j) Silver + chlorine → silver chloride

Section A: Checking basics needed for writing balanced symbol equations, sheet 2

DATE:

1. Give the formulae of the following **SCORE /21**

Chloride ion	Cl^-	Ammonia	NH_3	nitric acid	HNO_3
sulphate ion	SO_4^{2-}	Sulphide ion	S^{2-}	Silver ion	Ag^+
sulphuric acid	H_2SO_4	Zinc ion	Zn^{2+}	ammonium ion	NH_4^+
Nitrate ion	NO_3^-	ethanoate ion	CH_3COOH	hydrochloric acid	HCl
carbonate ion	CO_3^{2-}	ethanoic acid	CH_3COO^-	hydroxide ion	OH^-
Iron(III) ion	Fe^{3+}	Strontium ion	S^{2-}	Nitride ion	N^{3-}
Selenide ion	Se^{2-}	Iodide ion	I^-	Phosphide ion	P^{3-}

I/C or	Name	*If* **C or M**	**if Ionic**, work out ions ***then number of each needed***				
M?		formula	no	+ve ion	no	- ve ion	formula
I	Sodium oxide	**----**	**2**	**Na^+**	**1**	**O^{2-}**	**Na_2O**
C	oxygen	**O_2**	--	--	--	--	--
M	sodium	**Na**	--	--	--	--	--
I	Calcium hydroxide	**--**	**1**	**Ca^{2+}**	**2**	**OH^-**	**$Ca(OH)_2$**
C	Carbon dioxide	**CO_2**	--	--	--	--	--
I	Magnesium oxide	**--**	**1**	**Mg^{2+}**	**1**	**O^{2-}**	**MgO**
I	Iron(III) chloride	**--**	**1**	**Fe^{3+}**	**3**	**Cl^-**	**$FeCl_3$**
C	Chlorine	**Cl_2**	--	--	--	--	--
I	Barium chloride	**--**	**1**	**Ba^{2+}**	**2**	**Cl^-**	**$BaCl_2$**
I	Calcium carbonate	**--**	**1**	**Ca^{2+}**	**1**	**CO_3^{2-}**	**$CaCO_3$**
I	Sodium carbonate	**--**	**2**	**Na^+**	**1**	**CO_3^{2-}**	**Na_2CO_3**
I	Aluminum carbonate	**--**	**2**	**Al^{3+}**	**3**	**CO_3^{2-}**	**$Al_2(CO_3)_3$**
I	silver sulphate	**--**	**2**	**Ag^+**	**1**	**SO_4^{2-}**	**Ag_2SO_4**
M	Iron	**Fe**	--	--	--	--	--
I	Lead(IV) nitrate	**--**	**1**	**Pb^{4+}**	**4**	**NO_3^-**	**$Pb(NO_3)_4$**
I	Lead(IV) nitride	**--**	**3**	**Pb^{4+}**	**4**	**N^{3-}**	**Pb_3N_4**

Section A: Checking basics needed for writing balanced symbol equations, SEE PAGE 1 of notes for worked example

M	C		I : Al^{3+} + $3Cl^-$		
Aluminium	+ chlorine*	→	Aluminium chloride		
Al	**1.5Cl_2**		**$AlCl_3$**		

2.	**I : 1 Ca^{2+} + 1 CO_3^{2-}**		**I : 1 Ca^{2+} + 1 O^{2-}**	**C**	
	Calcium carbonate	→	Calcium oxide	+ carbon dioxide	
	$CaCO_3$		**CaO**	**CO_2**	

3.	**I : 2 Na^+ + 1 CO_3^{2-}**		**I : 2 Na^+ + 1 O^{2-}**	**C**	
	sodium carbonate	→	Sodium oxide	+ carbon dioxide	
	Na_2CO_3		**Na_2O**	**CO_2**	

4. M	**(l (aq))**		**I : 1 Mg^{2+} + 2Cl^-**	**C**	
Magnesium	+ hydrochloric acid	→	Magnesium chloride	+ hydrogen*	
Mg	**2HCl**		**$MgCl_2$**	**H_2**	

5. I : 1 Na^+ + 1 OH^-	**(l (aq))**		**I : 1 Na^+ + 1 NO_3^-**	**C**	
Sodium hydroxide	+ nitric acid	→	Sodium nitrate	+ water	
NaOH	**HNO_3**		**$NaNO_3$**	**H_2O**	

6. I: 1 Ca^{2+} + 2 OH^-	**(l (aq))**		**I : 1 Ca^{2+} + 2 NO_3^-**	**C**	
Calcium hydroxide	+ nitric acid	→	Calcium nitrate	+ water	
$Ca(OH)_2$	**2HNO_3**		**$Ca(NO_3)_2$**	**H_2O**	

7. I: 1 Al^{3+} + 3 OH^-	**(l (aq))**		**I : 1 Al^{3+} + 3 NO_3^-**	**C**	
Aluminium hydroxide	+ nitric acid	→	Aluminium nitrate	+ water	
$Al(OH)_3$	**3HNO_3**		**$Al(NO_3)_3$**	**3H_2O**	

8. I: 1 Pb^{4+} + 4 OH^-	**(l (aq))**		**I : 1 Pb^{4+} + 4 NO_3^-**	**C**	
Lead(IV) hydroxide	+ nitric acid	→	Lead(IV) nitrate	+ water	
$Pb(OH)_4$	**4HNO_3**		**$Pb(NO_3)_4$**	**4H_2O**	

9. I : 1 K^+ + 1 OH^-	**(l (aq))**		**I : 2 K^+ + 1 SO_4^{2-}**	**C**	
potassium hydroxide	+ sulphuric acid	→	potassium sulphate	+ water	
2KOH	**H_2SO_4**		**K_2SO_4**	**2H_2O**	

10. : 1 Ga^{3+} + 3 Br^-	**C**		**: 2 Ga^{3+} + 3O^{2-}**	**C**	
Gallium bromide	+ oxygen*	→	Gallium oxide	+ bromine*	
2$GaBr_3$	**1.5 O_2**		**Ga_2O_3**	**3Br_2**	

*** diatomic…**

Reaction of Acids 1 (a) Complete the word equation CHECK YOUR ANSWERS and then (b) Write balanced symbol equations

1. Magnesium + hydrochloric acid → Magnesium chloride + Hydrogen

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

2. Calcium oxide + sulphuric acid → Calcium sulphate + Water

$CaO + H_2SO_4 \rightarrow CaSO_4 + H_2O$

3. sodium hydroxide + nitric acid → Sodium nitrate + Water

$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$

4. Magnesium carbonate + hydrochloric acid → Magnesium chloride + carbon dioxide + water

$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$

5. sodium hydrogencarbonate + sulphuric acid → Sodium sulphate + carbon dioxide + water

$2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$

6. silver oxide + hydrochloric acid → Silver chloride + water

$Ag_2O + 2HCl \rightarrow 2AgCl + H_2O$

7. Lithium + sulphuric acid →Lithium sulphate + hydrogen

$2Li + H_2SO_4 \rightarrow Li_2SO_4 + H_2$

8. Calcium hydroxide + nitric acid → Calcium nitrate + water

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

9. potassium carbonate + hydrochloric acid → potassium chloride + carbon dioxide + water

$K_2CO_3 + 2HCl \rightarrow 2KCl + CO_2 + H_2O$

10. Barium hydrogencarbonate + nitric acid → Barium nitrate + carbon dioxide + water

$Ba(HCO_3)_2 + 2HNO_3 \rightarrow Ba(NO_3)_2 + 2CO_2 + 2H_2O$

11. sulphuric acid + barium oxide → barium sulphate + water

$H_2SO_4 + BaO \rightarrow BaSO_4 + H_2O$

12. Gallium hydroxide + ethanoic acid → Gallium ethanoate + water

$Ga(OH)_3 + 3CH_3COOH \rightarrow Ga(CH_3COO)_3 + 3H_2O$

Reaction of Acids 2 (a) Complete the word equation CHECK YOUR ANSWERS and then (b) Write balanced symbol equations

1a. Aluminum oxide + sulfuric acid → Aluminum sulphate + water

$Al_2O_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2O$

1b. Aluminum hydroxide + sulfuric acid → Aluminum sulphate + water

$Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2O$

2a. Lead(IV) carbonate + nitric acid → lead(IV)nitrate + carbon dioxide + water

$Pb(CO_3)_2 + 4HNO_3 \rightarrow Pb(NO_3)_4 + 2CO_2 + 2H_2O$

2b. Lead(IV) hydrogencarbonate + nitric acid → lead(IV)nitrate + carbon dioxide + water

$Pb(HCO_3)_4 + 4HNO_3 \rightarrow Pb(NO_3)_4 + 2CO_2 + 2H_2O$

3. Hydrochloric acid + magnesium → magnesium chloride + hydrogen

$HCl + Mg \rightarrow MgCl_2 + H_2$

4. Ammonium hydroxide + sulphuric acid → ammonium sulphate + water

$2NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2H_2O$

5. Ammonia + nitric acid → ammonium nitrate

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

6. copper(II) hydroxide + hydrobromic acid → copper(II) bromide + water

$Cu(OH)_2 + 2HBr \rightarrow CuBr_2 + 2H_2O$

7. calcium hydrogencarbonate + phosphoric acid → calcium phosphate + carbon dioxide + water

$3Ca(HCO_3)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6CO_2 + 6H_2O$

8. Vandium(V)oxide + hydroiodic acid → vanadium(V)iodide + water

$V_2O_5 + 10HI \rightarrow 2VI_5 + 5H_2O$

9. ammonia + hydrochloric acid → ammonium chloride

$NH_3 + HCl \rightarrow NH_4Cl$

10. strontium + nitric acid → strontium nitrate + hydrogen

$Sr + 2HNO_3 \rightarrow Sr(NO_3)_2 + H_2$

Reaction of Acids 3 (a) Complete the word equation CHECK YOUR ANSWERS and then (b) Write balanced symbol equations

1. Tin(II) hydroxide + hydrochloric acid → Tin chloride + Water

$Sn(OH)_2 + 2HCl \rightarrow SnCl_2 + 2H_2O$

2. Bismuth (V) + nitric acid → Bismuth nitrate + Hydrogen

$Bi + 5HNO_3 \rightarrow Bi(NO_3)_5 + 2.5H_2$

3. Iron(III)carbonate + sulphuric acid → iron (III) sulfate + water + carbon dioxide

$Fe_2(CO_3)_3 + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3CO_2 + 3H_2O$

4. ammonium hydrogencarbonate + ethanoic acid → ammonium ethanoate + water + carbon dioxide

$NH_4HCO_3 + CH_3COOH \rightarrow CH_3COONH_4 + H_2O + CO_2$

5. Copper(II)oxide + nitric acid → Copper (II) nitrate + water

$CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$

6. silver carbonate + phosphoric acid→ silver phosphate + water + carbon dioxide

$3Ag_2CO_3 + 2H_3PO_4 \rightarrow 2Ag_3PO_4 + 3CO_2 + 3H_2O$

7. ammonia + sulfuric acid → ammonium sulfate

$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$

8. Calcium hydroxide + sulphuric acid → calcium sulphate + water

$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

9. Caesium carbonate + hydroiodic acid → Caesium iodate + carbon dioxide + water

$Cs_2CO_3 + 2HI \rightarrow 2CsI + CO_2 + H_2O$

10. Polonium(VI) hydrogencarbonate + ethanoic acid → Polonium (VI) ethanoate + carbon dioxide + water

$Po(HCO_3)_6 + 6CH_3COOH \rightarrow (CH_3COO)_6Po + 6CO_2 + 6H_2O$

11 . sulphuric acid + Antimony (V) → Antimony(V)sulphate + hydrogen

$5H_2SO_4 + 2Sb \rightarrow Sb_2(SO_4)_5 + 5H_2$

12. Thallium hydroxide + Chloric acid → Thallium Chlorate + water

$Tl(OH)_3 + 3HClO_3 \rightarrow Tl(ClO_3)_3 + 3H_2O$

1. Indium carbonate + nitric acid → Indium nitrate + carbon dioxide + water $In_2(CO_3)_3 + 6HNO_3 \rightarrow 2In(NO_3)_3 + 3CO_2 + 3H_2O$
2. Rubidium oxide + hydrochloric acid → Rubidium chloride + water $Rb_2O + 2HCl \rightarrow 2RbCl + H_2O$
3. Ammonia + phosphoric acid → ammonium phosphate $3NH_3 + H_3PO_4 \rightarrow (NH_4)_3PO_4$
4. titanium + sulfuric acid → titanium(IV) sulfate + hydrogen $Ti + 2H_2SO_4 \rightarrow Ti(SO_4)_2 + 2H_2$
5. silver oxide + phosphoric acid → silver phosphate + water $3Ag_2O + 2H_3PO_4 \rightarrow 2Ag_3PO_4 + 3H_2O$
6. Aluminium + hydrobromic acid → Aluminium bromide + hydrogen $2Al + 6HBr \rightarrow 2AlBr_3 + 3H_2$
7. Gallium hydrogencarbonate + nitric acid → gallium nitrate + carbon dioxide + wate $Ga(HCO_3)_3 + 3HNO_3 \rightarrow Ga(NO_3)_3 + 3CO_2 + 3H_2O$
8. Antimony(V)oxide + nitric acid → antimony(v) nitrate + water $Sb_2O_5 + 10HNO_3 \rightarrow 2Sb(NO_3)_5 + 5H_2O$
9. ammonia + phosphoric acid → ammonium phosphate $3NH_3 + H_3PO_4 \rightarrow (NH_4)_3PO_4$
10. Lead(IV) oxide + bromic acid → Lead(IV) bromate + water $PbO_2 + 4HBrO_3 \rightarrow Pb(BrO_3)_4 + 2H_2O$
11. Antimony(III) + Sulfuric acid → Antimony(III) sulphate + hydrogen $2Sb + 3H_2SO_3 \rightarrow Sb_2(SO_3)_3 + 3H_2$
12. Polonium(VI) carbonate + selenic acid → Polonium(VI) selenate + carbon dioxide + water $Po(CO_3)_3 + 3H_2SeO_4 \rightarrow Po(SeO_4)_3 + 3CO_2 + 3H_2O$

SECTION A

1 $Ca + 0.5O_2 \rightarrow CaO$
2 $Na + S \rightarrow NaS$
3 $H_2 + 0.5O_2 \rightarrow H_2O$
4 $I_2 + Ca \rightarrow CaI_2$
5 $Mg + 2HCl \rightarrow MgCl_2 + H_2$
6 $Al + 1.5Br_2 \rightarrow AlBr_3$
7 $SrCO_3 + H_2SO_4 \rightarrow SrSO_4 + CO_2 + H_2O$
8 $Cl_2 + H_2 \rightarrow 2HCl$
9 $Cu_2O + 2HNO_3 \rightarrow 2CuNO_3 + H_2O$
10 $4Ag + O_2 \rightarrow 2Ag_2O$
11 $Sn + O_2 \rightarrow SnO_2$
12 $Na + H_2O \rightarrow NaOH + 0.5H_2$
13 $Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$
14 $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$
15 $Ba(NO_3)_2 \rightarrow BaO + 2NO_2 + 0.5O_2$

SECTION B

a $Cu + 0.5O_2 \rightarrow CuO$
b $2Cu + 0.5O_2 \rightarrow Cu_2O$
c $N_2 + O_2 \rightarrow NO$
d $NO + 0.5O_2 \rightarrow NO_2$
e $CH_4 + 1.5O_2 \rightarrow CO + 2H_2O$
f $P_4 + 3O_2 \rightarrow P_4O_6$
g $MgCO_3 \rightarrow MgO + CO_2$
h $Ca(OH)_2 \rightarrow CaO + H_2O$
I $Ca(NO_3)_2 \rightarrow CaO + NO_2 + 1.5O_2$
j $Al_2(CO_3)_3 \rightarrow Al_2O_3 + 3CO_{23}$
k $2LiNO_3 \rightarrow Li_2O + 2NO_2 + 0.5O_2$

SECTION C

a) $Na_2O + 2K \rightarrow K_2O + 2Na$
b) $2Li + SrO \rightarrow Li_2O + Sr$
c) $ZnO + CO \rightarrow CO_2 + Zn$
d) $CuSO_4 + Mg \rightarrow MgSO_4 + Cu$
e) $AlCl_3 + 3Li \rightarrow 3LiCl + Al$
f) $3Cu(NO_3)_2 + 2Ga \rightarrow 2Ga(NO_3)_3 + 3Cu$
g) $Cl_2 + 2NaBr \rightarrow 2NaCl + Br_2$
h) $2TlI + Br_2 \rightarrow 2TlBr + I_2$
i) $4PF_3 + 0.5N_2 \rightarrow P_4 + NF_3$

SECTION D

(a) $Li_2O + H_2O \rightarrow 2LiOH$
(b) $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$
(c) $SO_3 + H_2O \rightarrow H_2SO_4$
(d) $H_2SO_4 + Na_2O \rightarrow Na_2SO_4 + H_2O$
(e) $MgO + 2HCl \rightarrow MgCl_2 + H_2O$
(f) $SO_3 + CaO \rightarrow CaSO_4$
(g) $Al_2O_3 + 3H_2O \rightarrow 2Al(OH)_3$
(h) $CO_2 + H_2O \rightarrow H_2CO_3$
(i) $Sr(OH)_2 + 2HNO_3 \rightarrow Sr(NO_3)_2 + 2H_2O$
(j) $H_2SO_4 + Au_2O \rightarrow Au_2(SO_4)_2 + H_2O$
(m) $2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$
(n) $PbO + 2NO_2 + 1.5O_2 \rightarrow Pb(NO_3)_2$
(o) $6HCl + Al_2O_3 \rightarrow 2AlCl_3 + H_2O$
(p) $Ga(OH)_3 + 3HNO_3 \rightarrow Ga(NO_3)_3 + 3H_2O$
(r) $3SnO_2 + 4H_3PO_4 \rightarrow Sn_3(PO_4)_4 + 6H_2O$
(q) $3SiO_2 + 2Tl_2O_3 \rightarrow Tl_4(SiO_4)_3$

Section E Miscellaneous 1	Section F Miscellaneous 2
a. $2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O$	1. $Tl_2(SO_3)_3 + 3Mg \rightarrow 2Tl + 3MgSO_3$
b. $2LiNO_3 \rightarrow Li_2O + 2NO_2 + ½O_2$	2. $3Ba + N_2 \rightarrow Ba_3N_2$
c. $KNO_3 \rightarrow KNO_2 + ½O_2$	3. $Fe_2(SO_4)_3 \rightarrow Fe_2O_3 + 3SO_3$
d. $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$	4. $2LiNO_3 \rightarrow Li_2O + 2NO_2 + ½O_2$
e. $C_5H_{11}OH + 7.5O_2 \rightarrow 5CO_2 + 6H_2O$	5. $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$
f. $Cu_3N_2 + 3O_2 \rightarrow 3CuO + NO + NO_2$	6. $(NH_4)CO_3 + 2HNO_2 \rightarrow 2NH_4NO_2 + CO_2 + H_2O$
g. $2NH_3 + 2.5O_2 \rightarrow 2NO + 3H_2O$	7. $Ga_2S_3 + 6HBr \rightarrow 2GaBr_3 + 3H_2S$
h. $3Bi_2O_5 + 10H_3PO_4 \rightarrow 2Bi_3(PO_4)_5 + 15H_2O$	8. $3Ca(OH)_2 + 2H_3PO_4 \rightarrow Ca_3(PO_4)_2 + 6H_2O$
i. $2Tl(HCO_3)_3 + 3H_2SO_3 \rightarrow Tl_2(SO_3)_3 + 6H_2O + 6CO_2$	9. $Ga(HCO_3)_3 + 3HClO_3 \rightarrow Ga(ClO_3)_3 + 3H_2O + 3CO_2$
j. $PbO_2 + 2H_2SO_3 \rightarrow Pb(SO_3)_2 + 2H_2O$	10. $PbO_2 + 2H_2SO_3 \rightarrow Pb(SO_3)_2 + 2H_2O$
k. $Po(OH)_2 + (NH_4)_2SO_4 \rightarrow PoSO_4 + 2NH_3 + 2H_2O$	11. $2Bi(OH)_5 + 5(NH_4)_2SO_2 \rightarrow Bi_2(SO_4)_5 + 10NH_3 + 20H_2O$
l. $Zn + 4HNO_3 \rightarrow Zn(NO_3)_2 + 2NO_2 + 2H_2O$	12. $ZnO + 2Al(OH)_3 \rightarrow Zn(AlO_2)_2 + 2H_2O$
m. $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$	
n. $Ga(HCO_3)_3 + 3HClO_3 \rightarrow Ga(ClO_3)_3 + 3H_2O + 3CO_2$	

Section G

1. Aluminium + iodine → aluminium iodide
   $2Al + 3I_2 \rightarrow 2AlI_3$
2. Potassium hydroxide + sulfuric acid → potassium sulfate + water
   $2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$
3. Lithium + oxygen → Lithium oxide
   $4Li + O_2 \rightarrow 2Li_2O$
4. Lead(II) oxide + nitric acid → lead(II) nitrate + water
   $PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$
5. Polonium + nitrogen → polonium(II) nitride
   $3Po + N_2 \rightarrow Po_3N_2$
6. Ammonium carbonate + hydrochloric acid → ammonium chloride + carbon dioxide + water
   $(NH_4)_2CO_3 + 2HCl \rightarrow 2NH_4Cl + H_2O + CO_2$
7. Sodium + water → sodium hydroxide + hydrogen
   $Na + H_2O \rightarrow NaOH + ½O_2$
8. Iron(II) hydrogencarbonate + phosphoric acid → iron(II) phosphate + water + carbon dioxide $3Fe(HCO_3)_2 + 2H_3PO_4 \rightarrow Fe_3(PO_4)_2 + 6H_2O + 6CO$
9. Calcium + water → calcium hydroxide + hydrogen
   $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
10. Gallium + chloric acid → Gallium chlorate + hydrogen
    $2Ga + 6HClO_3 \rightarrow 2Ga(ClO_3)_3 + 3H_2$
11. Carbon dioxide + sodium hydroxide → sodium hydrogencarbonate
    $CO_2 + NaOH \rightarrow NaHCO_3$
12. Aluminium nitrate → aluminium oxide + nitrogen dioxide + oxygen
    $4Al(NO_3)_3 \rightarrow 2Al_2O_3 + 12NO_2 + 3O_2$
13. Methanethiol + oxygen → carbon dioxide + sulfur dioxide + water
    $CH_3SH + 3O_2 \rightarrow CO_2 + SO_2 + 2H_2O$
14. Silicon oxide + sodium oxide → sodium silicate
    $SiO_2 + Na_2O \rightarrow Na_2SiO_3$
15. Gallium + hydroiodic acid → gallium iodide + hydrogen
    $2Ga + 6HI \rightarrow 2GaI_3 + 3H_2$
16. Carbon dioxide + aluminium oxide → aluminium carbonate
    $CO_2 + Al_2O_3 \rightarrow Al_2(CO_3)_3$
17. Sulfur trioxide + copper oxide → copper sulfate
    $SO_3 + CuO \rightarrow CuSO_4$
18. Magnesium hydroxide + aluminium oxide ?? → magnesium aluminate + water
19. Nitrogen dioxide + oxygen + barium oxide → barium nitrate
    $4NO_2 + O_2 + 2BaO \rightarrow 2Ba(NO_3)_2$
20. carbon dioxide + sodium oxide → sodium carbonate
    $CO_2 + Na_2O \rightarrow Na_2CO_3$
21. Phosphorus trioxide + calcium oxide + oxygen → calcium phosphate
    $P_4O_6 + 6CaO + 2O_2 \rightarrow 2Ca_3(PO_4)_2$
22. Dodecane + oxygen → carbon monoxide + carbon + water
    $C_{12}H_{26} + 9O_2 \rightarrow 5CO + 7C + 13H_2O$
23. Ammonia + oxygen → nitric oxide + water
    $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
24. Phosphorus + chlorine → phosphorus pentachloride
    $P_4 + 10Cl_2 \rightarrow 4PCl_5$
25. Chlorine + oxygen → dichlorine heptoxide
    $2Cl_2 + 7O_2 \rightarrow 2Cl_2O_7$