Formula Mass and The Mole
Worked Examples

1. Formula Mass – this is the total mass of an element or compound in atomic mass units (a.m.u)

    a) Find the formula mass of nitrogen

    Formula = N_2
    Formula mass = 14 x 2 = 28 a.m.u

    b) Find the formula mass of copper(II) nitrate

    Formula = $Cu^{2+}(NO_3^-)_2$

    Formula mass = Cu N O
    (1x63.5)+(2x14)+(6x16)
    63.5 + 28 + 96 = 187.5 a.m.u

2. Mole – A mole of a substance is its Gram Formula Mass i.e. its formula mass given in grams.

    a) Find 1 mole of carbon

    Formula = C
    1 mole = 12g

    b) Find 1 mole of sulphur trioxide

    Formula = SO_3

    1 mole = S O
    (1x32) + (3x16)
    32 + 48 = 80g

3. <u>Changing moles to masses and masses to moles.</u>

a) Find 3.5 moles of zinc(II) chloride

Formula = $Zn^{2+}(Cl^{-})_2$

1 mole = Zn Cl

(1x65.5) + (2x35.5)

65.5 + 71 = 136.5g

1 mole ⟷ 136.5g

3.5 moles ⟷ Xg

1 x X = 136.5 x 3.5

X = <u>477.7g</u>

b) How many moles is 50g of calcium carbonate?

Formula = $Ca^{2+}CO_3^{2-}$

1 mole = Ca C O

(1x40) + (1x12) + (3x16)

40 + 12 + 48 = 100g

1 mole ⟷ 100g

X mole ⟷ 50g

100 x X = 1 x 50

X = 50/100

4. <u>Number of moles, volume and concentration</u>

Number of moles = volume x concentration

(moles) (litres) ($moll^{-1}$)

a) How many moles of NaCl would be needed to make up 200cm^3 of a 0.4moll^{-1} solution?

n = c x v
n = 0.2 x 0.4
n = 0.08moles

b) What volume of water would be needed to dissolve 5 moles of NaOH to make a 1 moll^{-1} solution?

v = n / c
v = 5 / 1
v = 5 litres

c) What concentration of solution would be made up when 0.2 moles of KOH is dissolved in 100cm^3 of water?

c = n / v
c = 0.2 / 0.1
c = 2 moll^{-1}

5. Two stage calculations.

a) What mass of calcium carbonate would be needed to make up 500cm^3 of a 0.4 moll^{-1} solution?

Stage 1 : First find the number of moles.

n = c x v
n = 0.5 x 0.4
n = 0.2 moles

Stage 2 : Then find the mass of the number of moles.

Formula of calcium carbonate = $Ca^{2+}CO_3^{2-}$

1 mole = Ca C O

(1x40) + (1x12) + (3x16)

40 + 12 + 48 = 100g

1 mole ⟷ 100g

0.2 mole ⟷ Xg

1 x X = 100 x 0.2

X = <u>20g</u>

b) What would be the concentration of a solution of 50g of calcium carbonate dissolved in 250cm^3 of water?

Stage 1 : Formula of calcium carbonate $Ca^{2+}CO_3^{2-}$

1 mole = 100g (from above)

1 mole ⟷ 100g

X mole ⟷ 50g

1 x 50 = 100 x X

50 = 100X

X = 50 / 100

X = 0.5mole

Stage 2 : Now find the concentration

c = n / v

c = 0.5 / 0.25

c = <u>2moll^{-1}</u>

Formula Mass and The Mole - Questions

1. Write the chemical formula for each of the following substances:

   a) lithium chloride
   b) nitrogen
   c) ammonium bromide
   d) magnesium sulphate
   e) sodium sulphide
   f) iron(III) chloride
   g) calcium
   h) strontium chloride
   i) iron(II) hydroxide
   j) sulphur trioxide

2. Calculate the relative formula mass for each of the following substances:

   a) CO_2
   b) Mg_3N_2
   c) Br_2
   d) $Al(OH)_3$
   e) sulphur dioxide
   f) hydrogen
   g) sodium carbonate
   h) carbon monoxide

3. Calculate the mass of one mole of each of the following substances:

   a) $Mg(OH)_2$
   b) $(NH_4)_2SO_4$
   c) magnesium sulphate
   d) copper(II) oxide

4. Calculate the mass of each of the following substances:

    a) 2 mol of Cu
    b) 3 mol of CH_4
    c) 0.5 mol of iron(II) hydrogensulphate
    d) 2.5 mol of potassium sulphate

5. Calculate the number of moles in each of the following substances:

    a) 25g $CaCO_3$
    b) 3.4g NH_3
    c) 80g sodium hydroxide
    d) 6.4g copper(II) sulphate

6. How many moles of potassium hydroxide are required to make $200cm^3$ of solution, concentration 0.5mol l^{-1}?

7. What is the concentration of a solution of a solution which contains 2 mol of hydrogen chloride dissolved and made up to 2 litres of solution?

8. What volume of a solution, concentration 0.2 mol l^{-1}, contains 0.005 mol of solute?

9. 52.5g of pure citric acid (formula mass 210) is dissolved in water and the solution is made up to $500cm^{3.}$

    What is the concentration of the resulting solution?

10. What mass of sodium nitrate is needed to make 1 litre of solution, concentration 0.2 mol l^{-1}?

Balanced Equations and Calculations
Worked Examples

Balanced Chemical Equations – is when the number of atoms (or ions) on the reactant side is equal to the number of atoms (or ions) on the product side.

Balanced Chemical Equations – can only be balanced by putting a number in front of symbols and formulae.
Never change a formula to make an equation balance.

Example: $N_2 + H_2 \longrightarrow NH_3$

N_2	H_2	NH_3
2N	2H	1N 3H

Two nitrogens are needed on the product side.

$N_2 + H_2 \longrightarrow 2NH_3$

N_2	H_2	$2NH_3$
2N	2H	2N 6H

Six hydrogens are needed on the reactant side.

$N_2 + 3H_2 \longrightarrow 2NH_3$

N_2	$3H_2$	$2NH_3$
2N	6H	2N 6H

The balanced chemical equation is:

$$N_2 + 3H_2 \longrightarrow 2NH_3$$

Calculations based on balanced equations.

Example 1:

Calculate the mass of water produced on burning 1g of methane.

Step 1 – balanced equation	CH_4 + $2O_2$ $\longrightarrow$ CO_2 + $2H_2O$	
Step 2 – number of moles	1 mole	2 moles
Step 3 – mass in grams	16g	36g
Step 4 – cross multiply	1g	Xg

$$16X = 36 \times 1$$
$$16X = 36$$
$$X = 36 / 16$$
$$X = \underline{2.25g}$$

Example 2:

Calculate the mass of lead (II) carbonate needed to produce 2.2g of carbon dioxide on heating.

Step 1 – balanced equation	$Pb(CO_3)$ $\longrightarrow$ PbO + CO_2	
Step 2 – number of moles	1 mole	1 moles
Step 3 – mass in grams	267g	44g
Step 4 – cross multiply	Xg	2.2g

$$X = \underline{13.35g}$$

Balanced Equations and Calculations – Questions

1. $CaCO_3 \longrightarrow CaO + CO_2$

   What mass of carbon dioxide is produced by the decomposition of 10g calcium carbonate?

2. $C_2H_4 + 3O_2 \longrightarrow 2CO_2 + 2H_2O$

   What mass of water is produced on burning 7g of ethene?

3. $CuO + CO \longrightarrow Cu + CO_2$

   What mass of copper oxide must be reduced to give 127g of copper?

4. $4Na + O_2 \longrightarrow 2Na_2O$

   What mass of sodium oxide is produced in the reaction of 2.3g of sodium with excess oxygen?

5. $Mg + CuSO_4 \longrightarrow MgSO_4 + Cu$

   What mass of copper is produced in the reaction of 1.2g of magnesium with excess copper(II) sulphate?

6. Aluminium reacts with oxygen to produce aluminium oxide. What mass of oxygen is required to react with 2.7g of aluminium?

7. What mass of carbon dioxide is produced on burning 8g of methane (CH_4)?

8. What mass of hydrogen is obtained when 6g of magnesium reacts with excess dilute hydrochloric acid (HCl)?

Polymers
Worked Examples

Polymers – are very big molecules with a long chain of carbon atoms.

Polymers – are made from smaller units called **monomers**.

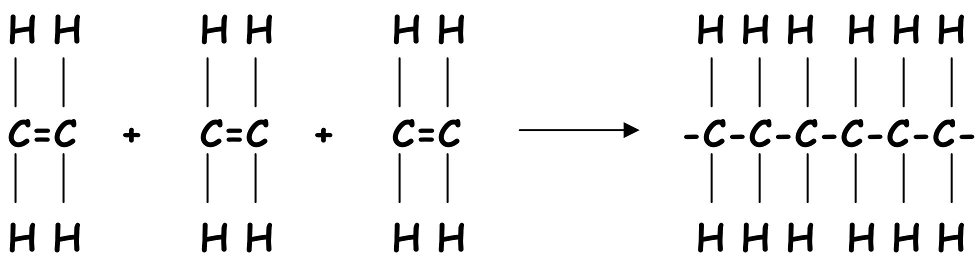
Polymerisation - is the making of a polymer by the joining up of monomer units.

Addition Polymerisation:

Polymers made from unsaturated monomer units by the opening of carbon to carbon double bonds are called **addition polymers.**

Example 1:

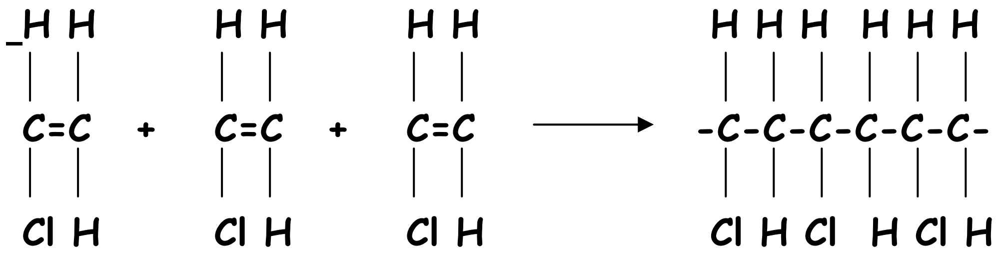
Ethene monomers add together by the opening of the double bond to form polyethene.



ethene monomers polyethene

Example 2:

Polyvinylchloride (PVC) is formed from vinyl chloride monomers.



vinyl chloride monomers polyvinylchloride

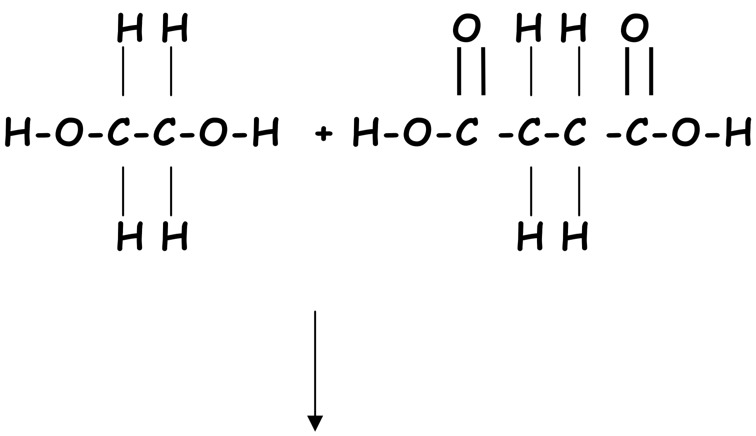
Condensation Polymerisation:

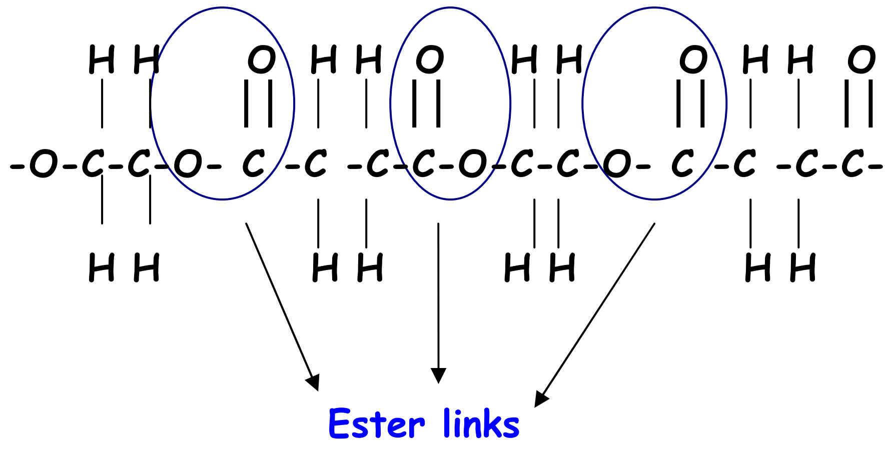
Condensation polymers are made from monomers with two functional groups in each molecule.

In condensation polymerisation, the monomers usually link together by the loss of the elements to make water. The hydrogen atom from one of the monomers joins with a hydroxyl group from the other monomer.

Example 1: Polyesters

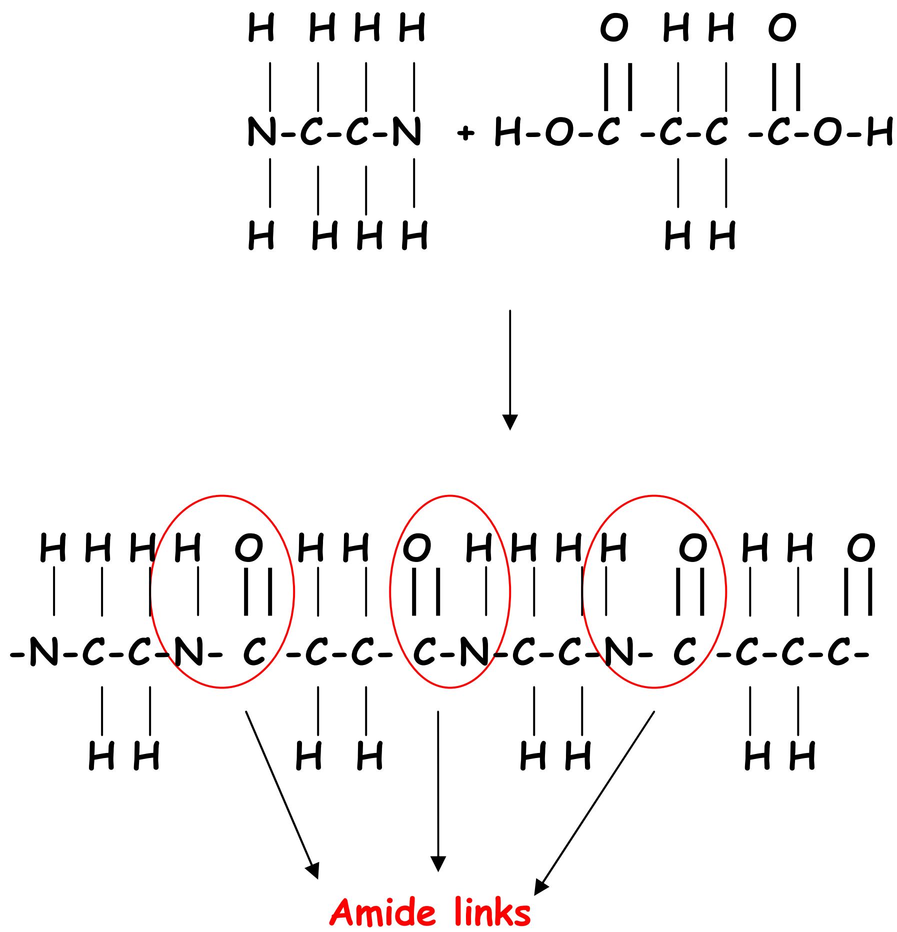
Polyesters are formed from diols and diacids joining together with the loss of water.





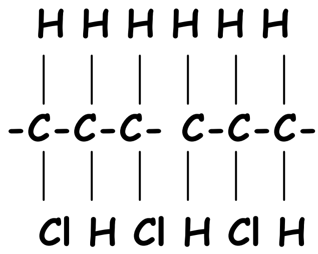
Example 2: Polyamides

Polyamides are formed from diamines and diacids joining together with the loss of water.



Polymers – Questions

Questions 1 to 5 refer to part of the polymer shown below:



1. **How many repeating units are shown?**

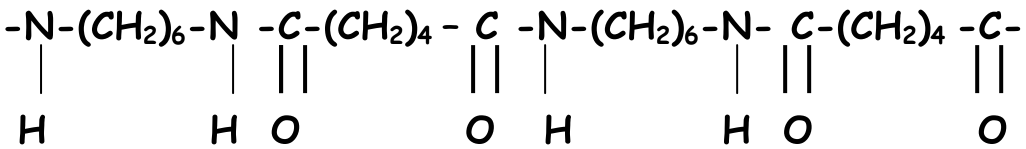
2. **Draw the repeating unit.**

3. **What is the name of the monomer?**

4. **Draw the monomer?**

5. **What is the name of the polymer?**

Questions 6 to 8 refer to part of the polymer nylon 6,6 shown below:



6. **Draw the repeating unit.**

7. **Draw the structural formulae for the <u>two</u> monomers form which nylon 6,6 is made.**

8. **What type of polymer is nylon 6,6?**

Bonding, Structures and Properties

Covalent bonding – is when two non-metal atoms join together by sharing their outer electrons, in order to achieve a stable electron arrangement.

Covalent bonding can either have a molecular structure or a network structure.

A covalent molecule is a group of atoms held together by covalent bonds.
A covalent network is a giant lattice of covalently bonded atoms.

Ionic bonding – is when a metal element and non-metal element join together with an electrostatic force of attraction.
The metal element loses electrons to become a positive ion and the non-metal element gains electrons to become a negative ion, then a force of attraction builds up between the oppositely charged ions.

Metallic bonding – this is an electrostatic force of attraction between positively charged ions and delocalised electrons within a metallic structure.

<u>Bonding, Structures and Properties - Questions</u>

1. Atoms are held together by ________.

2. When a bond is formed atoms achieve a ______________ ______________ arrangement which is the same as the __________ ___________.

3. A _______________ __________ is the attraction of the ____________ nucleus for a shared ________ of electrons.

4. Covalent bonds are strong bonds between two ___________ atoms.

5. Polar covalent bonds occur when the two nuclei have a _______________ attraction for the shared electrons.

6. Ionic bonds are formed by the transfer of _______________ from a ______________ to a non-metal.

7. Metals ____________ electrons to form ______________ ions and non-metals ______________ electrons to form _______________ ions.

8. Ionic compounds are held together by electrostatic forces of the _______________ and negative _____________ on the ions, forming an ionic crystal lattice.

9. Metallic bonds are electrostatic attractions formed between __________ electrons and __________ ions, forming a giant metallic structure.

10. A ___________ is a group of atoms held together by covalent ________.

11. A diatomic molecule is made up of ________ atoms.

12. Draw the <u>shape</u> of molecules of: HCl, H_2O, NH_3, CH_4

13. A covalent __________ is a giant lattice of covalently bonded atoms. The formula is the ________ of atoms and not the number of atoms.

14. The __________ electrons in metals are free to move and so metals can conduct electricity.

15. Covalent substances ________ conduct electricity.

16. Electricity is carried by __________ ions in ionic compounds, therefore the only conduct in __________ or as a ________ when the ions are _______ ___ ________.

17. Covalent _________ and _________ compounds have high melting points.

18. Ionic compounds are usually __________ in water and covalent compounds do not usually dissolve in water, but will dissolve in other solvents like ________.

19. An electric current is a flow of ions in an _________ and a flow of __________ in a metal or graphite.

20. Coloured ions can be seen ___________ in a solution during electrolysis.

Bonding, Structures and Properties – Answers

1. Atoms are held together by bonds.

2. When a bond is formed atoms achieve a stable electron arrangement which is the same as the noble gases.

3. A covalent bond is the attraction of the positive nucleus for a shared pair of electrons.

4. Covalent bonds are strong bonds between two non-metal atoms.

5. Polar covalent bonds occur when the two nuclei have a different attraction for the shared electrons.

6. Ionic bonds are formed by the transfer of electrons from a metal to a non-metal.

7. Metals lose electrons to form positive ions and non-metals gain electrons to form negative ions.

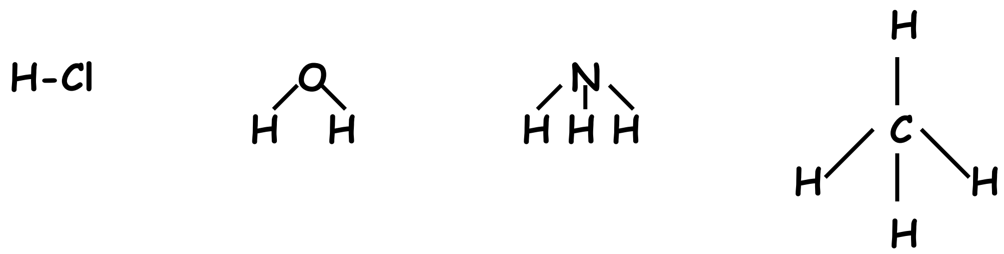
8. Ionic compounds are held together by electrostatic forces of the positive and negative charges on the ions, forming an ionic crystal lattice.

9. Metallic bonds are electrostatic attractions formed between delocalised electrons and positive ions, forming a giant metallic structure.

10. A molecule is a group of atoms held together by covalent bonds.

11. A diatomic molecule is made up of two atoms.

12. Draw the <u>shape</u> of molecules of: HCl, H_2O, NH_3, CH_4



13. A covalent network is a giant lattice of covalently bonded atoms. The formula is the ratio of atoms and <u>not</u> the number of atoms.

14. The delocalised electrons in metals are free to move and so metals can conduct electricity.

15. Covalent substances never conduct electricity.

16. Electricity is carried by ions in ionic compounds, therefore they only conduct in solution or as a melt, when the ions are free to move.

17. Covalent networks and ionic compounds have high melting points.

18. Ionic compounds are usually soluble in water and covalent compounds do not usually dissolve in water, but will dissolve in other solvents like hexane.

19. An electric current is a flow of ions in an electrolyte and a flow of electrons in a metal or graphite.

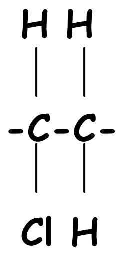
20. Coloured ions can be seen migrating (moving) in a solution during electrolysis.

Balanced Equations and Calculations – Answers

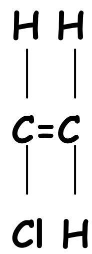
1. 4.4g
2. 9g
3. 159g
4. 3.1g
5. 3.1g
6. 2.4g
7. 22g
8. 0.49g

Polymers – Answers

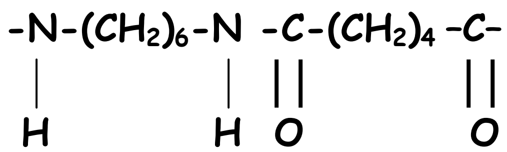
1. 3 repeating units.

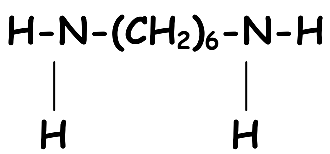
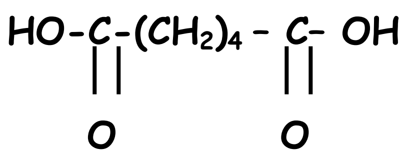
2. 

3. The monomer is Vinyl chloride.

4. 

5. The polymer is Polyvinylchloride.

6. 

7.  and 

8. Nylon 6,6 is a condensation polymer (or a Polyamide).

Formula Mass and The Mole - Answers

1. a) LiCl
   b) N_2
   c) NH_4Br
   d) $MgSO_4$
   e) NaS
   f) $FeCl_3$
   g) Ca
   h) $SrCl_2$
   i) $Fe(OH)_2$
   j) SO_3

2. a) 44
   b) 101.5
   c) 160
   d) 78
   e) 64
   f) 2
   g) 106
   h) 28

3. a) 58.5g
   b) 132g
   c) 120.5g
   d) 79.5g

4. a) 127g
   b) 48g
   c) 109g
   d) 435g

5. a) 0.25mole
   b) 0.2mole
   c) 2mole
   d) 0.04mole

6. 0.1mole

7. $1moll^{-1}$

8. 0.025litres (or 25ml)

9. $0.5moll^{-1}$

10. 17g

PPA - Answers

1. a) Colourless to blue/black

   b) $0.144 s^{-1}$

   c) Concentration of 2 = 312.5s
   Concentration of 4 = 138.9s
   Concentration of 6 = 90.9s
   Concentration of 8 = 62.5s
   Concentration of 10 = 54.3s

   d) As the concentration of sodium persulphate increases the reaction rate increases.

   e) Temperature of the solutions and the same person watching for the colour change.

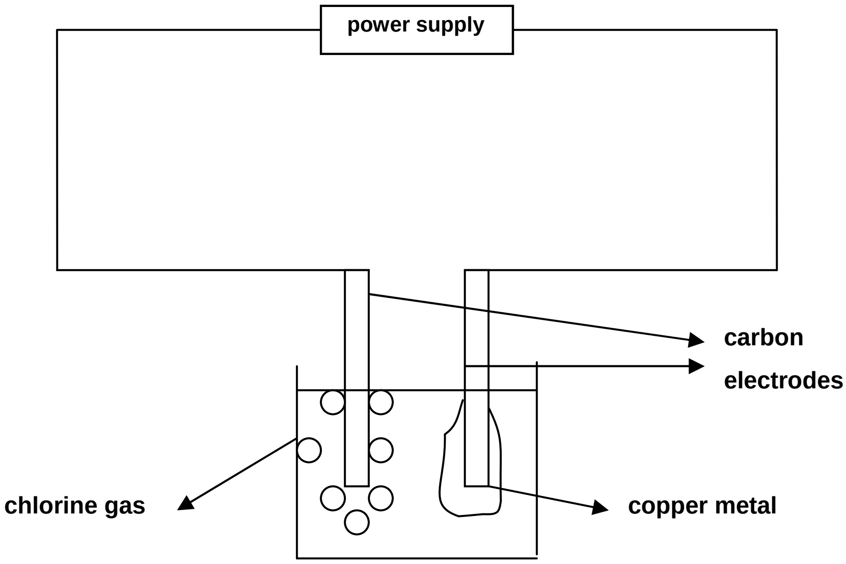
2. a) Add $20 cm^3$ of sodium thiosulphate solution to a beaker and place it over a cross drawn lightly in pencil on a piece of white paper.
   Next add $1 cm^3$ of hydrochloric acid to the beaker, it is stirred and the timer started.
   Viewing from above the beaker, note the time taken for the cross to be obscured (disappear) and note the final temperature of the mixture.
   Repeat the experiment three more times by heating the sodium thiosulphate solution to 30^0C, 40^0C and 50^0C.

   b) Teacher check.

   c) 16.95s

d) Concentration of sodium thiosulphate, concentration of hydrochloric acid, volume of sodium thiosulphate and volume of hydrochloric acid.

3. a)



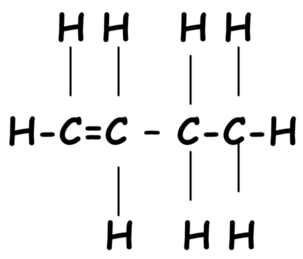
b) A brown/red coloured solid is deposited around the negative electrode.

c) (i) Bubbles of gas (chlorine)
(ii) hold moist blue litmus paper (or moist pH paper) above the positive electrode and if the litmus paper is bleached, chlorine gas is produced.

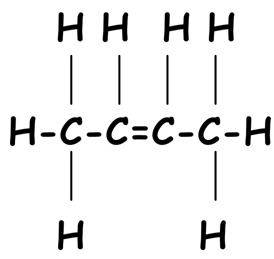
d) Chlorine is poisonous (toxic) and only a tiny amount should be sniffed using the 'wafting' technique.

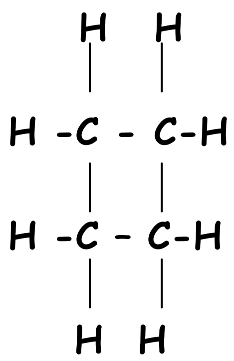
4. a) Unsaturated hydrocarbons have at least one carbon to carbon double covalent bond in there structure.

b) Add a small volume of a liquid hydrocarbon to a test tube. Add a few drops of bromine solution to the hydrocarbon. Carefully shake the test tube and record your observations.
Decolourisation indicates the presence of an unsaturated hydrocarbon and no decolourisations indicates a saturated hydrocarbon.

c) 

or



d) 

e) Bromine solution is toxic and the experiment should be carried out in a fume cupboard (well ventilated room).

5. a) X = ceramic wool
Y = aluminium oxide catalyst
Z = bromine solution

b) Cracking is breaking up a large molecule (hydrocarbon) into a mixture of smaller and more useful molecules.

c) To allow the reaction to take place at a lower temperature.

d) Limewater turns milky.

e) To avoid suckback, the delivery tube is removed from the bromine solution before heating is stopped.

f) $C_{10}H_{22} \longrightarrow$ decane

g) There are not enough hydrogen atoms to produce smaller alkanes only.

6. a) Add iodine solution to carbohydrates and if a blue/black colour appears, then starch is present.

b) Hydrolysis is when a large molecule is broken down into two or more smaller molecules by reaction with water.

c) Firstly heat the carbohydrate solutions with Benedict's solution. If there is a colour change from blue to the formation of a red/orange precipitate, then either glucose, fructose or maltose is present.

d) Amylase

e) To prove that it is the amylase that catalyses the reaction.

7. a) Magnesium sulphate, carbon dioxide and water are produced

b) (i) Add excess magnesium carbonate to 20cm^3 dilute sulphuric acid until no more bubbling and fizzing occurs.
(ii) Filter the excess magnesium carbonate out of the resultant solution.
(iii) Evaporate some of the water off.
(iv) Set aside the rest of the solution and leave to produce magnesium sulphate crystals.

c) If magnesium is used instead of magnesium carbonate, then hydrogen gas is produced and not carbon dioxide. Hydrogen gas is flammable.

8. a) The further apart the metals are in the electrochemical series, the higher the voltage produced.

b) Aluminium oxide is removed with sand paper.

c) Electrodes have to be the same distance apart and the same mass and the same electrolye must be used.

9. a) X = potassium permanganate

b) To ensure the metal is hot enough for a reaction to take place. If the metal was not heated first, no reaction would occur.

c) With magnesium, the silver coloured metal ribbon changes into a white powder and a bright white glow is seen.

d) Metals must be of the same state, i.e all powder or solid masses and must be the same mass for a fair test.

S4

Intermediate 2 Chemistry

Grade Boosters Answers

S4
Intermediate 2
Chemistry

Grade Boosters