KNOWING THE

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EDITION WITH ;

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- ✓ CONCISE INFORMATION

O level

EXAM SUCCESS SERIES

CHIKELE ALBERT .J

CONTENTS

CHAPTER 1 PARTICULATE NATURE OF MATTER

Question 1

Matter is classified as solid, liquid or gas. State two physical properties of each of the following:

(a) Solid [2]

(b) Liquid [2]

(c) Gas [2]

[SCIENCE-5124/3/q1/2012]

WORKED SOLUTIONS

(a) Two physical properties of solids are

- Has fixed volume
- Has fixed shaped

(b) Two physical properties of liquids are

- Has fixed volume
- Has no fixed shaped

(c) Two physical properties of gas are

- Has no fixed volume
- Has no fixed shape

TAKE NOTE: the table below summarizes the differences in the physical properties of the three states of matter:

Physical state	Volume	Density	Shape	Fluidity
SOLID	Has a fixed volume	High	Has definite shape	Does not flow
LIQUID	Has no fixed volume	Moderate to high	Has no definite shape	Generally flows easily
GAS	Has no fixed volume	Low	Has no definite shape	Flows easily

Question 2

Matter is made up of very small particles.

(a) Explain in terms of particle arrangement why :-

(i) Gases do not have definite shapes. [1]

(ii) Solids have definite shapes. [1]

(iii) State the effects of heat on the arrangement of particles in a liquid. [1]

[CHEMISTRY-5070/2/2010]

WORKED SOLUTIONS

(a)

i) Particles of gases are relatively far apart and have virtually no forces of attraction between each other. As a result, they do not have a fixed shape.

TAKE NOTE:

Even though particles of gases have more energy and they move rapidly and randomly and have no fixed shape or volume, they are however compressible.

ii) Particles of solids are arranged in a regular manner. They therefore, cannot move, but vibrate in a fixed position; hence their shapes are always fixed.

iii) Heat increases the kinetic energy of particles in a liquid, as a result they move further from each other, making the attractive forces between them weaker, they eventually become loosely packed and the liquid may attain a gaseous state.

Question 3

(a) Compare the movement of particles between solids and liquids.

(i) Solids

(ii) Liquids [2]

(b) How are the molecules arranged in a gas? [1]

(c) What is the physical effect of cooling on the three states of matter?

(i) solid

(ii) Liquid

(iii) Gas [3]

[SCIENCE – 5124/3/Q1/2004]

(a)

(i) In solids the particles vibrate in a fixed position

(ii) In liquids particles slide past each other/move about each other.

(b) In a gas particles are relatively far apart.

(c)

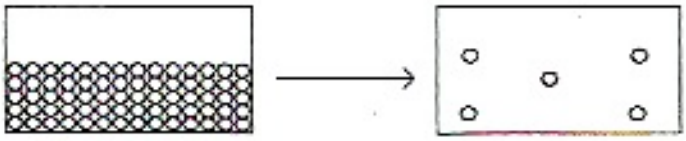
(i) Solids contract when cooled

(ii) Liquids contract and solidify when cooled

(iii) Gases condense when cooled

Question 4

When a substance is heated, it changes its physical state according to the model below.



A B

(a) What term is used to describe this change of state? [1]

(b) Describe what happens to the arrangement and movement of the particles when A changes to B. [2]

(c) A pure liquid C was found to have a boiling point of 118°c.

(i) Choose from the list below which liquid was C.

Liquid	Boiling point/°C
Ethanol	78
Water	100
Ethanoic acid	118
Butanamide	116

(ii) What happens to the temperature of a pure solid when it is melting? [1]

(iii) State whether melting is a physical or chemical change and give a reason for your answer. [2]

[Chemistry /5070/2/z/2009]

(a) Sublimation

** **TAKE NOTE:** Melting is the change of state from solid to liquid.*

(b) The particles in A (solid) are closely packed due to strong forces of attraction. When changing to B (liquid) the arrangement of particles is loosened due to weakened attractive forces.

Particles in A (solid) vibrate about a fixed position, when the change to B (liquid) occurs; the particles are able to slide past each other.

(c)

i) Ethanoic acid.

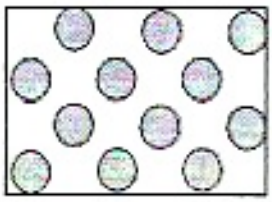
ii) The temperature of a melting pure solid remains constant during the process.

iii) The melting of a substance is a physical change because no new substance is formed and the change is reversible.

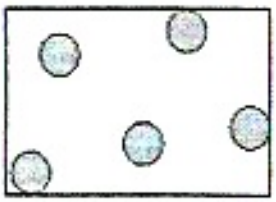
CONCISE INFORMATION (PARTICLE ARRANGEMENT ILLUSTRATED)

✓ *Particles are arranged differently in different states of matter as shown below.*

Particles are arranged in a regular manner and are closely packed due to strong attractive forces between them. The particles therefore, cannot move from one place to another but only vibrate about their fixed positions.

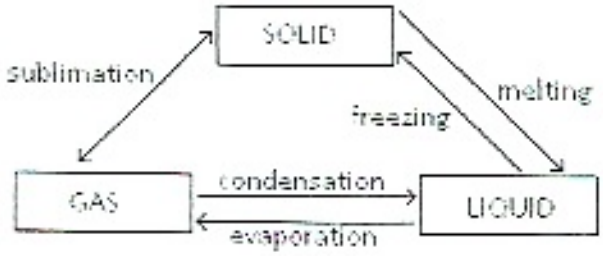


Particles are closely packed in an irregular manner with weaker attractive forces than those in solids. They however, are able to slide past each other.



Particles are relatively far apart due to very weak attractive forces and are able to move randomly and more rapidly

✓ *Changes of states; the change in temperature and pressure can cause substances to change their physical states. The diagram below summarizes these changes.*



✓ *A physical change is a change in which no new substance is formed; for it can easily be reversed e.g. water can turn into ice and vice versa. On the contrary, a chemical change is one in which a new substance is formed after the change. Energy is given out in these changes and they are therefore irreversible, e.g. burning of paper.*

Question 5

Some properties of four chemical elements are shown in the table below. Each element is represented by a letter.

Element	Melting point	Boiling point	Electrical conductivity at r.t.p	Action of cold water on element
D	-219	-183	None	Dissolves slightly
E	-39	357	Good	Unaffected
F	98	890	Good	Unaffected
G	3550	4827	Good	Unaffected

Write down the letter representing the element which:-

(a) Is a gas at r.t.p.[1]

(b) Is a liquid at r.t.p. [1]

(c) Is a solid at r.t.p and will melt when dropped into boiling water. [1]

(d) Is a transition metal. [1]

(e) Could be mercury. [1]

(a) D

*** TAKE NOTE.**

Room Temperature and Pressure (r.t.p) is taken to be 25°c. Therefore, any substance that boils at a temperature less than 25°c will be a gas at r.t.p.

(b) E

*** TAKE NOTE.**

Room Temperature and Pressure (r.t.p) is taken to be 25°c. Therefore, at 25°c element E will be a liquid. Both D and E would have melted by 25°c. However, at 25°c, D will be in gaseous form because of its low boiling point while E will be in liquid form because its boiling point is higher than 25°c.

(c) F

*** TAKE NOTE.**

F and G are solids because both have their melting and boiling points above 25°c but only F will melt when dropped into boiling water because its melting point is lower than 100°c, the boiling point of water.

(d) G

*** TAKE NOTE.**

One known fact about transition metals is that they have high densities, melting/boiling points because of strong forces which hold the electrons.

(e) E

*** TAKE NOTE.**

Mercury being a metal has a high boiling point. However because of its low melting point, it is always a liquid at room temperature.

Question 6

(a) State the basic units of matter present in

(i) Oxygen gas

(ii) Solid sodium chloride

(iii) Molten aluminium oxide [3]

(b) Substance A melts at 28◦C and boils at 246°C. In the boxes below show the arrangement of the particles at the given temperature.

16°C

262°C

[2]

[SCIENCE – 5124/P3/Q1/2007]

WORKED SOLUTIONS

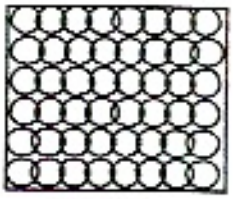
(a)

(i) Oxygen atoms

(ii) Sodium and chloride atoms

(iii) Aluminium and oxygen atoms

(b)



16°C

262°C

TAKE NOTE:

- *At 16°C the substance would be in solid state because it has not yet reached the melting point (28°C).*
- *At 262°C the substance would have past the boiling point, hence, it would be in gas state.*

Question 7

(a) Matter is made up of tiny particles. One piece of evidence that shows the particulate nature of matter is the process of **diffusion.**

(i) Explain what is meant by the term 'diffusion'. [2]

(ii) In what state(s) of matter does diffusion occur? [2]

(iii) State any two factors which affect the rate of diffusion. [2]

(b) A gas jar of oxygen was inverted and placed on top of a gas jar containing nitrogen dioxide as shown in figure 1.1 below.

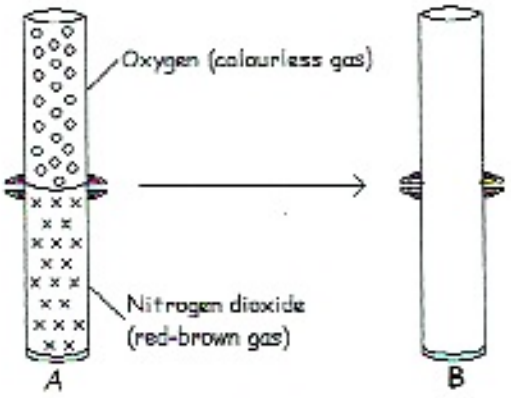


Figure 1.1

(c) Complete the diagram on figure 1.1 B to show the arrangement of the molecules of the two gases after being left in contact for 15 to 30 minutes. [2]

[SCIENCE - 5124/P3/Q1/2008]

WORKED SOLUTIONS

(a) Diffusion is the movement of particles from a region of their higher concentration to a region of their lower concentration down the concentration gradient.

ii) Diffusion occurs only in gases and liquids

TAKE NOTE.

Diffusion does not occur in solids because particles in solids are in a fixed position and only vibrate, they therefore cannot move from one region to another.

iii) Factors affecting the rate of diffusion include; temperature, concentration gradient and particle size.

*** TAKE NOTE.**

Temperature: when temperatures are high, solid or liquid particles gain more kinetic energy and move faster and vice versa.

Concentration gradient: diffusion is faster if there is a larger difference in the concentration of particles between two regions.

Particle size: generally, the greater the size of the particles, the greater the mass and so is the weight. Therefore particles which are heavier move slowly while those which are lighter move faster.

(b)

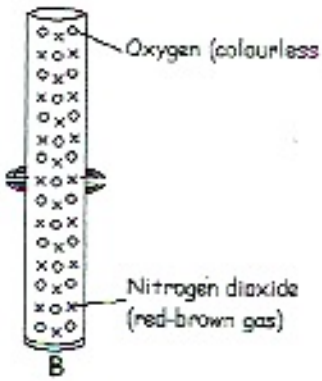


Figure 1.1(B)

*** TAKE NOTE.**

Particles of nitrogen dioxide move from their area of high concentration to that of their lower concentration (diffusion) and so do oxygen particles. This eventually results in the particles of the gases being evenly spread throughout the container. This is an illustration of diffusion.

CONCISE INFORMATION *(DIFFUSION)*

- ✓ *Diffusion is the movement of liquid or gaseous particles from a region of higher concentration to a region of lower concentration down the concentration gradient.*
- ✓ *The states of matter in which diffusion occurs i.e. Gases and liquids.*
- ✓ *Factors that affect the rate of diffusion i.e. Temperature, concentration gradient and particle size.*
- ✓ *Even distribution of particles in liquids or the even spread of gases are illustrations of diffusion.*

Question 8

Use your knowledge on the kinetic theory of matter to suggest a reason for each of the following occurrences.

(a) Wet clothes dry up faster on warm days than on cold days. [1]

(b) Solid ice loses its shape when it melts. [1]

(c) Salt dissolves faster in hot water than in cold water. [1]

(d) When sugar is dissolved into a glass of water even without stirring, the water soon tastes sweet. [1]

[SCIENCE - 5124/P3/Q1/2010]

WORKED SOLUTIONS

(a) Water particles in wet clothes gain more kinetic energy from high temperatures on a warm day and evaporate faster from the clothes, resulting in quick drying of the clothes.

***TAKE NOTE:** The higher the temperature, the faster the movement of particles on an average*

(b) Particles in solid ice vibrate in a fixed position, however as the ice melts, it gains heat which breaks the strong forces that hold the particles together. This results in particles being able to slide over each other and move in different directions, resulting in loss of shape.

***TAKE NOTE**

The only motion evident among solid particles is vibration, due to strong forces between particles, which results in solids having a fixed shape, however, particles in liquids have weak attractive forces and are free to move about, resulting in no fixed shape.

(c) The salt particles move faster with increased kinetic energy from the heat in the hot water. Hence the faster the movement of the salt particles, the more they collide with water molecules and dissolve.

(d) When sugar is dissolved in a glass of water, the particles of sugar begin to spread out evenly (diffuse) resulting in sweetening of the water even without stirring.

***TAKE NOTE:** Diffusion takes place.*

CONCISE INFORMATION (KINETIC THEORY OF MATTER)

- ✓ *The kinetic theory of matter explains the physical properties of matter in terms of the movement and behaviour of its constituent particles.*
- ✓ *The answers relating to the kinetic theory should be based on the movement of particles in relation to kinetic energy and heat.*
- ✓ *Appropriate assumption of the kinetic theory can be used to explain the physical behaviour of matter.*
  - *All matter is made up of tiny moving particles, invisible to the naked eye*
  - *Different substances have different types of particles (atoms, ions, molecules) which have different sizes*
  - *The particles move at all times. The higher the temperature, the faster the movement of the particles on average.*
  - *Smaller particles move faster than larger ones.*

CHAPTER 2 SEPARATION TECHNIQUES

Question 1

The table below shows some apparatus used in the laboratory.

Separating funnel	Beaker	Gas jar
Desicator	Spatula	Laboratory thermometer
Evaporating dish	Bunsen burner	Bee hivesheet
Burette	pippete	

State the apparatus used …

(a) As a source of heat [1]

(b) For measuring a fixed volume of liquid [1]

(c) For drying substances or keeping them free from moisture [1]

(d) For measuring temperature [1]

(e) For separating immiscible liquids [1]

[SCIENCE – 5124/P3/Q2/2007]

WORKED SOLUTIONS

(a) Bunsen burner

(b) Pipette

(c) desicator

(d) Laboratory thermometer

(e) Separating funnel

Question 2

Use the list of separation techniques below to answer the questions that follow.

Fractional distillation /Simple distillation /Use of separating funnel /Magnetism /Chromatography /Evaporation /Filtration.

Choose one method from the list above which can be used to separate ;-

(a) Sand from water. [1]

(b) Oil from water. [1]

(c) Water from ink. [1]

(d) Sulpher from iron fillings. [1]

(e) Salt from parrafin. [1]

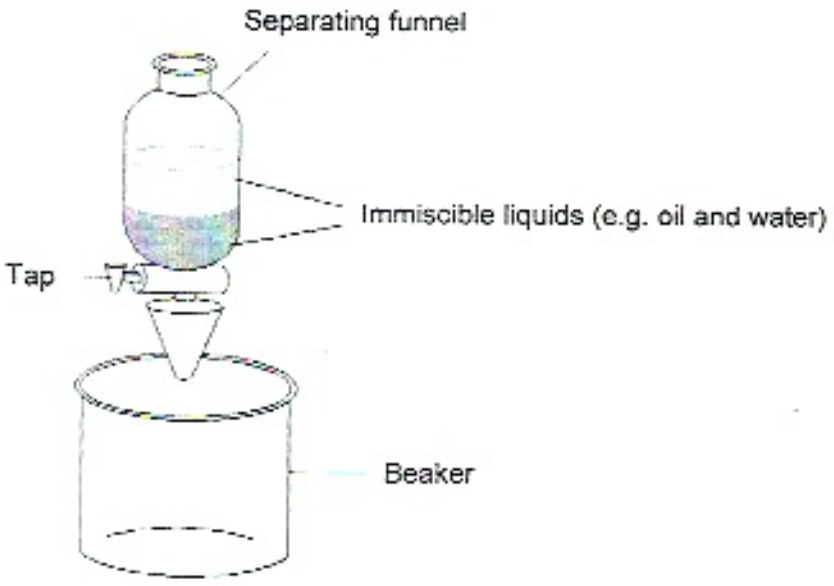
WORKED SOLUTIONS

(a) Filtration.

(b) Use of separating funnel.

***TAKE NOTE**

A separating funnel is a piece of apparatus used to separate immiscible liquids. Since water and oil do not mix, they qualify for separation by this technique. The denser liquid forms the lower layer and is drained off first when the tap is opened. This can be illustrated as follows.



(c) Simple distillation.

(d) Magnetism.

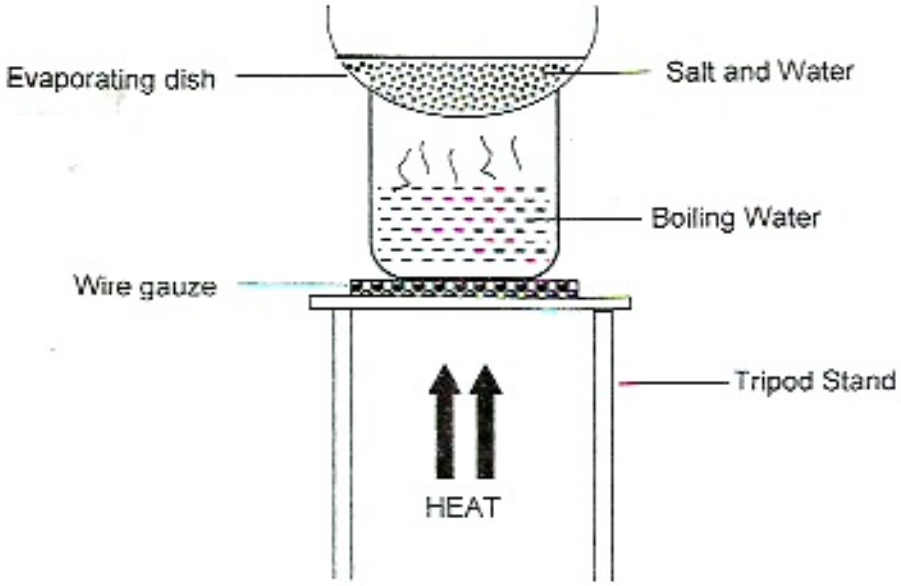
***TAKE NOTE**

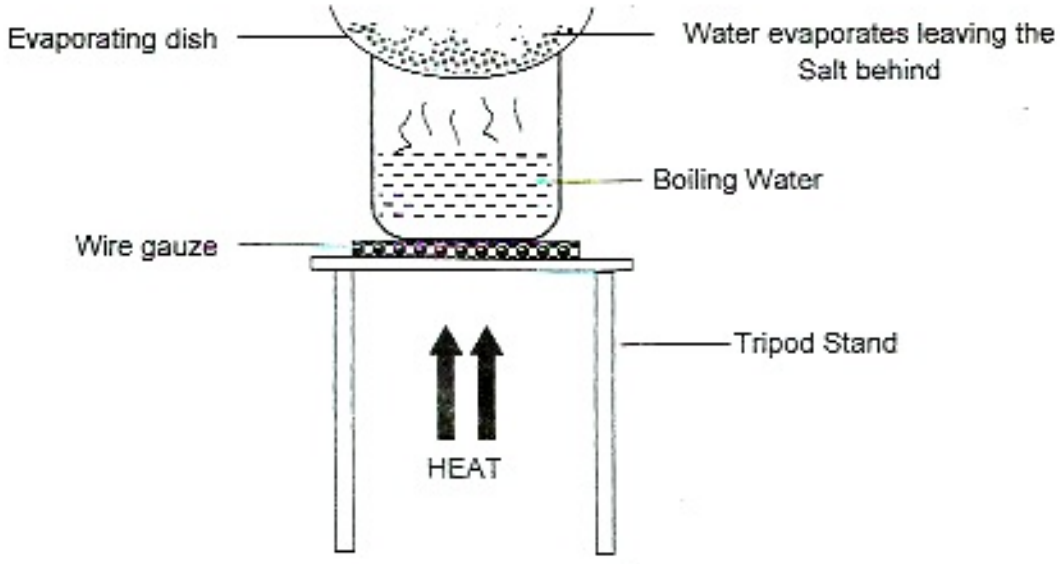
Separation by magnetism can be used where one component of the mixture is magnetc while the other is not. In this case. Iron is magnetic while Sulphur is not, therefore if a magnet where to be placed over the mixture, all the magnetic Iron would get attracted to the magnet, leaving only the sulphur behind.

(e) Filtration.

*** TAKE NOTE**

To separate salt from a solution of salt in water, the process of evaporation is used illustrated below.The water has a lower boiling point than the salt. The solution is heated, which causes the evaporation of the water, leaving behind the salt. However, in the case of parafin, filtration is used because salt being ionic cannot dissolve in paraffin which is an organic solvent.





Question 3

Below are some processes which are used in a laboratory, industry and at home:

Crystalisation

Distillation

Filtration

Neutralization

Combustion

Esterification

Galvanization

Polymerization

(a) Which of the processes listed above can be used to separate the following from a sample of sea water?

(i) Salt [1]

(ii) Water [1]

(iii) Sand [1]

(b) State the process from the list of processes above that can be used to:

(i) Manufacture plastics for making baskets. [1]

(ii) Produce carbon dioxide from carbon. [1]

[SCIENCE - 5124/P3/Q2/2010]

WORKED SOLUTIONS

(a) (i) Crystallisation

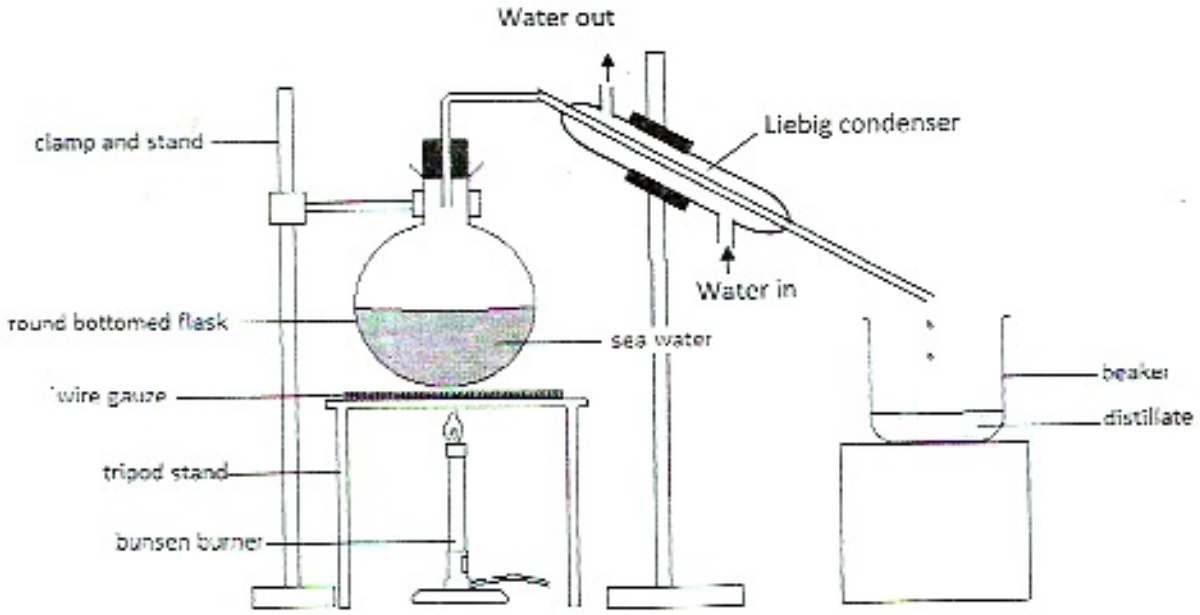
***TAKE NOTE**

Salt in water is in dissolved form therefore forming a solution. Separation of solids from solution can be carried out by evaporation or crystallisation. Evaporation gives only a powder, while crystallisation results in proper crystals.

(ii) Distillation

*** TAKE NOTE**

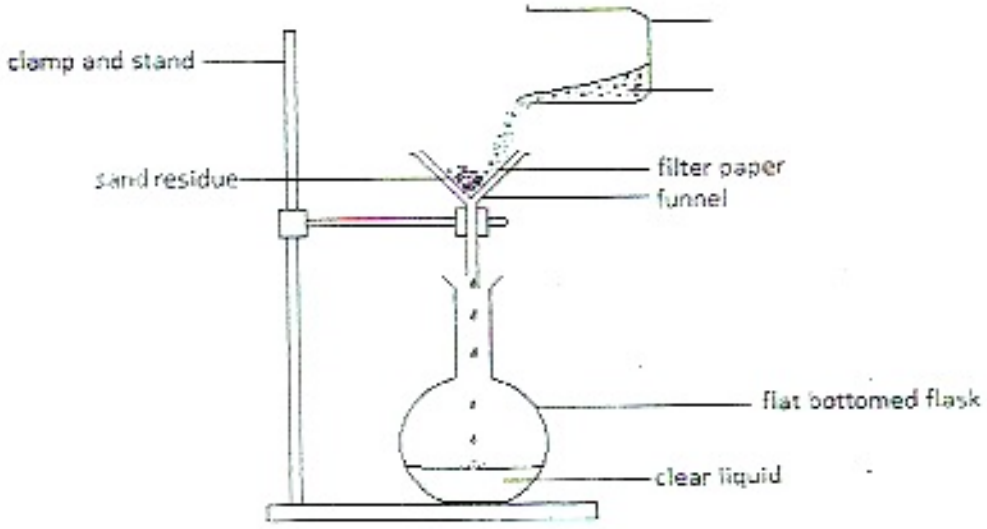
To separate a liquid from a solute dissolved in it, distillation is used. During distillation, the liquid is vaporised and then condensed. The liquid can easily be tapped off in a flask using the apparatus shown below:



(iii) Filtration

*** TAKE NOTE**

Insoluble sand can be separated from liquids by filtration. A filter paper i



(b)

(i) Polymerisation

(ii) Combustion

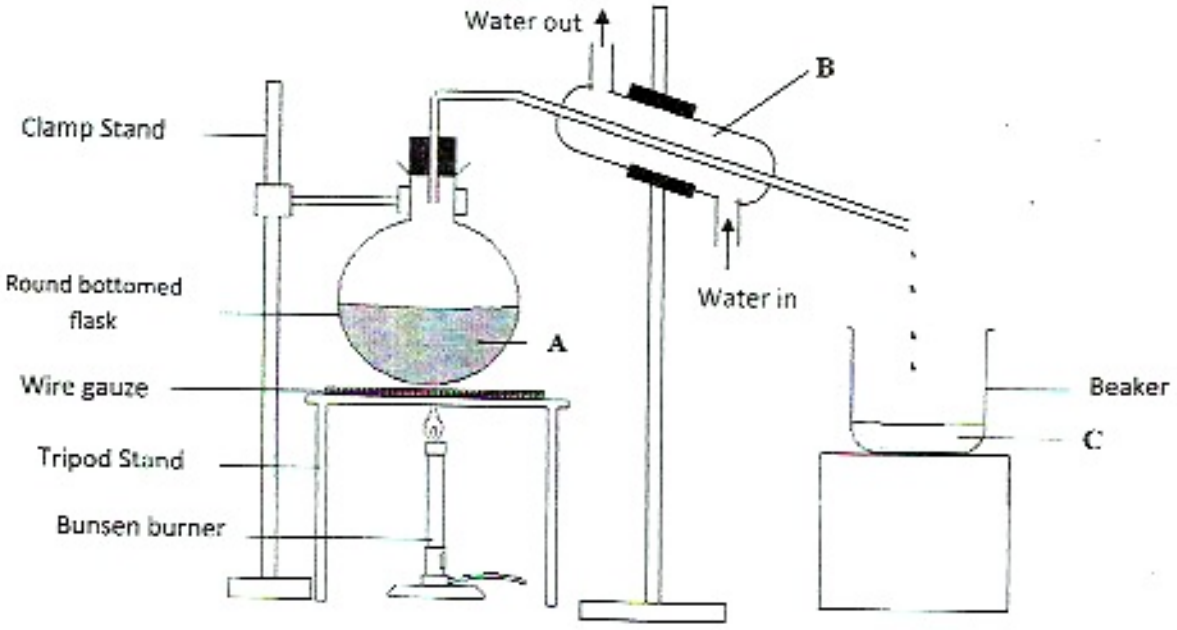
CONCISE INFORMATION *(SEPARATION OF SOLUTES AND SOLVENTS)*

✓ *Pupils commonly mistake the separation methods for solutes and solvents. A solute is a substance that dissolves in a liquid (solvent) and is separated from the solvent by evaporation or crystallisation. A solvent is a liquid in which a solid (solute) dissolves. It can de separated from the solute by evaporating the liquid and then condensing it, in a process called distillation. The boiling point of the liquid is usually very much lower than that of the dissolved solid, therefore when heat is applied the liquid evaporates before the solute can. For insoluble solids like sand, the liquid can simply be separated from the sand by use of a filter paper in a filter funnel and a beaker, a process known as filtration.*

Question 4

The diagram below shows the pieces of apparatus used to separate a certain mixture.

Liquid is vaporised and then condensed. The liquid can easily be tapped off in a flask using the apparatus shown below;



(a) Name the separation technique used. [1]

(b) State the type of mixture that can be separated by this method. [1]

(c) State the name of the apparatus labelled;

i) A

ii) B [2]

(d) State the term used to describe liquid C. [1]

(e) State one large sale use of this seperation technique. [1]

[CHEMISTRY/5070/2/Z/2010]

WORKED SOLUTIONS

(a) Distillation (i.e. Simple distillation)

(b) A solution (mixture of a solute and a solvent) can be separated using this technique.

***TAKE NOTE**

Distillation is used to separate liquid from solution. For this method to be used, the liquid must have a lower boiling point than the solute dissolved in it so that it can evaporate with the application of heat and then condensed in the condenser. The solute must be a non-volatile one such that it does not go into vapour phase itself on application of heat.

(c) i) A: is a round bottomed flask / distillation flask

ii) B: is a liebig condenser.

(d) The liquid collected after the process of distillation is called a distillate. Therefore liquid C is a distillate.

(e) Large scale uses of distillation include;

i) Making distilled water for filling of car batteries.

ii) Making distilled water for dissolving medicines (such as powdered injectables)

Question 5

Two miscible liquids with boiling points of 78°C and 100°C where accidentally mixed.

(a) Name the process which can be used to separate the mixture. [1]

(b) Draw a labeled diagram showing the arrangement of the apparatus used to separate the mixture.

(c) Explain how you can obtain hydrated sodium sulphate crystals from an aqueous solution of sodium sulphate. [2]

[SCIENCE – 5124/P3/Q2/2012]

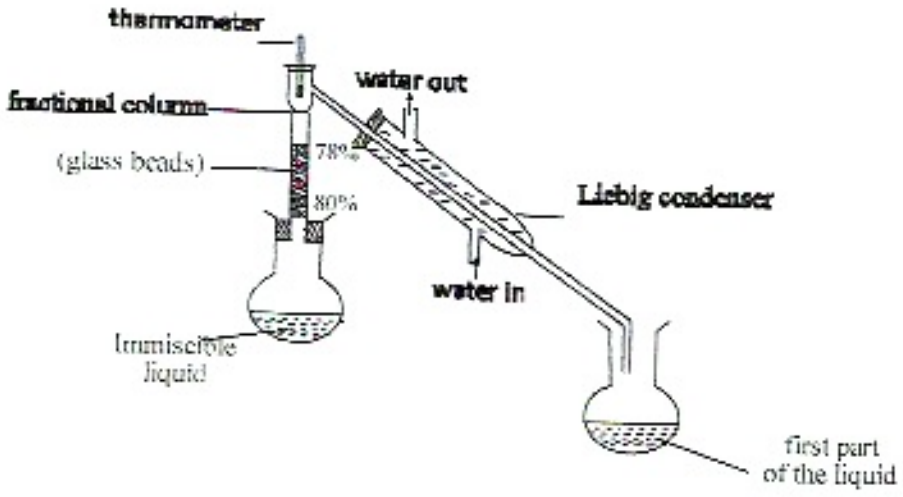
WORKED SOLUTIONS

(a) Fractional distillation

TAKE NOTE:

Fractional distillation process takes advantage of the different boiling points of miscible liquids to separate them.

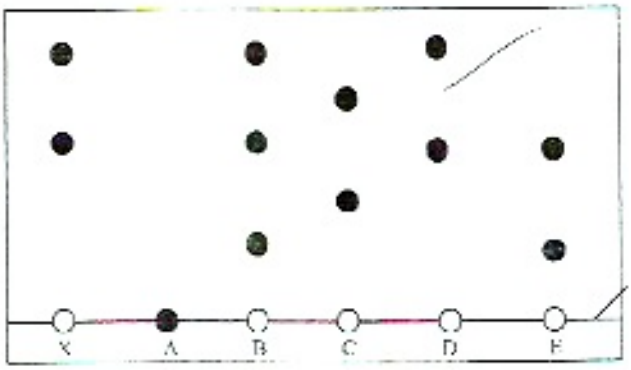
(b)



(c) Hydrated sodium sulphate crystals can be obtained from an aqueous solution of sodium sulphate by means of evaporation. Heat the solution in an evaporating dish. This will cause the water to evaporate leaving behind the hydrated sodium sulphate.

Question 6

Paper chromatography was used to catch a forger. A sample of ink, X from a forged signature was compared with inks from the pens of five suspects. The diagram below shows the chromatogram obtained.



(a) Draw the apparatus you would use to produce the chromatogram. [2]

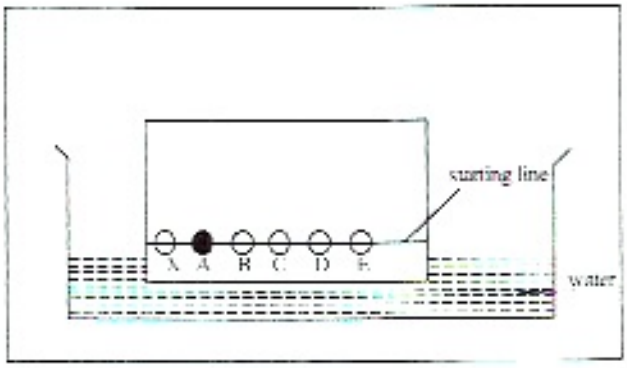
(b) Which of the inks A, B, C, D, or E could have been used to write the forged signature? [1]

(c) Which of the inks is insoluble in water? [1]

[SCIENCE – 5124/P3/Q3]

WORKED SOLUTIONS

(a)



(b) Ink D

*TAKE NOTE

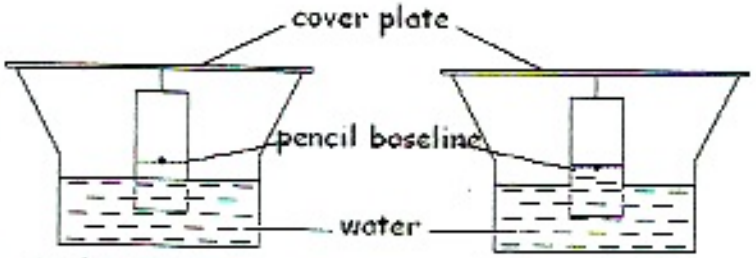
Ink D produced two spots and at similar positions to spots from ink X from forged signature indicating that the ink is the same.

(c) ink A

***TAKE NOTE:** ink A was immobile indicating that it did not dissolve in water.*

Question 7

A substance D contains three dyes, two of which are soluble in water, while the other is insoluble.



At the start of the experiment
Fig (1)

At the end of the experiment
Fig (2)

(a) Sketch the results one would expect to see if ink spot D were separated by paper chromatography. [2]

(b) Why was a pencil used to mark the baseline instead of ink? [2]

(c) Why must the baseline be placed above the level of water at the start of the experiment? [1]

(d) Define Rf value of a solute. [1]

(e) State one commercial application of chromatography. [1]

[CHEMISTRY/5070/2/Z/2007]

WORKED SOLUTIONS

(a)

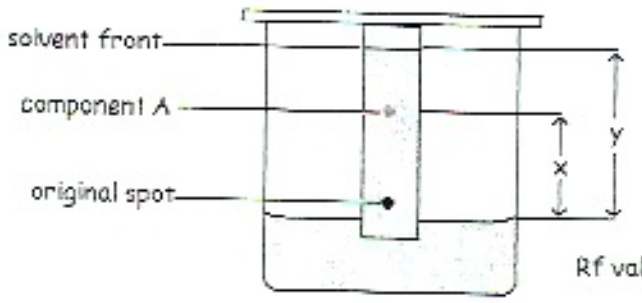
*** TAKE NOTE**

The original spot contains three different substances of different solubilities, of which two are soluble and one is not. The movement of a substance in chromatography depends on its solubility in the provided solvent, in this case, water. Hence, the two soluble dyes will ascend with the solvent while the insoluble dye will not ascend, resulting in the above results. Also, the more soluble the solute, the quicker the movement of the dye. Weakly absorbed dyes are carried along more rapidly by the advancing solvent.

(b) A pencil is used to mark the baseline instead of ink because ink contains a mixture of dyes and can affect or interfere with the results of the experiment by producing more other spots.

(c) The baseline must be placed above the solvent to enable the solvent (water) to ascend up the filter paper and dissolve the dye so that its components can be separated while being carried along by the advancing solvent.

(d) Rf value is the distance travelled by a given component divided by the distance travelled by the solvent front.



$$\text{Rf value} = \frac{\text{distance travelled by component A}}{\text{distance travelled by solvent front}} = \frac{X}{Y}$$

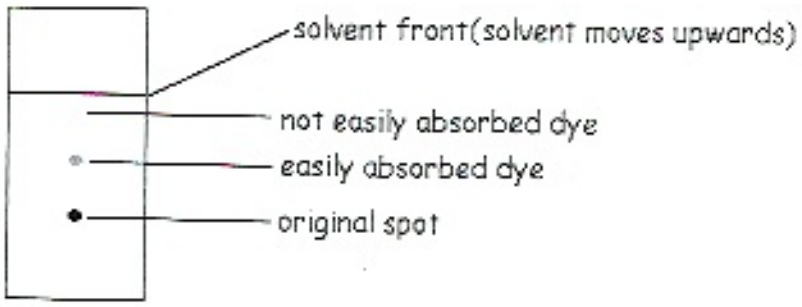
(e) Commercial applications of chromatography include;

- Identifying the flavouring components of food stuffs.
- Separating pigments in plants.
- Separating antibiotic drugs from growing media.
- Separating amino acids from proteins.

CONCISE INFORMATION (CHROMATOGRAPHY)

✓ *Ascending Chromatography*

- *In ascending chromatography the solute components are carried along by the solvent being absorbed by the paper and are also re-dissolved. Components that are easily absorbed lag behind, while those that are not easily absorbed are carried along by the rapidly advancing solvent. The solute compounds eventually become separated at different levels forming coloured bands. TIP☺ a person who has studied and prepared for an exam will finish answering faster than one who has not studied and prepared, in they same way, an easily absorbed dye will appear first and closest to the original spot, while a not easily absorbed dye will appear after the easily absorbed dye. As shown below.*



SUMMARY (THE MAIN SEPERATION TECHNIQUES)

✓ *Filtration*

This is used for separation of insoluble solids from liquids using a filter paper.

✓ *Separating funnel*

A separating funnel is a piece of apparatus used to separate immiscible liquids.

✓ *Evaporation/Crystallisation*

Evaporation is used to separate soluble solids (solutes) from their liquid solutions, but this only results in powdered solids, however, to obtain proper crystals, crystallisation is used.

✓ *Simple distillation*

This method is used to separate liquids (solvents) from their solutions.

✓ *Fractional distillation*

This method is used to separate miscible liquids with different boiling points.

✓ *Chromatography*

This is a technique used to separate mixtures of solute using a solvent and a separating medium.

CHAPTER 3 ATOMIC STRUCTURE/CHEMICAL BONDING

Question 1

(a) The table below shows the three isotopes of the element hydrogen and their nucleon (mass) numbers. Complete the table to show the number of particles in the three nuclides.

Symbol	Name	Nucleon (mass) number	protons	neutrons
H	Hydrogen	1		
D	Deuterium	2		
T	Tritium	3		

[3]

(b) Construct an equation for the reaction between D2O and calcium. [1]

[SCIENCE – 5124/P3/Q1/2006]

WORKED SOLUTIONS

(a)

Symbol	Name	Nucleon (mass) number	protons	neutrons
H	Hydrogen	1	1	0
D	Deuterium	2	1	1
T	Tritium	3	1	2

TAKE NOTE:

Isotopes have the same proton number but different mass (nucleon) number. What make their masses to be different is their differences in their neutron number. Knowing their proton number and their mass numbers you can use the equation below to calculate the mass number:

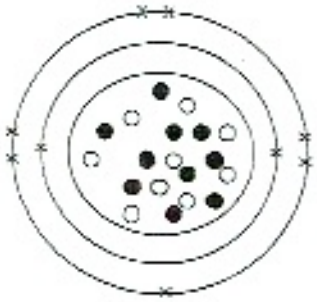
Mass number = proton number + neutron number

(b) $D_2O + Ca \rightarrow Ca(OD)_2 + D_2$

Question 2

(a) What is meant by the term 'proton number of an element'? [1]

(b) The diagram below shows the structure of an atom of the element B.



(i) Complete the table below about the three different sub atomic particles present in an atom of element B.

Sub-atomic particle	Number of particles	Name of particle
X		
•		
o		

[3]

(ii) In which group of the periodic table is element B found? [1]

(iii) State the formula of an ion formed by element B. [1]

(c) Element B reacts with magnesium to form a compound. Construct a 'dot and cross' diagram to show the bonding between element B and magnesium. (show outer shell only.)

[SCIENCE – 5124/P3/Q3/2007]

WORKED SOLUTIONS

(a) Proton number is the number of protons in the nucleus of an atom.

(b)

(i)

Sub-atomic particle	Number of particles	Name of particle
X	9	Elements
•	10	Neutrons
o	9	Protons

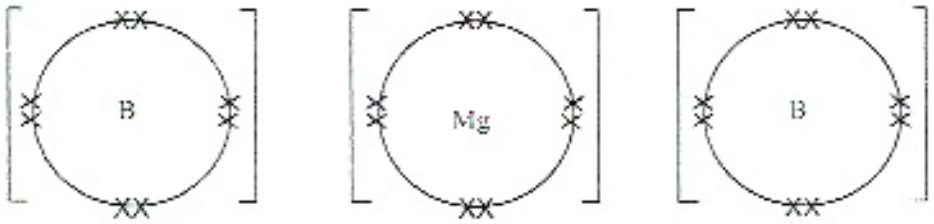
(ii) Group seven VII

Take note: group number is determined by the number of electrons in the outer shell. The element has seven electrons in the outer shell, therefore, it is in group VII.

(iii) B^-

TAKE NOTE: *element B gains one electron to to attain stability and becomes negatively charged.*

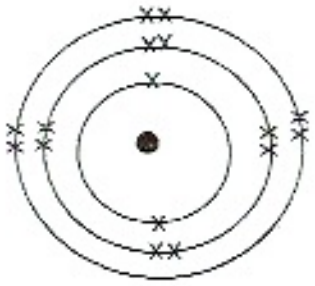
(c)



MgB_2

Question 3

The diagram below represents electrons (x) arrangement of a particular atom. Study this diagram and answer the questions that follow.



(a) The relative atomic mass of the atom represented is 32.

(i) What is its nucleon number? [1]

(ii) What is the neutron number of the atom? [1]

(b) (i) in which group of the Periodic Table is the element found?

(ii). Explain your answer in (b) (i) [1]

[SCIENCE – 5124/P3/Q4/2002]

WORKED SOLUTIONS

(a)

(i) Nucleon number is 32

Note: nucleon number is same as atomic mass

(ii) Neutron number is 16

TAKE NOTE: *neutron number = mass number – proton number*

(b)

(i) Group VI

(ii) Group number is equal to the number of electrons in the outer shell. There are 6 electrons in the shell the atom given.

Question 4

An element has an isotope with a nucleon number of 7. Each neutral atom of this isotope has three electrons and a nucleus containing two different types of particles.

(a) Give the names of these particles and the number of the particles present in each nucleus. [2]

Name of particle.	Number of particles.

ii) Compare the masses and the electrical charges of these particles.

Masses:

Electrical charges:

(b) What is the difference in the nuclei of this atom and its isotope whose nucleon number is 6? [1]

[SCIENCE - 5124/P3/2010]

WORKED SOLUTIONS

(a)

Name of particle.	Number of particles.
Proton	3
Neutron	4

***TAKE NOTE**

In order to arrive at the number of particles in an atom the following information is vital:

i) Proton number = no of electrons.

(Proton number is also equal to the atomic number).

ii) Mass number = atomic number (proton number) + neutron number, therefore neutron number = mass number – atomic number (proton number).

In the question above, the mass number is given as 7 and we are informed that the electron number is 3; the proton number is equal to the electron number, hence it is also 3. The neutron number is obtained as follows:

Neutron no = Mass no – Atomic no

= 7 – 3

= 4

ii) The proton has a mass of 1 a.m.u. and it is positively charged, whereas the neutron has a mass of 1 a.m.u. but has no charge.

(b) The two nuclei have different neutron numbers. The isotope with mass number 7 has 4 neutrons while the isotope with mass number 6 has 3 neutrons.

***TAKE NOTE**

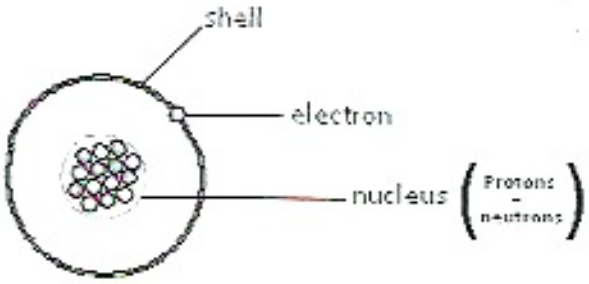
Isotopes are atoms of the same element having the same number of protons but different number of neutrons and mass numbers. The following is a summary of similarities and differences among isotopes:

Similarities	Number of particles
They are atoms of the same element.	They have different mass numbers.
They have the same number of protons.	They have different number of neutrons.

NOTE: what makes their masses different is the difference in the number of neutrons, since their proton numbers are the same in isotopes of the same element.

CONCISE INFORMATION (ATOMIC STRUCTURE)

✓ Atoms are made up of three fundamental particles, namely protons, neutrons and electrons. The protons and neutrons are contained in the nucleus while the electrons revolve around the nucleus on paths called shells or energy levels.



Characteristics of fundamental particles

Particle	Relative atomic mass	Charge
Proton	1	+1
Neutron	1	Neutral
Electron	1/1840	- 1

✓ Atomic and Mass numbers

- Atomic no: the number of protons in the nucleus of an atom. It is also referred to as proton number.
- Mass no: the sum of the number of protons and neutrons in a nucleus of an atom. It is also called the nucleon number.

MR. INNOCENT MULA KALALILIKA
10 TO 12 GREEN ALIFE

EDUCATION 4 LIFE

CHEMISTRY PAMPHLET

JUST STUDY HARD.

WORK LYK A SLAVE,
TO LIVE LYK A KING
IT IS VERY IMPOSSIBLE
TO ~~FAIL~~ AN EXAM BUT
POSSIBLE TO PASS. JUST
HAVE TIMING IN YOUR-
STUDIES AMEN: ALIFE

$= X \cdot Y Z$

Question 5

Fluorine can form either covalent or ionic bonds.

(a) Draw an electron shell diagram to show the bonding in;

i) Sodium fluoride NaF, *showing all the electrons.*

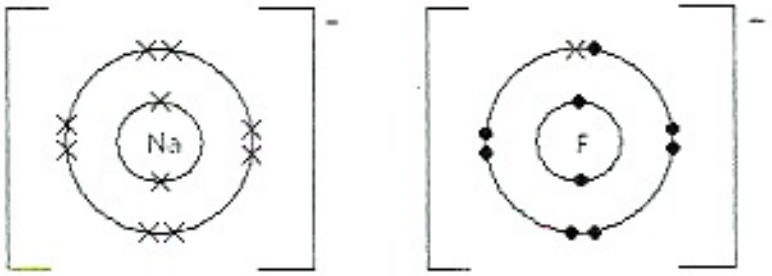
ii) Fluorine, F_2 showing all the electrons.

(b) Explain why sodium fluoride has a higher melting point than fluorine.

[CHEMISTRY/5070/2/2/2007]

WORKED SOLUTIONS

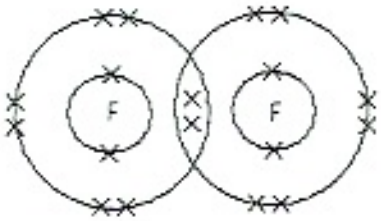
(a) (i)



*** TAKE NOTE**

Ionic bonding is the type of bonding that takes place between a metal and a non-metal, where the metal loses electron(s) and the non-metal gains the same electron(s) during the bonding process, turning both into charged ions. Sodium (Na) has 11 electrons (proton number =11) and its configuration is 2:8:1, it therefore needs to lose the only electron in its outermost shell to attain stability and a full outermost shell which will result in it becoming a positive ion (cation) with a configuration of 2:8. Fluorine, on the other hand, has 9 electrons (proton number =9) and its electronic configuration is 2:7, it therefore has seven electrons in its outermost shell and needs to gain one electron to attain stability and a full outermost shell which will result in it becoming a negative ion (anion) with a configuration of 2:8. Hence in the above situation, the electron lost by Sodium is gained by Fluorine, forming oppositely charged ions which attract each other, forming an ionic bond (force of attraction between a cation and an anion.)

(ii)



TAKE NOTE

Fluorine undergoes covalent bonding with itself. Covalent bonding thus occur between non-metals. This type of bonding involves the sharing of electrons by both non-metals so that both can attain stability. In the above situation, both atoms of fluorine need one more electron in their outer shell to be stable, hence, share two electrons with each other to form a bond.

(b) The force of attraction between Sodium and fluorine is stronger compared to the force of attraction between the shared electrons, as a result, sodium fluoride(NaF) requires a lot of energy (high temperature) for the bond to be broken, hence the melting point is higher.

CONCISE INFORMATION (BONDING)

- ✓ *Atoms combine with each other by forming bonds.*
- ✓ *Bonding is usually as a result of atoms trying to achieve stability by acquiring a stable configuration of electrons in the outermost shell. This can be achieved by losing and gaining, or sharing electrons*

  - *An uncombined atom has a neutral charge because it has an equal number of protons, (which are positively charged) and electrons (which are negatively charged). However, if it loses an electron(s) during the bonding process, it becomes positive because the number of positive protons becomes higher than the number of negative electrons. But if the atom gains electrons during the bonding process, it becomes negative because the number of negative electrons becomes higher than the number of positive protons.*

Question 6

Study the electronic configurations of sodium and chlorine atoms.

Sodium: 2.8.1

Chlorine: 2.8.7

(a) What is the charge on the sodium atom? [1]

(b) How many outer shell electrons are there around a chloride ion? [1]

(c) Write the equation for the reaction between sodium and chlorine. [2]

(d) Why is the relative atomic mass of chlorine not a whole number? [1]

(e) In the ionic compound of sodium and chlorine how are the two ions held together? [1]

[SCIENCE – 5024/P3/Q2/2004]

WORKED SOLUTIONS

(a) Positive charge

(b) 8 electrons

*TAKE NOTE: *to form an ion the chlorine atom will gain one more electron to complete the octate number.*

(c) $Na + Cl \rightarrow NaCl$

(d) Relative atomic mass of chlorine is not a whole number because it is an average of the masses of the chlorine isotopes.

(e) The two ions (Na^+ and Cl^-) are held together by an electrostatic force created by the opposite charges.

Question 7

Figure 2.1 below shows the structure of a compound.

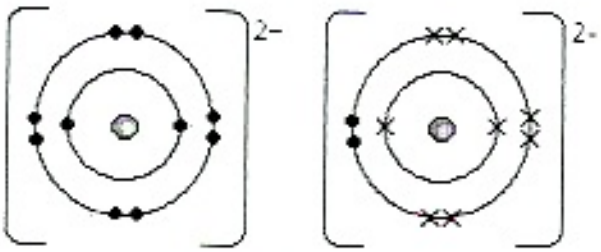


Figure 2.1

(a) Name the compound shown. [1]

(b) Write down the chemical formula of the compound. [1]

(c) What type of bonding is present in the compound? [1]

(d) State any two physical properties you would expect the compound to have. [2]

[SCIENCE - 5124/P3/2008]

WORKED SOLUTIONS

(a) Magnesium oxide

(b) MgO

(c) Ionic bonding

(d) -The compound is soluble in water, but insoluble in organic solvents like ethanol.

-The compound is a solid at room temperature.

Question 8

(a) Draw electron shell diagram to show the ionic bonding in ;

i) Magnesium Oxide [2]

ii) Lithium fluoride [2]

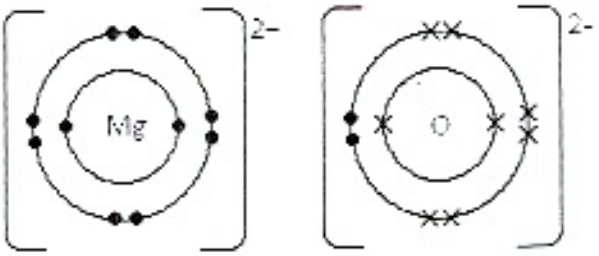
(b) Explain why;

i) metals are good conductors of electricity. [1]

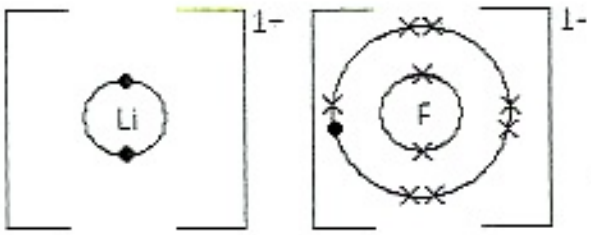
ii) ionic compounds have high melting and boiling points. [1]

[CHEMISTRY/5070/2/2008]

i)



ii)

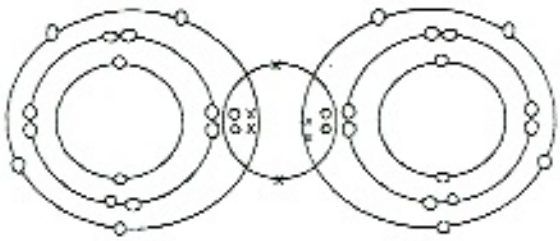


(c) i) Metals have free mobile (delocalized) electrons, which makes them able to conduct electricity.

ii) Ionic compounds have high melting and boiling points due to strong electrostatic forces of attraction between ions ,hence, breaking such bonds requires great energy.(high temperatures)

Question 9

The diagram below shows the dot and cross structure of compound R showing all the shells and the electrons.



(a) Use the Periodic Table to deduce the chemical and structural formulae of compound R. [2]

(b) Compare the bonding in compound R to that in calcium chloride. [1]

(c) Explain the difference in electrical conductivity between compound R and calcium chloride when in liquid form. [2]

[SCIENCE -5124/P3/Q2/2001]

WORKED SOLUTION

(a) Chemical formula xxxxxxxxxxxxxxx formula for calcium sulphide

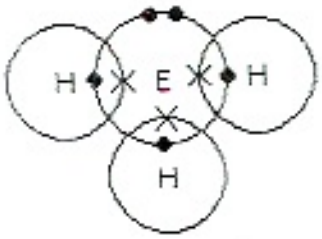
Structural formual: Ca=S

(b) The bonding in compound R involves sharing of electrons while that in calcium chloride involves transfer of electrons.

(c) In liquid form compound R does not conduct electricity while calcium chloride does. This is because unlike compound R the electrons are delocalised and mobile in calcium chloride.

Question 10

Element E whose proton number is 7 combines with hydrogen to form a gas.



(a) Identify element E. [1]

(b) What is the name of the gas? [1]

(c) Write the chemical formula of the gas. [1]

(d) What type of bonding holds the atoms together in this compound? [1]

(e) State one physical property of the gas that is due to the type of bonding it has. [1]

(f) Name another compound which has the same type of bonding. [1]

[SCIENCE - 512 4/P3/2011]

WORKED SOLUTIONS

(a) Nitrogen.

(b) Ammonia gas.

(c) NH_3

(d) Covalent bonding.

(e) Due to its type of bonding, ammonia is simple molecule with low melting point and low boiling point.

(f) Carbon dioxide (also water, hydrogen chloride, etc).

SUMMARY (IONIC AND COOVALENT BONDING)

✓ *Ionic bonding is the bonding that occurs between metals and non-metals and involves the transfer of electron(s) from the metal to the non-metal and ions are formed in the process. An ionic bond is formed during this process.*

- *Characteristics of ionic compounds include;*

- *They are made up of cations (positively charged metal ions) and anions (negatively charged non-metal ions)*
- *They conduct electricity in aqueous solution and in molten state.*
- *They are soluble in water but not in organic solvents*
- *They have generally high melting and boiling points*
- *They are non-volatile and generally solid at room temperature.*

✓ *Covalent bonding is the bonding that occurs between non-metals and involves the sharing of electron(s) between the non-metals and molecules are formed in the process. A covalent or molecular bond is formed during this process.*

- *Characteristics of covalent compounds include;*

- *They are made up of molecules.*
- *They do not conduct electricity in any state.*
- *They are insoluble in water but soluble in organic solvents such as petrol or ethanol.*
- *They have low melting and boiling points*
- *They are generally volatile.*

CHAPTER 4 CHEMICAL CHANGE (REACTIONS)

Question 1

The reaction below takes place during the production of calcium oxide when calcium carbonate is thermally decomposed.

$CaCO_3$ (g) → CO (s) + CO_2 (g)

(a) Give a common name for

(i) Calcium carbonate [1]

(ii) Calcium oxide [1]

(iii) Calcium hydroxide [1]

(b) What is the chemical formula of calcium hydroxide? [1]

[SCIENCE – 5124/P3/Q8/2009]

WORKED SOLUTIONS

(a) ..

(i) Chalk/limestone

(ii) Lime/quick lime

(iii) Slaked lime

(b) $Ca(OH)_2$

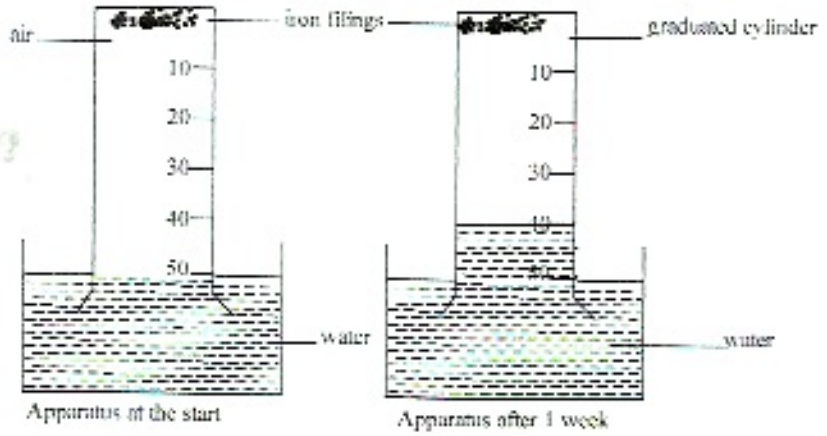
CONCISE INFORMATION (TRADE NAMES OF CHEMICALS)

The table below is a summary of common and trade names we encounter in the chemistry laboratory and names used in everyday life.

COMMON NAME	CHEMICAL NAME	FORMULA
Alcohol	Ethyl alcohol	
Baking Soda	Sodium hydrogen carbonate	NaHCO3
Baking Powder	Sodium bicarbonate	
Chalk/Egg Shells/Limestone/ Marble	Calcium carbonate	$CaCO_3$
Diamond	carbon	C
Lime/Quicklime/Sand/Silica	Calcium oxide	CaO
Quartz	Silicon dioxide	SiO2
Slaked Lime	Calcium hydroxide	Ca(OH)2
Soda Ash (Washing Soda)	Sodium carbonate	Na2CO2
Vinegar	Acetic, ethanoic acid	

Question 2

The following experiment was set up to investigate the effect of damp air on iron fillings. The graduated cylinder contained 50cm3 of air at the start.



(a) State two changes which would be observed after 1 week. [2]

(b) What volume of air was in the graduated cylinder after 1 week? [1]

(c) Calculate the % of air used up in the experiment. [2]

[SCIENCE – 5124/P3/Q9/2009]

WORKED SOLUTIONS

(a)

1. The iron fillings will turn brown (rusting)
2. The water level in the cylinder will rise

(b) 40cm3 of air

(c) $10cm^3/50cm^3$ X 100% = 20%

Question 3

a. Write a word equation for the reaction between Sodium hydroxide and Ammonium sulphate. [1]

b. Sodium hydroxide also reacts with sulphuric acid to form Sodium sulphate and Water.

i) Write a balanced chemical equation with state symbols for the reaction of sodium hydroxide with sulphuric acid. [1]

ii) Write an ionic equation for the above reaction. [1]

[CHEMISTRY/5070/2/2008]

WORKED SOLUTIONS

a. Sodium hydroxide + ammonium sulphate ⟶ sodium sulphate + ammonia gas + water

b. i) $2NaOH_{(aq)} + H2SO4\ (aq) \longrightarrow Na2SO4\ (aq) + 2H2O_{(l)}$

ii) $H^+_{(aq)} + OH_{(aq)} \longrightarrow H_2O_{(l)}$

CONCISE INFORMATION (CHEMICAL EQUATIONS)

- ✓ *The reaction between Sodium hydroxide and sulphuric acid is an example of a neutralisation reaction. In this type of reaction an acid (sulphuric acid) reacts with a base (sodium hydroxide) to form water and a salt.*
- ✓ *Chemical equations – An equation is a chemical sentence that describes what is going on in a chemical reaction. Chemical equations are always written with the reactants on the left and products on the right.*

Reactant(s) = product(s).
(LHS) (RHS)

The equation can contain the names (word equation) or formulae (symbol equation) of the substances. In addition to the formulae, in an equation, state symbols are added to the symbol or name of each product or reactant, to denote the physical states of the substances;

(s) – solids

(l) – liquids

(g) – gases

(aq) – aqueous [substance dissolved in water]

✓ *Steps to writing correct formulae equation.*

- *Write the correct symbols for the reactants and work out the formulae for the compounds formed using the valencies of the participating elements or radicals.*
- *add the state symbols to the formulae of the products and reactants.*
- *Balance the equation.*

Question 4

(a) Oxidation can be described as either the addition of oxygen to a substance or the removal of hydrogen from a substance. Study the reactions below and state whether the substance has been reduced or oxidised.

i) Copper(ii) oxide + ammonia ⟶ Copper + nitrogen + water

ii) Carbon dioxide + carbon ⟶ Carbon monoxide

iii) Iron(ii) oxide + aluminium ⟶ Aluminium oxide + iron

[3]

(b) Steam reacts with carbon as shown in the chemical equation.

$H_2O(g) + C(s) \longrightarrow H_2(g) + CO(g)$

Identify the oxidising agent. Give a reason for your answer. [2]

[SCIENCE - 5124/P3/Q7/2010]

WORKED SOLUTIONS

(a) i) Oxidised

ii) Reduced

iii) Oxidised

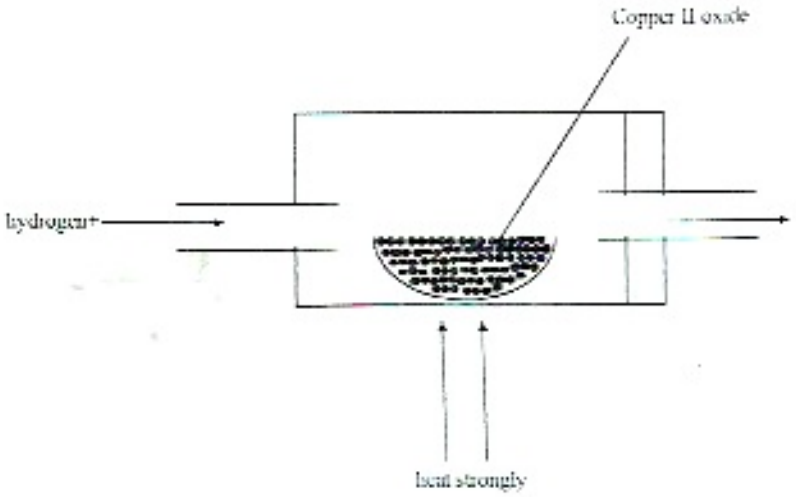
(b) In the reaction; H_2O is the oxidising agent. This is because an oxidising agent is a substance which causes another substance to be oxidised and is itself reduced. In the reaction, water loses oxygen (reduced) to carbon which is oxidized to carbon monoxide.

***TAKE NOTE**

A substance that causes oxidation is an oxidising agent while one that causes reduction is a reducing agent.

Question 5

The diagram below shows the action of hydrogen on copper(II) oxide.



During the reaction copper (II) oxide is changed to copper and steam is produced.

(a) Construct a balanced chemical equation including state symbols for the reaction. [2]

(b) In this reaction, state the oxidizing agent. [1]

(c) Describe the colour change that occurs on the copper (II) oxide as the reaction progresses. [2]

(d) What type of reaction is taking place in the diagram above? [1]

[SCIENCE – 5124/P3/Q5/2012]

WORKED SOLUTIONS

(a) H_2 (g) + CuO (aq) $\rightarrow$ Cu (s) + H_2O (l)

(b) Copper (II) oxide is oxidising agent

"TAKE NOTE:

Copper (II) oxide oxidizes hydrogen to hydrogen dioxide, therefore, it is the oxidising agent in the reaction.

(c) Copper (II) oxide turns red

(d) Redox reaction

Question 6

(a) State whether the following reactions could be decomposition, synthesis, displacement or redox reactions.

i) $2Fe(s) + 3Cl2(g) \longrightarrow 2FeCl3(s)$

ii) $CaCO3(s) \longrightarrow CaO(s) + CO2(g)$

iii) $Zn(s) + Pb(NO3)2(aq) \longrightarrow Pb(s) + Zn(NO3)_2(aq)$

iv) $Mg(s) + SnO(s) \longrightarrow Sn(s) + MgO(s)$

v) $FeCl3(aq) + H2S(g) \longrightarrow FeCl2(aq) + S(s) + 2HCl(aq)$

(b) 'When potassium chlorate is heated, oxygen is released. The release of oxygen is much easier when manganese (iv) oxide is used as a catalyst.'

i) What is a catalyst?

ii) What is the effect of a catalyst on a chemical reaction? (Total 7)

[SCIENCE - 5124/P3/I/20]

WORKED SOLUTIONS

(a) i) Synthesis reaction.

TAKE NOTE

Synthesis reactions are reactions where large complex molecules/compounds are built from simpler molecules/compounds.

ii) Decomposition reaction.

TAKE NOTE

Decomposition reactions are reactions where large complex molecules/compounds are broken down to form simpler molecules/compounds.

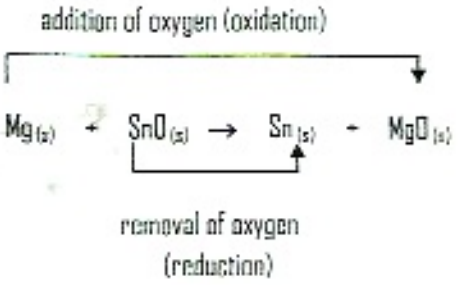
iii) Displacement reaction.

*** TAKE NOTE**

Displacement reactions are reactions where a more reactive element displaces a less reactive one from its compound.

iv) Redox reaction.

*** TAKE NOTE**



Redox reactions are reactions where an element is either reduced (loses oxygen) or oxidised (gains oxygen).

(b) A catalyst is a substance that increases the rate of a chemical reaction without itself undergoing any chemical change.

ii) Catalysts alter the speed of a chemical reaction by lowering the activation energy.

SUMMARY (CHEMICAL REACTIONS)

✓ *Types of reactions*

1. *Decomposition*

   Reactions in which a single compound is broken down into two or more products

   e.g. $CaCO_{3\,(s)} \xrightarrow{heat} CaO_{\,(s)} + CO_{2\,(g)}$

2. *Double decomposition*

   Reactions in which two compounds take part, both are decomposed and two new substances are formed by an exchange of radicals. E.g. AB + CD = AD + CB;

   $CuSO_4 + H_2S \longrightarrow CuS + H_2SO_4$

3. *Reversible reaction*

   This is a group of reactions in which the direction of chemical change can be reversed by changing the condition under which the reaction is taking place e.g

   $CuSO_4 \cdot 5H_2O \underset{H_2O}{\overset{heat}{\rightleftharpoons}} CuSO_4 + H_2O$

4. *Displacement reaction*

   Reactions that occur when a more reactive element(s) takes the place of a less reactive element(s) in its compound. A more reactive metal can displace a less reactive metal ion from its salt.

   $Zn_{(s)} + CuSO_4 \longrightarrow ZnSO_{4\,(aq)} + Cu_{\,(s)}$

5. *Endothermic reaction*

   Reactions which involve absorbance of heat from the surrounding. It has a positive change of enthalpy (Δ H);

   e.g. $\frac{1}{2} N_{2\,(g)} + \frac{1}{2} O_{2\,(g)} \longrightarrow NO_{(g)}\ \Delta H = +90.3\ kJ$

6. *Exothermic reaction*

   Reactions which involve release of heat to the surrounding. It has a negative charge of enthalpy (Δ H); e.g. $C_{(s)} + O_{2\,(g)} \longrightarrow CO_{2\,(g)}\ \Delta H = -40.6\ kJ/mol$

CHAPTER 5 ACIDS, BASES AND SALTS

Question 1

(a) What is an acid? [1]

(b) Describe what you would see when a little Copper (II) oxide is warmed with dilute nitric acid. [1]

(c) In what way is Copper (II) oxide behaving when it reacts with dilute nitric acid? [1]

WORKED SOLUTIONS

(a) An acid is a chemical substance that produces hydrogen ions (H^+) as the only positive ion when dissolved in water.

(b) Crystalline solids would be formed in the solution.

***TAKE NOTE**

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

(c) Copper (II) Oxide is behaving as a base which neutralizes acids.

***TAKE NOTE:** *In a neutralisation reaction, the base reacts with an acid to form a salt and water only.*

CONCISE INFORMATION (REACTION OF ACIDS AND BASES)

✓ *An acid is a chemical substance that produces hydrogen ions (H^+) when dissolved in water. For example, When hydrogen Chloride is dissolved in water, it produces hydrogen ions (positively charged) and chlorine ions (negatively charged) as follows:*

$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$

✓ *Reaction of acids with bases.*

- *Acids react with bases (metal oxides and hydroxides) to form salts at the point of neutralisation. Water is also produced in the reactions.*

Acid + Base ⟶ *Salt + Water*

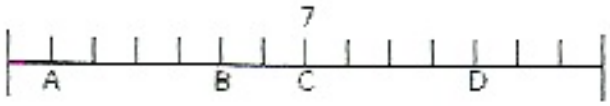
e.g. Copper (II) Oxide + Nitric acid ⟶ *Copper (II) nitrate + Water*

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

CuO is acting as the base in this reaction to neutralise the acid.

Question 2

Figure below shows a pH scale and the pH value of four solutions A, B, C, and D



(a) Which of the solutions is likely to be:

i) Sodium chloride. [1]

ii) Hydrochloric acid. [1]

(b) State the ion which is responsible for:

i) Acidity. [1]

ii) Alkalinity. [1]

(c) What type of reaction occurs when solution A is mixed with solution D? Write an ionic equation for the reaction which occurs. [2]

[SCIENCE - 5124/P3/2008]

WORKED SOLUTIONS

(a) i) C

***TAKE NOTE**

Sodium chloride is a salt which is a product of neutralisation reaction. Therefore, it is expected to be neutral with a pH of 7.

ii) A

***TAKE NOTE**

Hydrochloric acid is a strong acid and is expected to have a very low pH. So, according to the given scale hydrochloric Acid can only be A as it has the lowest pH of 1 while B has a pH too high for an acid.

(b) i) $H^+_{(aq)}$

***TAKE NOTE**

From the definition of an acid as a substance that produces H^+ ions, it is obvious that the H^+ ion is responsible for acidity.

ii) $OH_{(aq)}$

***TAKE NOTE**, Hydroxide ions or any Oxide ions are responsible for alkalinity.*

(c) Neutralisation reaction

TAKE NOTE

Neutralisation is the formation of water from hydroxide ions (of a base) and hydrogen ions (of an acid), where a salt is formed during the process.

Ionic equation: $H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$

Check notes on writing ionic equations on Question 5 page 50.

Question 3

An acid is said to have a sour taste.

(a) (i) What particle of an acid is responsible for the sour taste? [1]

(ii) Give a reason why hydrogen chloride has no effect on a dry blue litmus paper. [1]

(b) Describe how you would distinguish between a weak acid and a strong acid.

(c) Sodium hydroxide can react with a certain acidic oxide to form the salt sodium Sulphite.

Name the acidic oxide. [1]

(d) Write a balanced chemical equation for the reaction that occurs in (c) above. [1]

(e) Deduce the net ionic equation for the reaction in (d) above. [1]

[CHEMISTRY/5070/2/2011]

WORKED SOLUTIONS

(a) (i) the hydrogen ion

TAKE NOTE: *acidity is determined by the presence of the hydrogen ion*

(ii) Hydrogen chloride is a neutral alt

(b) A strong acid dissociates completely while a weak acid dissociates partially

(c) Sulphuric acid

(d) $2NaOH + H_2O_4 \rightarrow Na_2O_4 + 2H_2O$

(e) $OH^- + 2H^+ \rightarrow 2H_2O$

CONCISE INFORMATION (pH SCALE)

✓ *Strong and Weak acids*

- *A strong acid is one which ionizes (dissociates) completely in aqueous solution. The following are strong acids;*

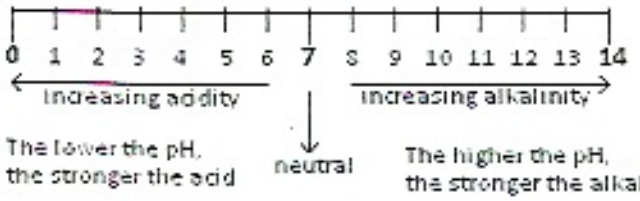
Name	Formula	Ionization
Hydrochloric acid	HCl	$H^+_{(aq)} + Cl_{(aq)}$
Sulphuric acid	H_2SO_4	$2H^+_{(aq)} + SO^{2-}_{4(aq)}$
Nitric acid	HNO_3	$H^+_{(aq)} + NO^-_{3(aq)}$

- *A weak acid is one which only dissociates partially in aqueous solution. The ionization is reversible and is indicated by the sign* $\rightleftharpoons$ *e.g.*

$$CH_3COOH_{(aq)} \rightleftharpoons H^+_{(aq)} + CH_3COO^-_{(aq)}$$

✓ *pH scale*

- *This is a scale designed by chemists to indicate if a solution is acidic, neutral or alkaline. It is also the measure of how acidic or alkaline a solution is and is numbered from 0 to 14.*



- *A substance is acidic if its pH is lower than 7, and the substance is alkaline if its pH is higher than 7*
- *If the concentration of OH^- and H^+ ions is equal, then the substance is neutral, meaning the pH is exactly 7.*

Question 4

A group of students measured the pH of some substances they found in their houses. The results are shown below.

Substance	pH
Apples	3.0
Baking Soda (sodium hydroxide solution)	8.5
Black coffee	5.0
Household ammonia	12.0
Lemon juice	2.5
Milk	6.5
Salt	7.0
Sugar	7.0
Toothpaste	9.0
Vinegar	3.0
Washing soda (sodium carbonate)	11.5

(a) Suggest what the students used to measure the pH of the above substances.[1]

(b) Which solution is the most;

i) Acidic. [1]

ii) Alkaline. [1]

(c) Which solutions are neutral? [2]

(d) A first aid kit manual suggests that vinegar should be used to treat wasp stings and baking soda for bee stings.

i) What does this information tell you about the chemical nature of wasp stings? [1]

ii) If there was no baking soda in the house, what other household substance could you use to treat bee stings? [1]

(e) Vinegar contains ethanoic acid, CH_3COOH. Write down a balanced chemical equation for the reaction that occurs when vinegar is added to a sample of washing soda. [2]

[CHEMISTRY 5070/2/2/2007]

(a) pH meter

(b) i) Lemon juice

***TAKE NOTE**: The lower the pH the stronger the acidity, on the list given, lemon juice has the lowest pH value.*

ii) Household ammonia

***TAKE NOTE**

The higher the pH the stronger the alkalinity, on the list given, household ammonia has the highest pH value.*

(c) Salt and Sugar.

***TAKE NOTE**: A neutral substance has the pH value of 7.*

(d) i) A wasp sting is alkaline (base), therefore an acid, in this case vinegar will be used to act on the alkaline wasp sting to cause a neutralisation.

ii) Toothpaste

***TAKE NOTE**

Toothpaste has the value closest to that of baking soda; therefore it would do the work of baking soda in neutralising the bee sting.*

(e) $2CH_3COOH_{(aq)} + Na_2CO_{3(aq)} \longrightarrow 2CH_3COONa_{(aq)} + CO_{2(g)} + H_2O_{(l)}$

***TAKE NOTE**

Generally:*

Metal carbonate + acid $\longrightarrow$ salt + carbon dioxide + water

A reaction of an acid with a metal carbonate always produces three products, a metal salt, carbon dioxide and water.

Question 5

(a) A solid substance J, soluble in water is suspected to be either acidic or basic. Describe how you would determine whether J is an acid or a base. [1]

(b) A small amount of vinegar was added to baking soda (sodium hydrogen carbonate). Effervescence occurred as a result, of the formation of a gas.

i) Name the gas produced. [1]

ii) Write an ionic equation for the reaction in which the gas is produced. [2]

(a) To determine whether substance J is acidic or basic, it must be given the litmus test. First, substance J should be dissolved in water as it is soluble. Then, either blue or red litmus paper can be used to determine whether the solution is acidic or alkaline. Blue litmus paper will turn red when dipped in an acidic medium and remain blue when dipped in alkaline medium, while red litmus paper will remain red when dipped in an acidic medium and turn blue when dipped in alkaline medium.

(b) i) Carbon dioxide

***TAKE NOTE**

All but the weakest acids react with carbonates to liberate carbon dioxide which will form lime water (milky).

Acid + metal carbonate ⟶ salt + water + carbon dioxide.

ii) $H^+_{(aq)} + HCO_3^-{}_{(aq)} \longrightarrow CO_{2\,(g)} + H_2O_{(l)}$ [net ionic equation]

***TAKE NOTE**

To write net ionic reactions, one must follow these steps:

Step 1: write the balanced chemical reaction including state symbols.

Step 2: ionise substances in aqueous state (all acids and ionic compounds) into their respective ions (cations and anions)

Step 3: cancel out ions that appear on both sides of the equation and if there is a common coefficient for all the species simplify to the simplest whole number. this will result in an ionic equation. The following shows how the steps are used:

Step 1: balanced equation (already balanced)

$CH_3COOH_{(aq)} + NaHCO_{3\,(aq)} \longrightarrow CH_3COONa_{(aq)} + CO_{2\,(g)} + H_2O_{(l)}$

Step 2: formation of ions

$CH_3COO^-{}_{(aq)} + H^+_{(aq)} + Na^+_{(aq)} + HCO_3^-{}_{(aq)} \longrightarrow CH_3COO^-{}_{(aq)} + Na^+_{(aq)} + CO_{2\,(g)} + H_2O_{(l)}$

Step 3: cancelling the spectator ions .

$\cancel{CH_3COO^-{}_{(aq)}} + H^+_{(aq)} + \cancel{Na^+_{(aq)}} + HCO_3^-{}_{(aq)} \longrightarrow \cancel{CH_3COO^-{}_{(aq)}} + \cancel{Na^+_{(aq)}} + CO_{2\,(g)} + H_2O_{(l)}$

$H^+_{(aq)} + HCO_3^-{}_{(aq)} \longrightarrow CO_{2\,(g)} + H_2O_{(l)}$ (net ionic equation

CONCISE INFORMATION (IDENTIFICATION OFACIDS & BASES)

- ✓ *Litmus paper is used in the identification of the nature of solutions (either basic or acidic). Red litmus paper turns blue in alkaline medium while blue litmus paper turns red in acidic medium.*
- ✓ *Other indicators such as methyl orange, phenolphthalein and bromothymol blue can be used.*

Question 6

Zinc chloride is a normal salt and soluble in water.

(a) What is a normal salt? [1]

(b) Pure zinc chloride is best prepared by a neutralization reaction. Suggest two reactants that could be used to prepare zinc chloride and give the equation for the reaction including state symbols.

i) Reactant 1. [1]

ii) Reactant 2. [1]

iii) Equation. [2]

(c) Describe how you would prepare a sample of pure zinc chloride solution. [2]

(d) Describe how you would obtain zinc chloride crystals from the resulting solution. [2]

[CHEMISTRY 5070/2/2/2006]

WORKED SOLUTIONS

(a) A normal salt is a salt which contains no replaceable hydrogen.

(b) (i) Reactant1: Hydrochloric acid

(ii) Reactant 2: Zinc hydroxide

(iii) Equation:

Zinc hydroxide + hydrochloric acid ⟶ Zinc chloride + water

$$Zn(OH)_{2(s)} + HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_2O_{(l)}$$

*** TAKE NOTE:** *In a neutralisation reaction, a base reacts with an acid, forming a salt and water.*

(iv) Measure a volume of hydrochloric acid in a beaker. Add a little at a time of zinc hydroxide solid to the acid in the beaker until solid is in excess. Filter off the excess sodium hydroxide and collect the filtrate of Zinc chloride.

(v) To obtain the crystals, place the resulting solution in an evaporating dish and heat the solution gently to concentrate it. Remove the heat source and allow the solution to cool and crystallise. Filter off the crystals on a filter funnel with filter paper and wash them with a little cold distilled water. Put the crystals in between clean, dry filter paper and squeeze gently. These solids are the crystals of zinc chloride.

CONCISE INFORMATION (TYPES OF SALTS)

- ✓ *A salt is a compound formed when the hydrogen ions in an acid are replaced by metal ions or ammonium ions.*
- ✓ *Types of salts;*
  - *Normal salts: salts which contain no replaceable hydrogen ions e.g. Sodium chloride (table salt)*
  - *Acidic salts: salts which contain replaceable hydrogen ions e.g. $NaHSO_4$*
  - *Basic salts: salts formed when some of the base are retained together with metallic ions and the negative ions of acids e.g. Zn(OH)Cl*

Question 7

(a) Define a salt and give one example. [2]

(b) Iron (II) sulphate ($FeSO_4$) can be prepared by reacting iron metal with dilute sulphuric acid.

i) Write a balanced equation for the reaction. [2]

ii) Which reactant should be in excess? [2]

(c) How would you obtain fairly pure crystals of Iron (II) sulphate from its solution? [2]

(d) Name a salt that can be prepared by precipitation. [1]

(a) A salt is a compound formed when the hydrogen ions in an acid are replaced by metal ions or by ammonium ions, e.g. NaCl (Sodium chloride), NH_4Cl (ammonium chloride).

(b) i) $Fe_{(s)} + H_2SO_{4\,(aq)} \longrightarrow FeSO_{4\,(aq)} + H_{2\,(g)}$

ii) Iron (Fe) should be in excess.

(c) To obtain the pure crystals of Iron (II) sulphate, filter off the excess iron metal and heat the solution gently to concentrate it. Remove the solution from heat and allow it to cool so that the crystals can form. Filter off the crystals and wash them with a little cold distilled water. Dissolve the crystals in a little volume of hot water, filter the solution and recrystallize them. Filter off any excess liquid and allow the crystals to dry on the filter paper. The crystals formed are those of fairly pure Iron(II) sulphate.

(d) barium sulphate.

** TAKE NOTE: Insoluble salts can be prepared by precipitation.*

Question 8

Barium sulphate (BaSO4) is an insoluble salt which is prepared by precipitation.

(a) Using sodium sulphate as one of the reactants:

(i) Name the other reactant you would use to prepare barium sulphate. [1]

(ii) Write a balanced chemical equation for the reaction, include state symbols [2]

(iii) Write an ionic equation for the reaction. [1]

(b) Briefly explain how you would obtain a fairly pure dry sample of the salt. [3]

(c) Name one salt that can be prepared by the reaction of a metal with a dilute acid. [1]

(d) Calcium chloride ($CaCl_2$) can be prepared by reacting calcium carbonate and dilute hydrochloric acid as shown in vthe equation below:

$CaCO_3\,(s) + 2HCl\,(aq) \rightarrow CaCl_2\,(aq) + CO_2\,(g) + H_2O\,(l)$

Calculate the mass of calcium chloride produced by 150g of calcium carbonate.

[SCIENCE5124/ P3/Q11 2011]

(a)

(I) Barium chloride

(II) $BaCl\ (aq) + Na_2SO_3\ (aq) \rightarrow BaSO_4\ (s) + NaCl_2\ (aq)$

(III) $Ba^{2+} + SO_4^{2-} \rightarrow BaSO4$

(b) To obtain a pure dry sample of salt, evaporate the water from the salt solution by gently applying heat to the solution on the evaporating dish. After water has evaporated cool the remaining concentrate and crystallize it. What remains on the dish is dry salt.

(c) Zinc sulphate

TAKE NOTE: *the mixture of zinc metal and dilute sulhpuric acid will give you zinc sulphate.*

(d)

$$CaCO_3\ (s) + 2HCl\ (aq) \rightarrow CaCl_2\ (aq) + CO_2\ (g) + H_2O\ (l)$$

150g ↓ mass?

Mol of $CaCO_3$ = 150/100

= 1.5mol

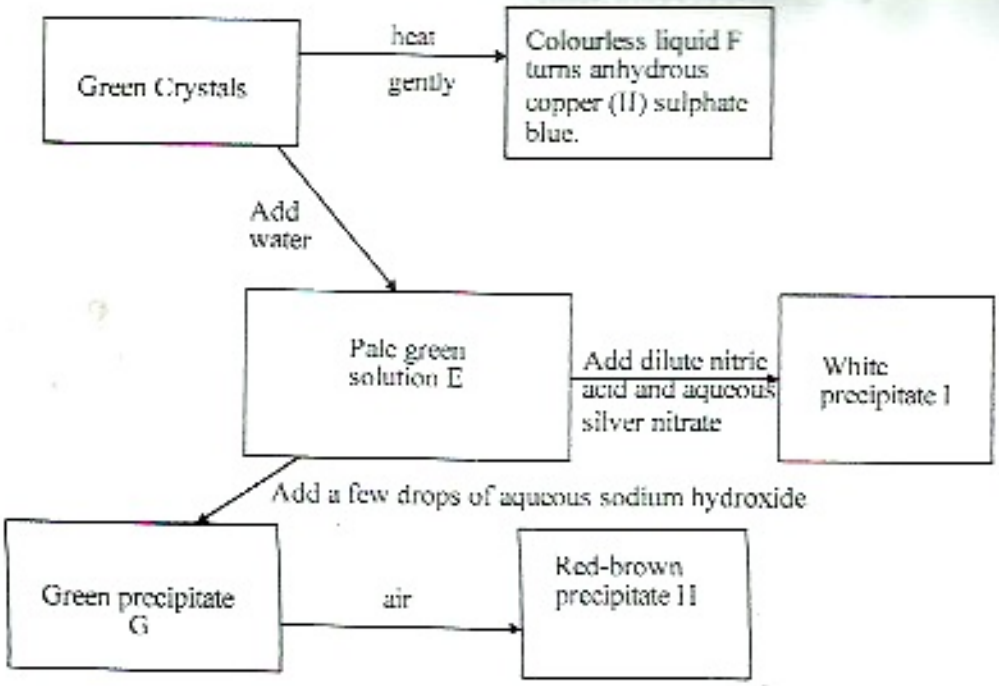
Mole ratio for calcium carbonate to calcium chloride is 1:1, therefore, mol of $CaCl_2$ is 1.5mol

Mass of $CaCl_2$ = 1.5 x 111

= 166.5g

Question 9

The figure below shows the properties and reactions of some substances.



Identify, by name or formula:

(a) The green precipitate G [1]

(b) The white precipitate I [1]

(c) The red-brown precipitate H [1]

(d) The colourless liquid F [1]

(e) The green crystals E [1]

[CHEMISTRY – 5070/P2/Q4/2009]

WORKED SOLUTIONS

(a) Iron (II) or (Fe^{2+})

(b) Chloride or (Cl^-)

(c) Iron (III) or (Fe^{3+})

(d) Water

(e) Iron sulphate

N.B. see notes for use in qualitative analysis – appendix

CONCISE INFORMATION (SALT PREPARATION)

✓ *Salt preparation.*

- *Several general methods are used for preparing salts. The method chosen for preparing any particular salt depends largely on whether it is soluble in water or not. The following simple rules are helpful in preparing salts:*
- *Soluble salts can be prepared by:*
  - *i) Action of an acid on a metal e.g. Zinc sulphate,*
  - *ii) Action of an acid on a carbonate e.g. Lead (II) nitrate.*
  - *iii) Titration (neutralising of an acid by a base or vice versa) e.g. Sodium chloride, Potassium nitrate.*
- *Insoluble salts can be prepared by:*
  - *i) Precipitation or double decomposition (e.g. barium sulphate, Lead chloride and silver chloride).*

CHAPTER 6 STOICHIOMETRY AND MOLE CONCEPT

Question 1

(a) Work out the relative formula mass, R.F.M, of the following;

i) $Ca(HCO_3)_2$. [1]

ii) $Al_2(SO_4)_3$. [1]

(b) When water containing dissolved calcium hydrogen carbonate is boiled, the calcium hydrogen carbonate decomposes according to the equation below:

$$Ca(HCO_3)_{2\,(aq)} \longrightarrow CaCO_{3\,(S)} + H_2O_{(l)} + CO_{2\,(g)}$$

i) Name the white solid formed in this equation. [1]

ii) If the water boiled contained 16.2g of the calcium hydrogen carbonate, calculate the mass of $CaCO_3$ formed. [2]

[SCIENCE 5124/P3/2009]

WORKED SOLUTIONS

(a) Relative formula mass:

i) $40 + (2 \times 1) + (2 \times 12) + (6 \times 16) = \underline{162}$

ii) $(2 \times 27) + (3 \times 32) + (12 \times 16) = \underline{342}$

***TAKE NOTE**

To find the relative formula mass, the relative atomic masses of all the atoms in the formula are added up. The following arrangement can be used for clarity sake.

To solve for the formula $Ca(HCO_3)_2$ list the elements present and multiply their total (amount) in the molecules or compounds by their relative atomic masses:

	no		atomic mass		summation
O	6	x	16	=	96
H	2	x	1	=	2
C	2	x	12	=	24
Ca	1	x	40	=	+ 40
					162

(b) i) Calcium carbonate.

TAKE NOTE

When naming a compound, you must always start with the name of the metal in that compound then other components last.

ii) $Ca(HCO_3)_2 \longrightarrow CaCO_3 + H_2O + CO_2$

16.2g → mass?

- no of moles [$Ca(HCO_3)_2$] = 16.2g ÷ 162g/mol = 0.1mol
- Mole ratio 1 : 1
- no moles of $CaCO_3$ is therefore 0.1
- mass of $CaCO_3$ = 0.1 x 100 (molar mass of $CaCO_3$)

= **10g**

TAKE NOTE

The number of moles of a compound is found by using the formula:

no of moles = given mass ÷ molar mass.

The given mass of a compound (if you have been given the number of moles) is found by using the formula:

Given mass = no of moles x molar mass.

(check notes under Q3 for further tips on calculation of moles and masses of chemical equations)

Question 2

Iron is extracted from iron (III) oxide in a blast furnace. One of the main reactions in the furnace is

$Fe2O3 + 3CO \rightleftharpoons 2Fe + 3CO2$

(a) Name two ores of iron. [2]

(b) Calculate the relative molecular mass of iron (III) oxide, Fe2O3. [1]

(c) What is the mass of iron that can be obtained from 80 tonnes of iron (III) oxide. [3]

(d) Iron often rusts. State three ways of preventing the rusting of iron. [3]

(e) Give one use of iron. [1]

[SCEINCE – 5124/P3/Q9/2012]

(a) .

1. Haematite (Fe_2O_3)
2. Magnetite (Fe_3O_4)

(b)

Fe O

3 X 16 = 48

2 X 56 = 112

160g

Molecular mass of Fe_2O_3 is 160g/mol

(c) $Fe2O3 + 3CO \longleftrightarrow 2Fe + 3CO2$

80 tones mass?

Moles of Fe_2O_3 = 80 000 000g/160gmol^{-}

= 500. 000 mol

Mol ratio of Fe2O3 to Fe is 1 : 2, therefore, the mol of Fe is 250. 000 mol

Mass of Fe = 250 000 mol X 56g

= 14. 000,000g

= **14 tonnes**

(d) Three (3) ways of preventing rusting are as follows:

1. Galvanizing
2. Electroplating
3. Oiling and greasing
4. Plastic coating

(e) Iron is used for making hot water popes

NOTE: *it is also used in railing and Bunsen burner bases.*

Question 3

An oxide of iron, Fe_3O_4 was reduced to iron using aluminium metal according to the equation below.

Fe_3O_4 (s) + Al (s) → Fe (s) + Al_2O_3 (s)

(a) Write the balanced equation for the above reaction. [1]

(b) 5.8g of the iron oxide, Fe_2O_4 reacted completely with aluminium.

Calculate:

(i) The mass of aluminium which reacted.

(ii) The mass of iron formed. [2]

[CHEMISTRY - 5070/2/Z2010]

WORKED SOLUTIONS

(a) $3Fe_3O_4\ (s) + 8Al\ (s) \rightarrow 9Fe\ (s) + 4Al_2O_3\ (s)$

(b) (i)

Moles of Fe_3O_4 = 5.8g/232gmol-

= 0.025 mol

Mole ratio of Fe_3O_4 : Al

3 : 8

Therefore, mole of Al reacting with Fe3O4 is 0.066 mol

Mass of Al = 0.066mol x 27g/mol

= **1.78g**

(ii). Mass of Fe

Mole ratio Fe_3O_4 : Fe = 3 : 9, therefore, moles of Fe formed is 0.075

Mass of Fe = 0.075 x 56

= **4.2g**

Take note:

in an equation where the number of mole or the mass of one reacting/product species is given the following steps can be used to calculate the mass or moles of the other species:

- ✓ *Find the number of moles of the species whose mass is given*
- ✓ *Using mole ratio find moles the species whose mass you need to calculate*
- ✓ *Calculate the mass/volume using the appropriate formula*

e.g mass = moles x molar mass

Question 4

Urea, $(NH_2)_2CO$ and water are formed when ammonia reacts with carbon dioxide. Urea is obtained as a solid from the reaction mixture.

(a) i) Write a balanced chemical equation including state symbols for this reaction. [1]

ii) how many atoms of hydrogen are present in one molecule of Urea? [1]

(b) What mass of urea in tonnes can be formed from 34tonnes of ammonia? [1]

[SCIENCE 5124/P3/2/2011]

WORKED SOLUTIONS

(a) i) $2NH_{3\,(aq)} + CO_{2\,(g)} \longrightarrow (NH_2)_2CO_{\,(s)} + H_2O_{(l)}$

ii) 4 atoms of hydrogen

(b) Calculation of the mass of urea

$2NH_3 + CO_2 \longrightarrow (NH_2)_2CO + H_2O$

34 tonnes. mass?

Note: 1 tonne = 1 000 000g

- No of moles of NH_3 = $\frac{34\,000\,000\ g}{17g/mol}$

$= \underline{2\,000\,000\ mol}$

- Mole ratio = 2 : 1

∴ no of moles of $(NH_2)_2CO$ = $\frac{2\,000\,000}{2}$

$= \underline{1\,000\,000\ mol}$

Mass of $(NH_2)_2CO$ = 1 000 000 mol x 60 g/mol

= 60 000 000g

= **60 tonnes**

Question 5

Part of the processes for the extraction of Uranium uses the reaction of Uranium Tetrafluoride (UF4) with magnesium.

$UF4 + 2Mg \rightarrow 2MgF_2 + U$

(a) State whether Uranium is more or less reactive than Magnesium. Explain your answer. [1]

(b) (i) calculate the relative molecular mass of Uranium Tetrafluoride (UF_4). [1]

(i) How many tones of Uranium can be produced in the above reaction using 24 tonnes of magnesium? [2]

(c) Natural Uranium has several isotopes. Define the term isotopes. [1]

[SCIENCE – 5124/P3/Q2/2009]

WORKED SOLUTIONS

(a) Uranium is less reactive than magnesium. This is because it is lower down the electrochemical series.

Take note:

✓ Also have it in mind that transition metals are less reactive than group I and II metals.

✓ On the Periodic Table, reactivity increases down the group and to the left of the table.

(b)

(i) Molecular mass of UF4 is 314g/mol

U F

4 x 19 = 76

1 x 238 = 238

314

(ii) $UF_4 + 2Mg \rightarrow 2MgF_2 + U$

24 tonnes mass?

Mol of Mg = 24 000 000/24

= 1,000,000mol

Mol ratio of Mg to U is 1:1, therefore, the mol of U is 2 x 1000,000 = 2,000,000mol

Mass of U = 2,000,000 x 238

= 476,000,000g

= 476 tonnes

(c) Isotopes are atoms with the same number of protons but different mass number as well as neutron number.

Question 6

When Copper (II) nitrate is heated strongly, it decomposes according to the equation below.

$$2Cu(NO_3)_{2\,(aq)} \xrightarrow{heat} 2CuO_{(s)} + 4NO_{2(g)} + O_{2\,(g)}$$

9.4g of copper (II) nitrate were decomposed when heating, calculate;

(a) The mass of copper (II) Oxide formed in the reaction. [1]

(b) The volume of nitrogen dioxide measured at r.t.p formed. [1]

[SCIENCE - 5124/3/2008]

WORKED SOLUTIONS

$$2Cu(NO_3)_2 \xrightarrow{heat} 2CuO + 4NO_2 + O_2$$

(a) Calculate the no of moles of 9.4g of $Cu(NO_3)_2$ first, then use the mole ratio to get the no of moles of CuO which will in turn be used to find its mass.

No of moles = $^{given\ mass}/_{molar\ mass}$

No of moles of $Cu(NO_3)_2$ = $^{9.4}/_{(1 \times 64) + (2 \times 14) + (16 \times 6)}$

= $^{9.4g}/_{188g/mol}$

= 0.05 mol

Mole ratio; 2$Cu(NO_3)_2$: 2CuO

1 : 1

Therefore no of moles in CuO = 0.05 mol

Mass = no of moles x molar mass

= 0.05 mol x 80g/mol

= **4g**

(b) No of moles = $^{volume}/_{molar\ gas\ volume}$. therefore to find the volume the following formula can be used;

Volume = no of moles x molar gas volume

- First use the mole ratio between $CuO(NO_3)_2$ or CuO and NO_2 to get moles of nitrogen gas.

Mole ratio; $\underline{2}CuO(NO_3)_2 : \underline{4}NO_2$

1 : 2

Therefore the no of moles in NO_2 = (0.05 x 2) mol

= 0.1 mol

Volume = no of moles x molar gas volume

= 0.1 x $24dm^3$ ($24dm^3$ is the volume of 1mole of any gas at r.t.p.)

= **$2.4dm^3$**

TAKE NOTE

Mole ratio is found using the number of molecules of each compound or element. e.g. in the above question the mole ratio can be found by getting the 2 from $2CuO(NO_3)_2$ and the 4 from $4NO_2$ hence when we take the mole ratio 2 : 4 to its lowest term, we get the ratio 1 : 2. For a compound or element that has no number in front of its formula, the number of molecules is taken to be 1" refer to Question 1.b(ii)"

CONCISE INFORMATION *(WRITING BALANCED CHEMICAL EQUATIONS)*

- ✓ *Calculations from chemical equations involve five main steps. (in some cases, as in the previous question, the first three steps have been done for you).*
- ✓ *Steps*
  - *i) Write a balanced chemical equation for the reaction and note the problem to be solved by writing down information given in the equation.*

    e.g. $2Cu(NO_3)_2 \xrightarrow{heat} 2CuO + 4NO2 + O_2$

    9.4g (given) *? (to be found)*
  - *ii) Calculate the number of moles of the substance where mass is given. In the above case, the no of moles of $Cu(NO_3)_2$ will be calculated..*
  - *iii) Write down the relevant mole ratio from the balanced chemical equation of the concerned substances. The relevant ratio of $Cu(NO_3)_2$ to CuO in the above case is 2:2 i.e. 2 mol $Cu(NO_3)_2 \rightarrow$ 2 mol CuO*
  - *iv) Using the mole ratio, calculate the no of moles of the other substance.*

v) *Calculate the required mass or volume using relevant formulae or relationship based on the balanced chemical equation.*

Question 7

A spillage of 9.8 tonnes of sulphuric acid results from an accident by a road tanker. Slaked lime is used to neutralize the acid.

(a) State the effects of the acids on vegetation. [1]

(b) The chemical equation for the neutralization is given below;

H_2SO_4 (aq) + $Ca(OH)_2$ (s) $\rightleftharpoons$ $CaSO_4$ (s) + H_2O (l)

(ii) Balance the equation. [1]

(iii) Calculate the mass of slaked lime needed to neutralize 9.8 tonnes of split sulpuric acid. [2]

[SCIENCE – 5124/P3/2010]

WORKED SOLUTIONS

(a) Acids burns the vegetation

(b)

(i) H_2SO_4 (aq) + $Ca(OH)_2$ (s) → $CaSO_4$ (s) + $2H_2O$ (l)

(ii) H_2SO_4 (aq) + $Ca(OH)_2$ (s) → $CaSO_4$ (s) + $2H_2O$ (l)

9.8 tonnes mass?

Mol of H_2SO_4 = 9800 000g/98g/mol

= 100 000 mol

The mole ratio of H_2SO_4 to $Ca(OH)_2$ is 1:1, therefore, mol of $Ca(OH)_2$ is 100 000mol

Mass of $Ca(OH)_2$ = 100 000 x 74

= 7,400,000g

= 7.4 tonnes

Question 8

Of the twenty three minerals so far identified as rock samples from the moon, one is named Tranquilityte and has chemical formulae $Fe_8Zr_2Ti_3Si_3O_{24}$.

(a) What is the total no of moles of atoms present in one mole of this compound? [1]

(b) What is the mass of one mole of Tranquilityte? [1]

(c) How many moles of Tranquilityte would be present in 62.1g of the pure mineral? [1]

(d) What is the percentage by mass of Zirconium in Tranquilityte? [1]

(e) If the Zirconium present in lunar rock has concentration of 0.05% by mass, how many grams of Zirconium are present in 100g of lunar rock? [1]

[CHEMISTRY 5070/2/Z/2007]

WORKED SOLUTIONS

(a) Total no. of moles of atoms in one mole of Tranquilityte, $Fe_8Zr_2Ti_3Si_3O_{24}$.

= (8 + 2 + 3 + 3 + 24) mol atoms

= **40 mol atoms**

(b) Mass = no of moles x molar mass

= 1 mole x [(8 x 56) + (2 x 91) + (3 x 48) + (3 x 28) + (24 x 16)]g/mol

= 1 mole x 1242g/mol

= **1242g**

** TAKE NOTE*

The equation that links mass to moles is: no of moles = $^{mass}/_{molar\ mass}$

From this equation, conversions can be made to calculate mass or molar mass depending on information provided.

(c) Moles = $^{mass}/_{molar\ mass}$

= $^{62.1g}/_{1242g/mol}$

= 0.05mol

(d) $\%\ by\ mass = \frac{2 \times (Zr)}{M_r\ (Fe_8Zr_2Ti_3Si_3O_{24}} \times 100\%$

$$\%\ by\ mass = \frac{91 \times 2}{1242}$$

$$= \underline{14.65\% \approx 15\%}$$

***TAKE NOTE**

The percentage by mass helps us to know how much of a compound is made up of a particular element in terms of mass. It can be found from calculations involving relative formula mass as follows: % by mass = Relative Atomic Mass (RAM) x no of atoms x 100

Total relative molecular mass of compound

(e) 1 242 g lunar rock $\xrightarrow{\text{contains}}$ 182 g Zr

100 g lunar rock $\xrightarrow{\text{would contain}}$ x

$$x = \frac{100 \times 182\,g\,Zr}{1242} = 14.6 \approx 15\,g\,Zr$$

In 100 g of lunar rock with concentration of 0.05% by mass:

$$mass = \frac{0.05}{100} \times 15\,g\,Zr = 0.0075\,g\,Zr$$

***TAKE NOTE**

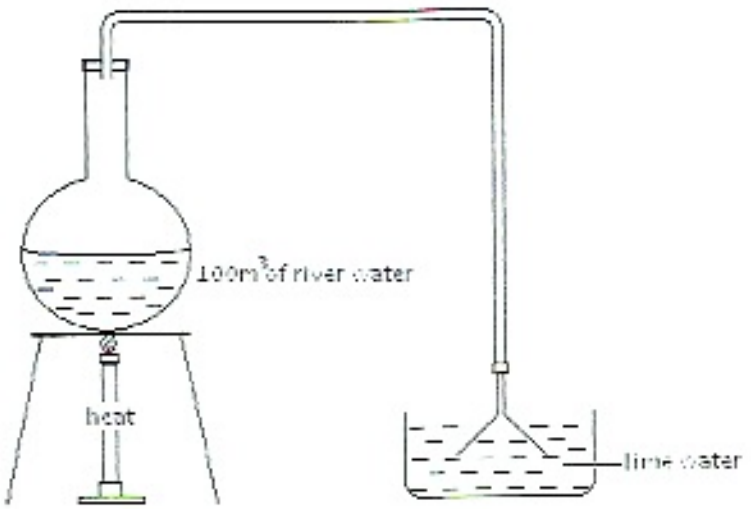
The percentage composition of a particular element in a compound is always taken to be percentage by mass of that particular element in the compound.

Question 9

A sample of water obtained from one of the rivers in the limestone districts of Lusaka was found to contain calcium hydrogen carbonate, $Ca(HCO_3)_2$.

(a) Write a balanced chemical equation to show how the calcium hydrogen carbonate is formed from limestone.

(b) The following experiment was done to determine the concentration of calcium hydrogen carbonate in the water sample. $100cm^3$ of the river water collected was boiled and the resulting carbon dioxide gas was absorbed in an excess of lime water using the apparatus below.



Calcium hydrogen carbonate decomposes when heated to form calcium carbonate, water and carbon dioxide. Write a balanced chemical equation for the decomposition of calcium hydrogen carbonate. [1]

(c) When carbon dioxide is absorbed in lime water, the following reaction occurs;

$$Ca(OH)_{2(aq)} + CO_{2(g)} \longrightarrow CaCO_{3(s)} + H_2O_{(l)}$$

In the experiment, 0.160g of calcium carbonate was precipitated, which represented a yield percentage of 80%.

i) Calculate the volume of carbon dioxide measured at r.t.p which reacted with the lime water. [3]

ii) Calculate the volume of carbon dioxide measured at r.t.p which was produced in the experiment. [2]

iii) Calculate the molarity of the calcium hydrogen carbonate in the river water. [3]

(d) The presence of calcium hydrogen carbonate makes the water 'hard'. When such water is boiled in an electric kettle, a solid deposit is produced on the heating element.

i) Name the solid deposit. [1]

ii) Write a balanced equation for the reaction which occurs when dilute hydrochloric acid (spirit of salt) is added to dissolve out the solid deposit. [3]

[CHEMISTRY 5070/2/2009]

WORKED SOLUTIONS

(a) $CaCO_{3\,(s)} + H_2O_{(l)} + CO_{2\,(g)} \longrightarrow Ca(HCO_3)_{2\,(aq)}$

Lime stone

TAKE NOTE

The word 'limestone' is applied to any rock which is made up mostly of carbonates - usually calcium carbonate ($CaCO_3$).

(b) $Ca(HCO_3)_{2\,(aq)} \xrightarrow{heat} CaCO_{3\,(s)} + H_2O_{(l)} + CO_{2\,(g)}$

(c) i) $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

Volume = ? ↓ 0.160 ↓

No of moles of $CaCO_3 = {}^{0.160\,g}/_{[40 + 12 + (3 \times 16)]\,g/mol}$

$= \underline{0.0016}$mol

Mole ratio = 1 : 1 ,therefore no of moles of CO_2 = 0.0016 mol

Volume of CO_2 = 0.0016 mol x $24dm^3/mol$

$= \underline{0.0384}\ dm^3$

TAKE NOTE

The formula relating to calculation of volume of gases is: no of moles = ${}^{volume}/_{molar\ gas\ volume}$

Using this formula, conversions can be made to calculate the volume if the no of moles is known. At room temperature and pressure (r.t.p) the molar gas volume is 24dm^3.

ii) Since 80% is equivalent to a volume of carbon dioxide equal 0.0384 dm^3,
100% would be → X.

80% yield CO_2 → 0.0384 dm^3 CO_2

100% yield CO_2 → X

$$x = \frac{100 \times 0.0384\,dm^3\ CO_2}{80} = 0.048\,dm^3$$

Volume of carbon produced in the experiment = 0.048 dm^3

iii) 1 mol $Ca(HCO_3)_2$ → 1 mol CO_2

$$x \quad \leftarrow \frac{0.048\,dm^3}{24\,dm^3/mol}\ CO_2$$

since $n = \frac{V_g}{V_m}$

$$x = \frac{0.048}{24}\ mol\ Ca(HCO_3)_2 = 0.002\ mol\ Ca(HCO_3)_2$$

$$\therefore Molarity\ Ca(HCO_3)_2 = \frac{n}{V(dm^3)} = \frac{0.002\,mol}{100/1000\,dm^3} = 0.02\ mol/dm^3$$

TAKE NOTE

Molarity is the amount of solute dissolved in 1dm^3 (1000cm^3) of a solution.

Molarity = number of moles / volume (dm^3)

(d) i) Calcium carbonate

TAKE NOTE

Decomposition of calcium hydrogen carbonate gives calcium carbonate ($CaCO_3$) and water. Therefore the solid deposit is calcium carbonate.

ii) $2HCl_{(aq)} + CaCO_{3\,(s)} \longrightarrow CaCl_{2\,(aq)} + CO_{2\,(g)} + H_2O_{(l)}$

TAKE NOTE

A reaction of an acid with a metal carbonate always produces three products. i.e.

Metal salt, carbon dioxide and water

- *Note that the salt is made from the metal and halogen (e.g. Chlorine) or other radicals.*

Question 10

75g of Magnesium bromide was reacted with 150g of silver nitrate according to the equation:

$2AgNO_3 + MgBr_2 \rightarrow 2AgBr + Mg(NO_3)_2$

(a) Showing all stages, calculate the mass of silver bromide produced in this reaction. (4)

(b) What mass of the reactant in excess remained? (2)

(c) If only 119.44g of silver bromide was obtained, calculate the percentage yield. (2)

[CHEMISTRY - 5070/2/2011]

WORKED SOLUTIONS

(a)

✓ First find the limiting reagent

(Given both masses of reacting species you need to first determine the limiting reagent in the reaction,

1. Moles of reacting species

   Mole of $AgNO_3$ = 150g/170gmol- = 0.882

   Moles of $MgBr_2$ = 75g/182gmol- = 0.412 moles

2. Mole ratio of reacting species is 2:1, therefore

   0.882 moles $AgNO_3$ X 1mol $MgBr_2$/2mol $AgNO_3$ = 0.441 mol $MgBr_2$

   or

   0.412 $MgBr_2$ X 2 $AgNO_3$/1ml $MgBr_2$ = 0.824 mol of $AgNO_3$

3. 0.882 moles of $AgNO_3$ need to react with 0.441 moles of $MgBr_2$

   or 0.412 $MgBr_2$ need to react with 0.824 $AgNO_3$. Therefore $MgBr_2$ is limiting.

- $MgBr_2$ and $AgBr_2$ are in the 1: 2 ratio, therefore moles of AgBr is 0.824 mol.

Mass of AgBr = 0.824 X 187

= 154.08g

(b) Mass of $AgNO_3$ in excess

0.058 moles are in excess

Mass = 0.058 X 170g/mol

= **9.86g**

(c) %yield – actual yield/expected yield X 100

=11944g/154.08g X 100

77.52%

CONCISE INFORMATION *(PERCENTAGE YIELD AND LIMITING REAGENT)*

✓ ***how to find the percentage yield***

A reaction may not always yield the total amount of product predicted by the equation. The loss may be due to several factors as stated bellow:

- *The reaction may not be totally complete*
- *Errors may be made in weighing the reactant or the products*
- *Material may be lost in carrying out the reaction, or in transferring and separating the product.*

The equation gives us an ideal figure for the yield of a reaction; reality often produces less. This can be expressed as the percentage yield for particular experiment. Percentage yield is calculated as follows:

Percentage yield = actual yield/expected yield × 100

✓ ***how to determine the limiting reagent***

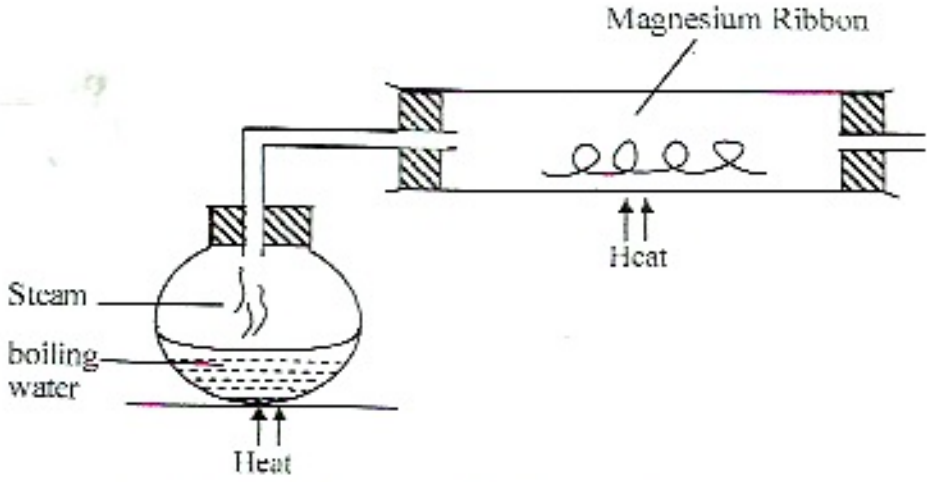
- *A limiting reagent is a reagent (reactant) that limits or determines the amount of product that can be formed in a reaction.*
- *The reactant that is not completely used (or remain unused) up in a reaction is called the excess reagent.*

- ***Steps in determining limiting reagents***

1. *Convert the value (e.g. mass) of each reactant to moles*
2. *Multiply the known moles of one of the reactant by mole ratio from the balanced equation to calculate the required amount of the other reactant*
3. *Determine the amount of reagent needed to react with each other.*

Question 1

The rate of the reaction between a magnesium ribbon and an excess of dilute hydrochloric acid could be measured using the apparatus shown below.



(a) (i) What is the purpose of the test tube? [1]

(ii) How would you get the reaction to start? [1]

(b) The volume of hydrogen produced was recorded every minute as shown in the table below.

Time (min)	0	1	2	3	4	5	6	7
Volume of hydrogen (cm^3)	0	14	23	31	38	40	40	40

(i) Plot the results on a graph paper and draw the graph. [3]

(ii) What was the total volume of hydrogen produced when the reaction was over? [1]

(iii) Why did the reaction stop? [1]

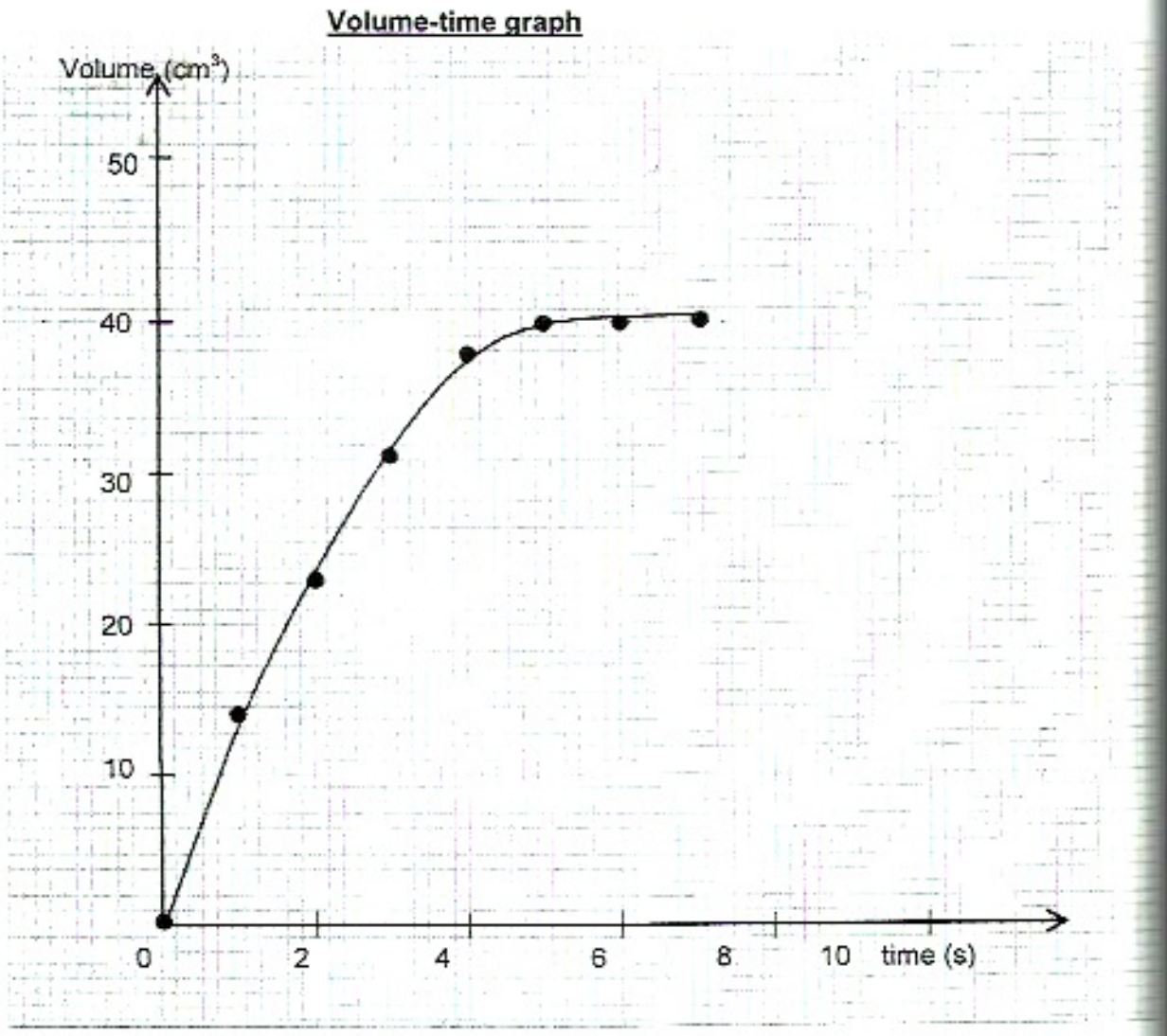
(iv) How could you make the reaction go faster? [3]

[SCEINCE – 5124/P3/Q11/2009]

(a) (i) The purpose of test tube in the set up is to hold contain magnesium ribbon separating from the hydrochloric acid.

(ii) By allowing the magnesium ribbon and excess dilute hydrochloric acid to come into contact.

(b) (i) graph



(ii) $40cm^3$

(iii) The system ran out of magnesium as it was continually consumed in the reaction.

**TAKE NOTE:* *hydrochloric acid was in excess; therefore, magnesium ribbon was a limiting reagent in the reaction.*

(iv) 1. Adding more magnesium ribbon (increasing concentration)

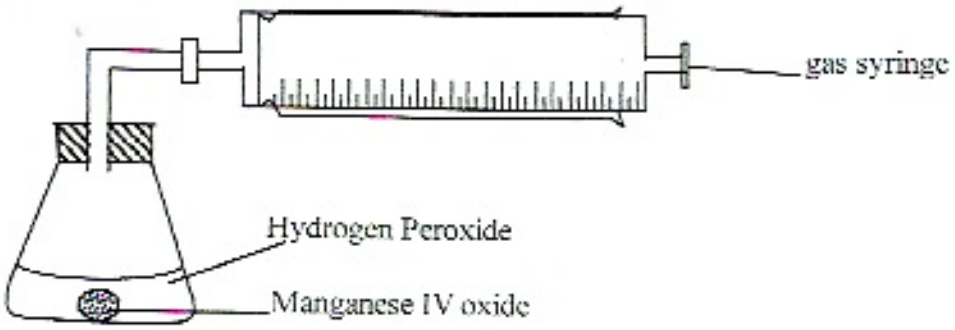
2. Increasing the temperature of the reaction

3. Crashing the magnesium to powder. (this increases the surface area)

N.B: *see concise information on factors affecting rate of reaction for better understanding in tackling (b) (iv) type questions.*

Question 2

Some hydrogen peroxide solution is placed in a small flask attached to a gas syringe. At zero time, a small quantity of manganese (IV) oxide is added to the flask.



The readings of the volumes of oxygen gas given off are taken at intervals as shown below.

Time/s	0	5	10	15	20	30	40	50	60	70	80	90	100
Volume/cm3	0	11	20	27	32	42	50	57	63	67	69	70	70

(a) Plot the graph of volume of oxygen evolved against time in seconds. [4]

(b) What is the total volume of oxygen gas produced? [1]

(c) What is the total time of the reaction? [1]

(d) Use your graph to determine

(i) The volume of gas produced during the first half of the reaction. [1]

(ii) The volume of gas produced during the second half of the reaction. [1]

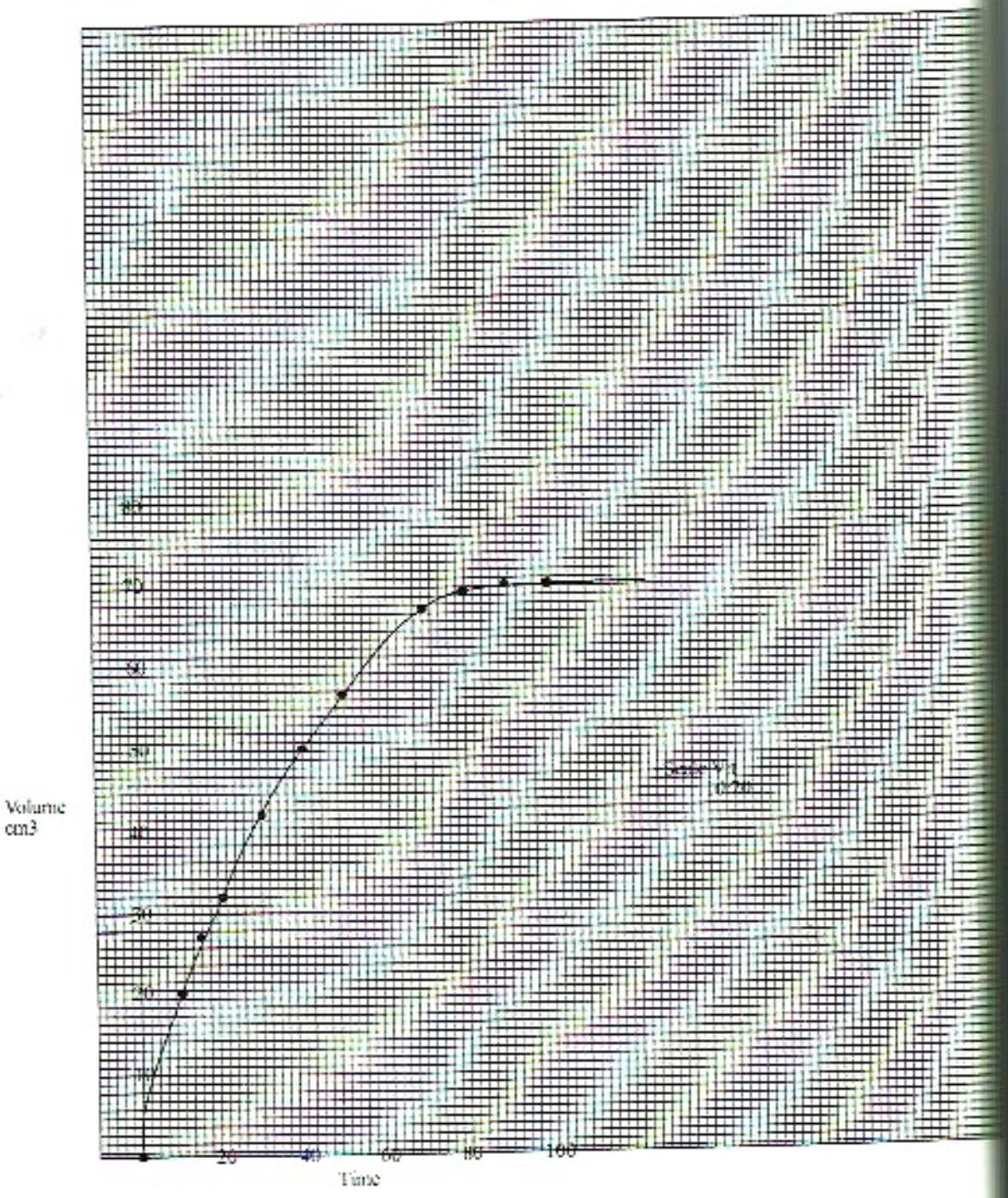
(iii) Explain why the volume of gas produced during the first half of the reaction is more than that produced during the second half of the reaction. [2]

(e) State two factors which can be altered to increase the rate of the above reaction. [2]

(f) If 2g of magnesium (IV) oxide is used, what mass of magnesium oxide is present at the end of the reaction? Explain. [2]

(g) What is the purpose of the magnesium (IV) oxide? [1]

(a)

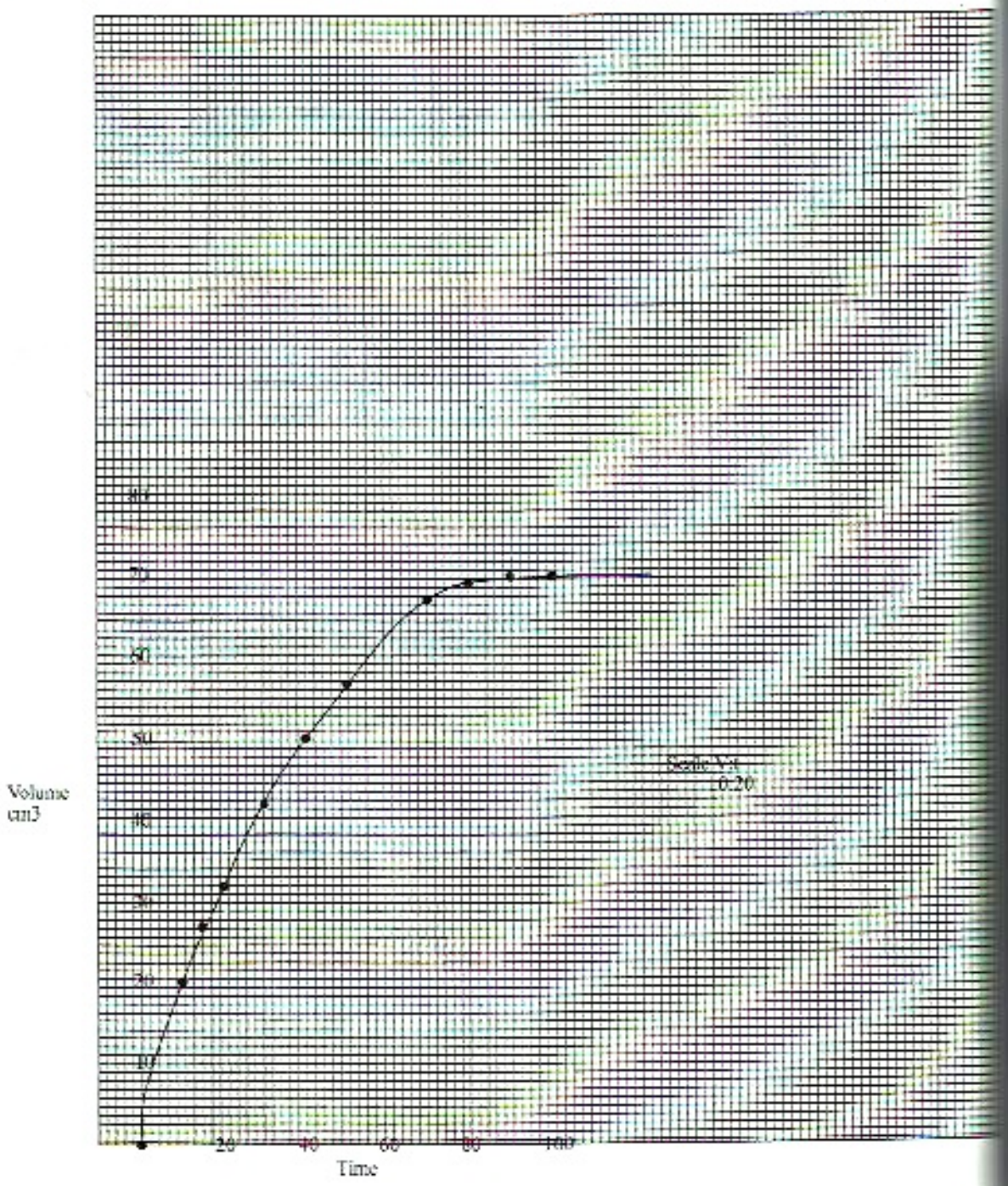


(b) 70 cm^3

**TAKE NOTE:* *Total volume is not the summation of the particle volumes per unit but the final volume at the end of experimentation.*

(c) 100 seconds

(a)



(b) 70 cm^3

***TAKE NOTE:** Total volume is not the summation of the particle volumes per unit but the final volume at the end of experimentation.*

(c) 100 seconds

(d)

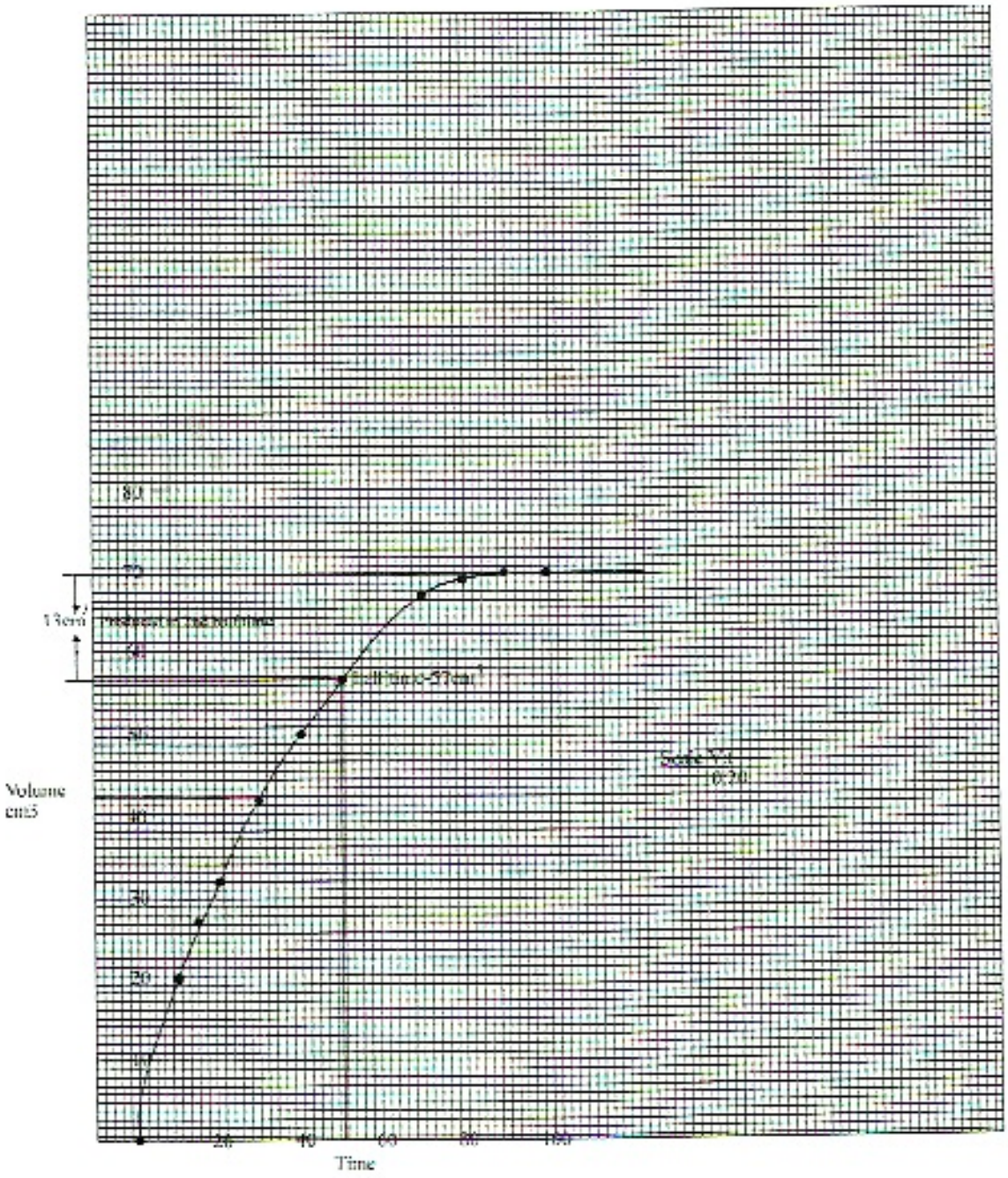
(i) 57cm3 of gas was produced

(ii) 13cm3 of gas was produced

(iii) During the first half of the reaction the reagent (hydrogen peroxide) were in high concentration, therefore colliding faster with Manganese (IV) oxide to produce more gas. As the reagent was used concentration reduced therefore producing less gas in the second half of the reaction.

TAKE NOTE:

Check the illustration in the graph below. It is important that you come up with your scale and draw the graph to answer the question on a graph paper, then compare your graph with the one illustrated.



(e) 1. Temperature of the reaction

2. Concentration (amount) of hydrogen peroxide and magnesium oxide.

***N.B**: see concise information (factors affecting rate of reaction)*

(f) 2g of magnesium (IV) oxide

***TAKE NOTE**: magnesium is unused in the reaction. It is simply acting as a catalyst.*

(g) To act as a catalyst and increase the rate of the reaction.

CONCISE INFORMATION (FACTORS AFFETING THE RATES OF REACTION)

Factors affecting the rate of reactions are as follows:

1. ***Surface area***

   The more finely divided a solid reactant is, the more surface area it exposes, and the faster it takes part in a reaction.

   NOTE: *reactions involving solids take place on the surface of solids. A solid has a much large surface area when it is powdered than when it is in large pieces.*

2. ***Concentration of reactants***

   The rate of a reaction increases when the concentration of a reactant in solution is increased.

   NOTE*: the more crowded the particles are, the more often they bump into each other.*

3. ***Change in temperature***

   The rate of reaction increases with increasing temperature.

   Note: *any factor which increases the rate at which the particles collide increases the rate of reaction. Increase in temperature of a reaction increases the speed at which particles move due to acquired kinetic energy.*

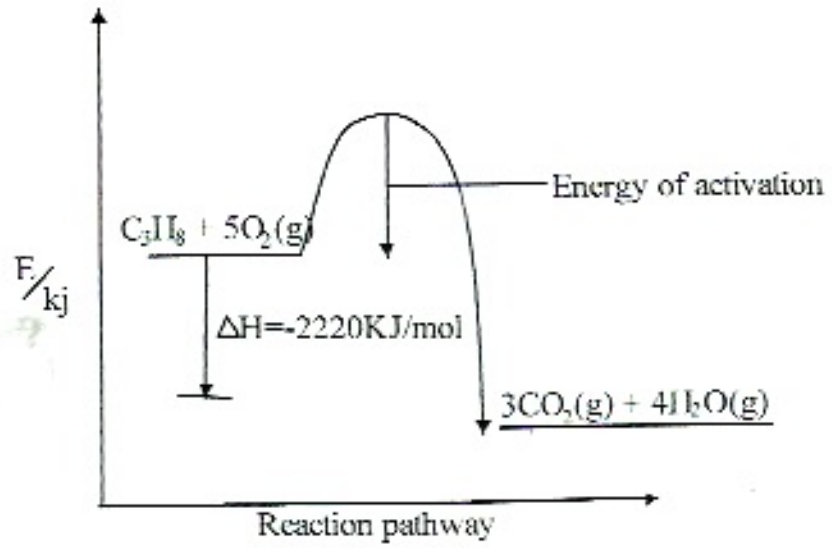
4. ***Catalysts***

   Usually catalysts increase the rate of chemical reactions, (positive catalysis).

   NOTE*: a catalyst is a substance which changes the speed of a chemical reaction but is itself unchanged at the end of the reaction.*

Question 3

Figure 8.1 below shows the energy profile diagram for the combustion of propane, C_3H_8.



(a) Why is energy of activation needed in combustion? [1]

(b) What is the enthalpy of combustion of propane? [1]

(c) Is combustion of propane an endothermic process? Give a reason for your answer. [2]

(d) Calculate the amount of heat change involved when 4.4g of propane is burned completely. [2]

[CHEMISTRY - 5070/2/Z2009]

WORKED SOLUTION

(a) Energy of activation is needed to overcome the reaction barrier initiate the reaction.

(b) Enthalpy is -2220 KJ/mol

TAKE NOTE:

the difference between the energy level of the reactants and that of products is the enthalpy as shown in the energy diagram.

(c) Exothermic reaction. This is because negative enthalpy indicates exothermic reaction.

TAKE NOTE:

- Conventionally ΔH is negative for exothermic reactions and positive for endothermic reactions.

- *Another way to tell whether the reaction is exothermic or endothermic is by considering the energy levels of reactants and products. If the reactants energy level is higher than that of products, then energy is lost to the surrounding in proceeding to the products. if products energy level is higher than reactants then heat is gained when proceeding to the products. Therefore, reactions will be exothermic and endothermic respectively.*

(d) -222 KJ

Calculation:

find moles of propane then use mole ratios to get the amount of heat.

mol of C_3H_8 = 4.4/(12X3) + (8X1)

= 4.4g/44g/mol

= 0.1 mol

Since ΔH is -2220 KJ per mol, mol of propane will be

1 mol = -2220 KJ

0.1 mol = x

x = 0.1 mol X -2220 KJ/1 mol

= **-222 KJ**

Question 4

(a) Define dynamic equilibrium in a reversible reaction. [1]

(i) State Le Chatelier's principle. [1]

(ii) How does an increase in pressure affect the position of the equilibrium in the Haber process reaction show below?

$N_2 (g) + 3H_2 (g) \rightleftharpoons 2NH_3 (g)$ [1]

(a) In a reversible reaction dynamic equilibrium is a state where the rate of the forward and backward reactions is equal.

(b) (i) The principle state that 'if a stress is applied to a system in dynamic equilibrium, the system changes to relieve the stress.

TAKE NOTE:

Another version of the principle is that ' a change affecting a chemical equilibrium is offset by compensatory changes in other components of the equilibrium, thus producing little effects'.

(ii) the position of equilibrium will shift to the right, favoring the formation of products (NH_3)

TAKE NOTE:

Increasing the pressure moves the equilibrium to the side with the smaller volume of gas. Decrease in temperature has the opposite effects.

check concise information on dynamic equilibrium

Question 5

In an experiment to determine the rate of a reaction, lumps of calcium carbonate and $25cm^3$ dilute hydrochloric acid was used.

The table below shows the volume of carbon dioxide gas rrcorded at various time intervals.

Time (t) in sec	0	5	10	15	20	25
Volume (v) in cm3	0	15	25	35	40	40

(a) Why is dilute hydrochloric acid preferred to dilute sulphuric acid? [1]

(b) Calculate the rate of reaction after 10 seconds. [2]

(c) Explain how temperature increase and reducing the size of lumps would change the rate of reaction. [2]

[SCEICNE – 5124/P3/Q3/2004]

(a) The reaction of $CaCO_3$ with hydrochloric ac id runs smoothly and produces more of the desired carbon dioxide gas than the reaction with sulphuric acid.

**TAKE NOTE:*

When $CaCO_3$ reacts with dilute sulphuric acid a layer of insoluble calcium sulphate is produced over $CaCO_3$. This stops the reaction as the contact of sulphuric acid is detached from $CaCO_3$. When $CaCO_3$ reacts with dilute hydrochloric acid, soluble $CaCl_2$ is produced. So, the reaction runs smoothly.

(b) Rate of reraction = volume of gas evolved/time take

= $25cm^3$/10sec

= **$2.5cm^3$/sec**

(c) Temperature increase and reducing the size of lumps would increase the rate of reaction.

**TAKE NOTE:*

- *Increase in temperature increases the kinetic energy of reacting species which collide more frequently and increase the rate of reaction*
- *Reducing the size of lumps increases the surface area. The larger the surface area the faster the species take part in a reaction*

Question 6

In the reaction between methane and oxygen, the energy given out when new bonds are made is greater than the energy taken in to break the old bonds.

(a) In terms of energy change, what type of reaction takes place between methane and oxygen? [1]

(b) Give an everyday application of the type of reaction in part (a). [1]

(c) Name one chemical process in which the opposite of what happens in the reaction between methane and oxygen is observed. [1]

(d) Write a chemical equation for the process mentioned in part (c). [1]

[SCIENCE – 5124/P3/Q8/20003]

(a) Exothermic reaction

TAKE NOTE:

in exothermic reaction energy is given out. This is because the formation of new bonds releases more energy than the energy required to break old bonds.

(b) Respiration (tissue combustion)

***TAKE NOTE:** like methane, glucose burns in oxygen to produce CO2 and H2O and heat is also evolved.*

(c) Photosynthesis

***TAKE NOTE:** Photosynthesis is the opposite reaction of tissue combustion (respiration)*

(d) $6CO_2 + 6H_2O \rightleftharpoons C_6H_{12}O_6 + 6O_2$

Question 9

A student gradually adds magnesium powder to dilute hydrochloric acid in a beaker to form magnesium chloride and hydrogen. The ionic equation for the reaction is given below.

$Mg\ (s) + 2H^+\ (aq) \rightarrow Mg^{2+}\ (ag) + H_2\ (g), \quad \Delta H = -463kJ/mol$

(a) Write down the oxidation and reduction half-reactions for this redox reaction. [2]

(b) Is the reaction between magnesium and hydrochloric acid endothermic or exothermic? Give reason for your answer. [2]

(c) Calculate the amount of heat energy that would be released to the surrounding if 8g of magnesium are reacted with excess hydrochloric acid. [2]

(d) Draw the energy profile diagram for the above reaction. [2]

(e) Another student notices that the reaction in his experiment is fast. State two changes the student would make to make the reaction slower when reacted. [2]

1. ***Temperature change***

- *If the reaction is exothermic increase in temperature will move the position of equilibrium to the left. i.e., in a reversible reaction reactants will be more than products, (favoours endothermic reaction). However, decrease in temperature will shift equilibrium to the right, favoring forward reaction which is exothermic.*
- *If the reaction is endothermic, increasing the temperature shifts equilibrium to the right (forward reaction) to favor the products. That is, favouring the exothermic reaction. Decrease in temperature will however, shift equilibrium to the left, favouring backward reaction which is exothermic.*

2. *Pressure change*

- *Increasing the pressure shifts the equilibrium to the side with the smaller volume (or molecules) of gas.*
- *Decreasing the pressure shifts equilibrium to the side with larger volume (or molecules) of gas*
- *If there are equal volumes or moles of gas on both sides of the equation, increasing/decreasing the pressure has no effect.*

3. ***Change in concentration***

- *Increase in concentration of reactants in a reversible reaction shifts the position of equilibrium to the right, favouring products.*
- *Decrease in concentration of reactants shifts the position of equilibrium to the left favouring the formation of reactants.*

NOTE: *change in the concentration of products will have an opposite effects.*

CHAPTER 8 THE PERIODIC TABLE

Question 1

Use the periodic table to answer the following questions.

(a) Give the symbol of;

i) A non-metal used to sterilise water. [1]

ii) An element which forms diatomic molecules. [1]

iii) An element which reacts with water to give an alkaline solution. [1]

iv) An element which forms an ion of the type X^{2-}. [1]

(b)

i) Oxygen, Sulphur and Selenium are in group VI of the periodic table. At room temperature, oxygen is a gas and sulphur is a solid. Predict whether selenium is a liquid or solid or gas at room temperature. [1]

ii) The trend in group VI is similar to that of group VII. Suggest the most reactive element in group VI. [1]

[SCIENCE - 5124/P3/7/2011]

WORKED SOLUTIONS

(a) i) Chlorine

** **TAKE NOTE:** Chlorine is used to kill germs in drinking water (sterilisation).*

ii) Fluorine

** **TAKE NOTE:** All group VII elements are diatomic (e.g. fluorine, chlorine, bromine and iodine).*

iii) Sodium

** **TAKE NOTE:** All group I elements react with water to form alkaline solutions.*

iv) Oxygen

** **TAKE NOTE:** All group VI elements need two electrons to gain stability; as a result they form ions of the type X^{2-}.*

(b) Selenium is a solid at room temperature.

***TAKE NOTE:** For elements in group VI & VII, the boiling point increases down the group.*

ii) Oxygen

***TAKE NOTE:** In group VI and VII, reactivity increases up the group.*

Question 2

(a) The following terms are used for elements in the periodic table. Name one kind of each type of element.

i) Alkali metal [1]

ii) Alkali earth metal [1]

iii) Halogen [1]

iv) Noble gas [1]

v) Transition metal [1]

(b) i) The table below shows the three (3) isotopes of the element hydrogen and their nucleon (mass) numbers. Complete the table to show the no. of particles in the three nuclides. [3]

symbol	name	Nucleon(mass) number	proton	neutron
H	Hydrogen	1		
D	Deuterium	2		
T	Tritium	3		

ii) Construct an equation for the reaction between D2O and Calcium. [1]

[CHEMISTRY 5070/2/Z/2006]

WORKED SOLUTIONS

(a)

i) Sodium

***TAKE NOTE:** All group I elements are called alkali metals.*

ii) Magnesium

***TAKE NOTE:** All group II elements are called alkali earth metals.*

iii) Chlorine

***TAKE NOTE:** All group VII elements are called halogens.*

iv) Neon

** TAKE NOTE: All group VIII elements are called noble gases.*

v) Iron

** TAKE NOTE: Most transition metals have more than one valency and have very high boiling and melting points.*

(b) i)

symbol	name	Nucleon(mass) number	proton	neutron
H	Hydrogen	1	1	0
D	Deuterium	2	1	1
T	Tritium	3	1	2

**** TAKE NOTE***

Isotopes are atoms of the same element having the same number of protons but different number of neutrons; hence their mass numbers are also different.

The formula used to find the mass number is; Mass no = Proton no + Neutron no. therefore to find the neutron number Neutron no = Mass no - Proton no

Ordinary hydrogen (protium) has proton number one and so has deuterium and tritium. In accordance with the definition of an isotope, they have same atomic number but different neutron numbers hence their neutron numbers can be found by subtracting 1 from their mass numbers.

ii) $Ca_{(s)} + 2D_2O_{(l)} \longrightarrow Ca(OD)_{2(aq)} + D_{2(g)}$

Question 3

A forensic chemist uses specific codes to identify chemical species. The chemist uses the Periodic Table and the positions of the elements to code the elements.

Example: sodium is in Group 1, Period 3, so its code is (1:3) and hence NaCl is coded (1:3) (7:3)

Complete the following table filling in the blank spaces.

	CODE	CHEMICAL FORMULA	CHEMICAL NAME
(a)	(2:4) (6:2)		
(b)	$(1:3)_2$ (6:2) $(6:2)_4$	$NaSO_4$	
(c)			Alimunium Nitrate

[SCIENCE - 5124/P3/2008]

WORKED SOLUTIONS

	CODE	CHEMICAL FORMULA	CHEMICAL NAME
(a)	(2:4) (6:2)	CaO	Calcium Oxide
(b)	$(1:3)_2$ (6:3) $(6:2)_4$	Na_2SO_4	Sodium Sulphate
(c)	$(3:3)_2$ (5:2) $(6:2)_3$	Al_2NO_3	Alimunium Nitrate

Question 4

(a) Lithium, Sodium, Potassium and Rubidium are members of group I of the periodic table.

i) For these four elements, construct a table using the following headings; name, chemical symbol, atomic number, electronic configuration and formula of oxide. [5]

ii) What name is given to group I metals? [1]

iii) Describe the trend in reactivity of group I elements. [1]

iv) Sodium reacts vigorously with water. For this reaction state the products formed. [2]

(b) Calcium is a metallic element in group II of the periodic table. Explain in terms of structure why calcium conducts electricity in its solid state. [2]

(c) Calcium and chlorine react together to form calcium chloride, an ionic solid.

i) Give the formula of calcium chloride. [1]

ii) Give the formula of the two ions present in calcium chloride. [2]

iii) Would you expect calcium chloride to dissolve in water? Give reason for your answer. [2]

[CHEMISTRY 5070/2/Z/2007]

WORKED SOLUTIONS

(a)

Name	Chemical symbol	Atomic mass	configuration	Formula of oxide
Lithium	Li	3	2:1	Li2O
Sodium	Na	11	2:8:1	Na_2O
Potassium	K	19	2:8:8:1	K_2O
Rubidium	Rb	37	2:8:18:8:1	Rb_2O

'kali metals

'v increases down the group.

and Sodium hydroxide

ith water to form metal hydroxides and hydrogen gas is given off.

[5]

[2]

A fo

Perio s formed

Example terms of

(7:3)

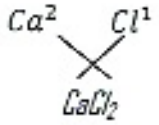
free electrons between the rows of its atoms

conduct electricity.

(c) i) $CaCl_2$

TAKE NOTE

Calcium has a valency of 2, while chlorine has a valency of 1, therefore, their valences are exchanged to find the formula of calcium chloride as shown below.



ii) Ca^{2+} and Cl^-

iii) Yes, Calcium chloride dissolves in water. This is because it is an ionic compound and ionic compounds dissolve in water.

CONCISE INFORMATION (FAMILY NAMES - GROUPS OF PERIODIC TABLE)

- ✓ *The periodic table is a way of classifying elements and is used to predict properties of elements.*
- ✓ *Trend in groups*
- ✓ *Trend in periods*

- *There are eight groups in the periodic table and these are given special names as follows;*
- *Group I: Alkali metals (all of which are soft metals)*
- *Group II: Alkali earth metals.*
- *Group VII: Halogens (which means salt producers)*

  - these exist as diatomic molecules (i.e. two atoms per molecule)
- *Group O: Noble gases (inert gases)*

Question 5

One of the groups in the periodic table contains elements which have seven (7) valency electrons. Choose one element from this group and give the following information:

(a) The name of this element [1]

(b) The chemical formula of the element. [1]

(c) The formula of the ion which this element forms. [1]

(d) The group and period of this element. [1]

(e) The type of oxide the element forms. [1]

[SCIENCE - 5124/P3/2008]

WORKED SOLUTIONS

(a) Chlorine

TAKE NOTE:

on the periodic table, the group number is equal to the valency electron number, i.e. number of electrons in the outermost shell.

(b) Cl

(c) Cl^-

TAKE NOTE:

to attain stability chlorine atom gains one electron and becomes negatively charged

RULE: *if the atom has more than four (4) electrons in the outer shell it gain electrons to attain stability. If the electrons in the outer shell are less than four (4) the atom will lose the electrons and become positively charged.*

(d) Group 7, period 3

TAKE NOTE: *The atom's period is determines by the number of shells of he atm.*

RULE: *group number is equal to valency electron number while period number is equal to number of shells of the atom.*

(e) Acidic oxide

TAKE NOTE: *Non-metals form acidic oxides when combined with oxygen.*

Question 6

Caesium, lithium, potassium and sodium are all in group 1 of the periodic table.

(a) Place these metals in order of reactivity, **starting** with the **most** reactive. [1]

(b) All group I elements react in a similar manner with water.

(i) Name the chemical products of the reaction between caesium and water. [2]

(ii) Write a chemical equation for the reaction of caesium with water. Include state symbols. [3]

(iii) What three things would you expect to see if small pieces of caesium were dropped in water in a glass trough? [3]

(c) What is the other name for group I elements? [1]

[SCIENCE – 5124/P3/Q9/2011]

WORKED SOLUTIONS

(a) Caesium, Potassium, sodium, lithium

TAKE NOTE:

In group I and II, reactivity of the metals increase down the group. Each metal lower in the group is more reactive than the one above it.

(b)

(i) $Cs\ (s) + H_2O\ (l) \rightarrow CsOH\ (aq) + H_2\ (g)$

(ii)

- fizzing (violent reaction)
- Bubbles of a gas (hydrogen) are produced
- Production of heat, enough to boil the water

(c) Alkali metals

Question 7

Part of the periodic table is shown below. **Use it** to answer the questions that follow.

H							He
Li	Be	B	C	N	O	F	Ne
Na	Mg	Al	Si	P	S	Cl	Ar

(a) State the chemical symbol for;

i) An element which is a noble gas. [1]

ii) The most reactive metal. [1]

iii) The most reactive halogen. [1]

iv) The element which supports burning. [1]

(b)

i) Write the formula of the compound which would be formed if the element whose atomic no is 13 reacted with an element whose atomic number is 8. [1]

ii) State the type of bonding which would be present in the compound in (b) above. [1]

WORKED SOLUTIONS

(a)

i) He

TAKE NOTE:

All group 0 elements are noble gases: therefore neon and argon are all noble gases.

ii) Na

TAKE NOTE:

In a group consisting of metals. (e.g. group I) reactivity increases down the group.

iii) F

TAKE NOTE

In group VII. (the halogens) reactivity increases up the group. therefore fluorine is the most reactive halogen.

iv) O

***TAKE NOTE:** Oxygen supports burning.*

(b)

i) A_2B_3 which can be Al_2O_3

TAKE NOTE

An element whose atomic number is 13 has 3 electrons in its outermost shell (2:8:3) which it can lose to become a stable element of formula A^{3+}

An element whose atomic number is 8 has 6 electrons in its outer shell (2:6) and needs 2 more to gain stability and a formula B^{2-}

The opposite ions will interchange to form the formula below:

A^{3+} B^{2-}

A_2B_3

Aluminium and Oxygen combine in this manner to form Al_2O_3

ii) Ionic bonding.

Question 8

The diagrams below show the electron arrangement of the outer shells of five elements A to E. All elements are from period 3 of the periodic table.

(a) Put the letters A to E in the table to show which elements are metals and non metals. [2]

Metals	Non-metals

(b) Which element is most likely to be in group VI of the periodic table? [1]

(c) Which element will form an ion of the type X^{2+} ? [1]

(d) Which element has an atomic number of 15 ? [1]

[SCIENCE - 5124/P3/2004]

WORKED SOLUTIONS

(a)

Metals	Non-metals
C	A
D	B
	E

(b) Element A

***TAKE NOTE**

In order to locate the element on the periodic table, one must know that the group number is equal to the number of electrons in the outer shell. Therefore element A has 6 electrons in its outermost shell.

(c) Element D

***TAKE NOTE**

Element D has 2 electrons in its outermost shell; therefore it is easier for it to lose 2 electrons than gain 6 electrons to attain stability. Therefore once it loses the two electrons it will form the ion of type X^{2+}.

(d) Element E

***TAKE NOTE**

Element E is in period 3, group 5, this means that it has 3 shells and 5 electrons in its outer shell, therefore its configuration will be as follows 2:8:5 which adds up to 15.

... elements in group VII of the periodic table. The ... from the table.

		Electronic structure	Melting point °C	Boiling point °C	Atomic radius/pm
		2,7	1220	-188	64
Chlorine	Cl	2,8,7	-110	-35	99
Bromine	Br	2,8,18,7	-7	59	144
Iodine	I	2,8,18,18,7	113	183	133

Question 9

The table gives some properties of elements in group VII of the periodic table. The properties for astatine are missing from the table.

Element	Atomic symbol	Electronic structure	Melting point °C	Boiling point °C	Atomic radius/pm
Fluorine	F	2,7	1220	-188	64
Chlorine	Cl	2,8,7	-110	-35	99
Bromine	Br	2,8,18,7	-7	59	144
Iodine	I	2,8,18,18,7	113	183	133
Astatine	At				

Using the above information:

(a) (i) Which halogen is a liquid at room temperature and pressure? [1]

(ii) How many electrons does one atom of astatine have in its outer energy level? [1]

(iii) Predict the atomic radius of astatine. [1]

(iv) Predict the state and colour of astatine at room temperature and pressure. [1]

(v) Predict the molecule formula for astatine. [1]

(b) Complete the following table that describes what happens when aqueous chlorine is added to an aqueous metal halide.

Aqueous halide	observation	Name of products
Potassium bromide	Colourless solution turns orange	
Potassium iodide		

[CHEMISTRY/5070/2/2007]

(a) (i) Bromine

TAKE NOTE:

in order for it to be liquid at room temperature, the halogen should have a melting point below that of room temperature and a boiling point of above room temperature

(ii) 7 electrons

**** TAKE NOTE:***

Electronic configuration of astatine is 2, 8, 18, 32,18,7.

Note that astatine is in group 7, having valency electrons of 7.

(iii) Atomic radius / pm: 145

Take note: the atomic radius of a chemical element is a measure of the size of its atoms, usually the mean or typical distance from the nucleus to the boundary of the surrounding cloud of electrons

(iv) black

TAKE NOTE: *following the trend of colour in halogens, astatine would be expected to be nearly black solid, which, when heated, sublimes into a dark, purplish vapour.*

(vi) At_2

****TAKE NOTE:*** *two electrons of At would share electrons to form a molecule.*

(b)

Aqueous halide	Observation	Name of products
Potassium bromide	Colourless solution turns orange	Potassium chloride and bromine
Potassium iodide	colouless solution turning reddish brown	Potassium chloride and iodine

SUMMARY (THE PERIODIC TABLE)

The periodic table is a way of classifying elements. It is also described as an arrangement of all elements so that patterns in their properties are highlighted by the position of elements in the table.

Vertical columns in the periodic table are called are called groups, while horizontal rows are called periods. You will notice that metals are found on the left hand side while non-metals are found on the right hand side of the table.

✓ ***Groups***

These are the eight (8) vertical columns of elements from the left to the right of the periodic table.

✓ ***Trends in a group***

- *Elements have similar chemical properties*
- *Elements have same number of electrons in the outermost shell*
- *The group number is the same as the number of electrons in the outermost shell except for helium*

✓ ***Periods***

These are the seven horizontal rows of elements ranging from top to bottom of the periodic table.

✓ ***Trends in a period***

- *Elements have the same number of shells.*
- *The periodic number is same as the number of shells each atom has*

CHAPTER 9 METALS

Question 1

Iron, calcium and copper are metals. The table below describes the reactions of these metals with cold water and steam.

(i) Put a tick ( ) if a reaction will take place and a cross (X) if a reaction will not take place.

Metal	Reaction of metal with cold water	Reaction of metal with steam
Copper		
Iron		
calcium		

(ii) Place these three metals in order of chemical activity, starting with the most reactive.[1]

- ✓ Before experimenting with aluminium to place it in the above series, the surface of the aluminium must first be scraped. Why is this necessary? [2]
- ✓ Give two reasons why it is important to recycle metals. [2]

[SCIENCE - 5124/P3/Z2010]

WORKED SOLUTIONS

(a) (i) Table

Metal	Reaction of metal with cold water	Reaction of metal with steam
Copper	X	X
Iron	X	✓
calcium	✓	✓

(ii) Calcium, iron, copper

TAKE NOTE:

Calcium reacts with cold water but iron with steam. therefore calcium is more reactive than iron. Copper reacts neither with cold water nor with steam.

***N.B.** refer to table ... showing the reactivity series of metals.*

(b) The reactivity of aluminium is masked by a layer of aluminium oxide. Therefore it is necessary to scrape the surface of aluminium to remove the oxide layer and allow aluminium to react.

(c) It is important to recycle metals because

1. Metals are diminishing resources
2. Recycling helps reduce on environmental degradation.

Question 2

Magnesium is a more reactive metal than iron.

(a)

(i) Given a piece of magnesium metal and iron (II) chloride solution, describe how you would confirm the above statement. [2]

(ii) Write a balanced equation with state symbols for the reaction. [2]

(b) Strontium is in the same group as magnesium. Is strontium more or less reactive than magnesium? [1]

(c) Magnesium chloride is an ionic solid. Give the formulae of the particles present in the solid. [1]

(d) Iron and copper are metals in the same period.

(i) Give one chemical similarity. [1]

(ii) Give one physical similarity [1]

(iii) Name a common ore for each metal. [2]

[SCIENCE – 5124/P3/Q11/2004]

(a)

(i) When you put a piece of magnesium in the iron (II) chloride solution, the pale green solution will turn clear/white. This is a confirmation that magnesium is more reactive than iron and displaces the iron metal from the salt and white/clear magnesium solution is formed.

(ii) $Mg\ (s) + FeCl_2\ (aq) \rightarrow MgCl_2\ (aq) + Fe\ (s)$

(b) Strontium ia more reactive than Magnesium

TAKE NOTE:

reactivity increases down the group. ie.. metal lower in the group is more reactive than the ones above it.

(c) Mg^{2+} and Cl^-

(d)

(i) They react less strongly with oxygen to form oxides

(ii) They are solid at room temperature

(iii) Iron –heamatite

Copper – copper pyrite

CONCISE INFORMATION (REACIVITY SERIES of metals)

Reactivity series is the listing of metals according to how quickly they undergo chemical reactions. Table below shows the reactions of metals with air, water and dilute hydrochloric acid.

Reactivity series	Reaction with		
	Air	Water	Dilute HCl
Sodium Calcium Magnesium	Burn very strongly in air to form oxide	React with cold water to give hydrogen	React very strongly to give hydrogen
Aluminium Zinc Iron	Burn less strongly in air to form oxide	React with steam, when heated, to give hydrogen	React le to give hydrogen strongly
Lead Copper	Reacts slowly to form oxide layer when heated	Do not react	Do not react
Silver Gold	Do not react	Do not react	Do not react

NOTE: *the reactivity of aluminium is masked by a layer of aluminium oxide. This position is established with the layer removed*

Question 3

Below are four metals listed in order of decreasing activity.

Magnesium, Aluminium, Iron, Copper

A worksheet used by a pupil to check the order of reactivity of the metals is shown below. Each metal oxide was reacted with all other metals in turn. A cross,(X), shows that no reaction took place.

(a) Complete the work sheet. Some of the results have been done for you. [5]

Metal / Metal oxide	Aluminium	Copper	Iron	Magnesium
Aluminuim oxide		X		✓
Copper (II) oxide			✓	✓
Iron (II) oxide	✓			
Magnesium (II) oxide	X	X		

(b) Suggest which of these metals would be most suitable for making:

(i) Car bodies [1]

(ii) Fireworks [1]

(c) Copper is widely used for water pipes and hot water tanks.

Suggest a reason for this. [1]

(d) To produce aluminium economically large quantities of electricity are needed.

Bearing this fact in mind, suggest a reason for sitting plants for the extraction of aluminium in mountainous regions. [1]

[SCIENCE - 5124/P3/Z2006]

WORKED SOLUTIONS

(a)

Metal / Metal oxide	Aluminium	Copper	Iron	Magnesium
Aluminuim oxide		X	X	✓
Copper (II) oxide	✓		✓	✓
Iron (II) oxide	✓			✓
Magnesium (II) oxide	X	X		

***TAKE NOTE:** a more reactive metal will displace the less reactive metal from its oxide*

(b) (i) aluminium

(ii). Magnesium

TAKE NOTE:

- *Aluminium is a light metal a property suitable for making car bodies*
- *Magnesium is highly reactive. hence. can be used in making fire works.*

(c) Copper does not react with either cold water nor hot water, hence, it cannot corrode

TAKE NOTE:

Some metals react easily with water to form rust. hence, not suitable to use for water pipes and water tanks.

(d) In mountainous regions hydro electric power can easily be made available to meet the demands for high power for electrolytic extraction plants.

***N.B.**: study notes on activity series of metals below (concise information)*

Question 4

The list below shows metals arranged in ascending order of reactivity:

Silver

Zinc

Aluminium

Sodium

Using metals from this list only, name:

(a) A metal which can be displaced by copper. [1]

(b) A metal which reacts with cold water to produce an alkaline solution. [1]

(c) A metal which forms an amphoteric oxide when burnt. [1]

(d) A metal whose carbonate does not decompose when heated. [1]

(e) A metal which forms a stable oxide layer. [1]

(f) Write a balanced chemical equation for the reaction between sodium and water. [2]

[SCEINCE – 5124/P3/Q8/2012]

(a) Silver

TAKE NOTE:

Silver is in a position lower than copper in the metal reactivity series, therefore, it is displaced by copper.

(b) Sodium

(c) Zinc

***TAKE NOTE:** Metals that form amphoteric oxides include zinc, tin, lead, aluminium and beryllium*

(d) Sodium

TAKE NOTE:

Carbonates of metals high up in the reactivity series i.e. potassium and sodium do not decompose on heating. N.B. the more reactive the metal, the more stable its nitrates, carbonate or hydroxides. So the carbonate of sodium is very stable and does not decompose when heated.

(e) Aluminium

(f) $2Na\ (s) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + H_2\ (g)$

Question 5

(a) Most metals exist in a combined state. They are too reactive to occur native.

However a few metals do occur native. Give an example of one metal which

(i) Never occurs native

(ii) Occurs both native and combined

(iii) Always occurs native [3]

(b) Why do metal extractions always produce slag? [1]

(c) Why are some metals used to make bells [1]

[SCIENCE – 5124/P3/Q7/2007]

(a)

(i) Sodium or any group one metal

*TAKE NOTE: *Group I metals are highly active, so cannot occur native*

(ii) Aluminium

(iii) Gold

(b) Metal extraction produces slag because the ores of the metals contain impurities which are removed by slag formation

(c) Because metals are sonorous, they produced a high sound.

CONCISE INFORMATION (NATIVE METALS)

A native metal is any metal that is found in its metallic form, either pure or as an alloy, in nature.

Metals that occur native include aluminium, chromium, cobalt, iron, manganese, nickel, zinc, etc.

The gold group and platinum group also occur native:

1. Gold group include gold, copper, lead, aluminium, mercury and silver.
2. Platinum group include platinum, iridium, osmium, palladium, rhodium and ruthenium.

N.B: Only gold, silver, copper and platinum metals occur in nature in larger amount. This is because they are less reactive and can resist natural processes such as oxidation.

Question 6

The list below shows metals arranged in ascending order of reactivity.

Copper

Zinc

Magnesium

Calcium

Potassium

Using metals from this list only, name

(a) A metal which occurs native [1]

(b) The metal which can be displaced from its compounds by zinc. [1]

(c) A metal which reacts violently with cold water [1]

(d) A metal which is likely to form complex ions

(e) A metal which reacts with steam but not with cold water. [1]

(f) A metal whose carbonate does not decompose when heated. [1]

[CHEMISTRY - 5070/2/2010]

WORKED SOLUTIONS

(a) Copper

***TAKE NOTE:** native elements/metals are those that can exist independently in their pure form, not combined with other elements. Examples are copper, silver, gold and platinum.*

(b) Copper

***TAKE NOTE:** in the list provide only copper is less reactive than zinc. A less reactive metal is displaced from its compound by a more reactive metal.*

(c) Potassium

***TAKE NOTE:** Potassium is the most active of the metals in the list and it reacts violently with cold water.*

(d) Zinc (copper can also form complex ions)

***TAKE NOTE:** Unlike group I and group II metals which lose 1 and 2 electrons respectively to from ionic compounds, transition elements are not so straight forward. E.g. zinc can lose either 1 electron to form Zn^{+} or two electrons to form Zn^{2+} ion.*

(e) Zinc

(f) Potassium

***NOTE:** (study notes on thermal stability to understand the decomposition of metals on heat; concise information below)*

CONCISE INFORMATION (THERMAL DECOMPOSITION OF METAL COMPOUNDS)

Stability of particular metal compounds (e.g. carbonates, nitrates and hydroxides) is related to the reactivity of the metal.

- *Carbonates of metals high up in the reactivity series, i.e., potassium and sodium do not decompose on heating.*
- *However, metal carbonates below sodium in the reactivity series decompose on heating to metal oxides and carbon dioxide.*
- *Hydroxides and nitrates of metals also decompose to give the metal oxide (except Na and K)*

  e.g.

  $Ca(OH)2\ (s) \rightleftharpoons CaO\ (s) + H_2O\ (g)$

  $2Pb(NO3)2\ (s) \rightleftharpoons 2PbO\ (s) + 4NO_2\ (g) + O_2\ (g)$

NOTE: *the nitrates of sodium and potassium do not decompose as far as those of less reactive metals. They lose oxygen to form sodium or potassium nitrite:*

$2KNO_3\ (s) \rightleftharpoons 2KNO_2\ (s) + O_2\ (g)$

Question 7

Fe_3O_4 is one of the ores from which iron is extracted in a blast furnace.

(i) State the common name of this ore. [1]

(ii) State the reducing agent used in the extraction of iron. [1]

(iii) Name another ore from which iron is extracted. [1]

[CHEMISTRY - 5070/2/Z2010]

WORKED SOLUTIONS

(i) Magnetite

(ii) Coke is the reducing agent

(iii) Heamatite (Fe_2O_3)

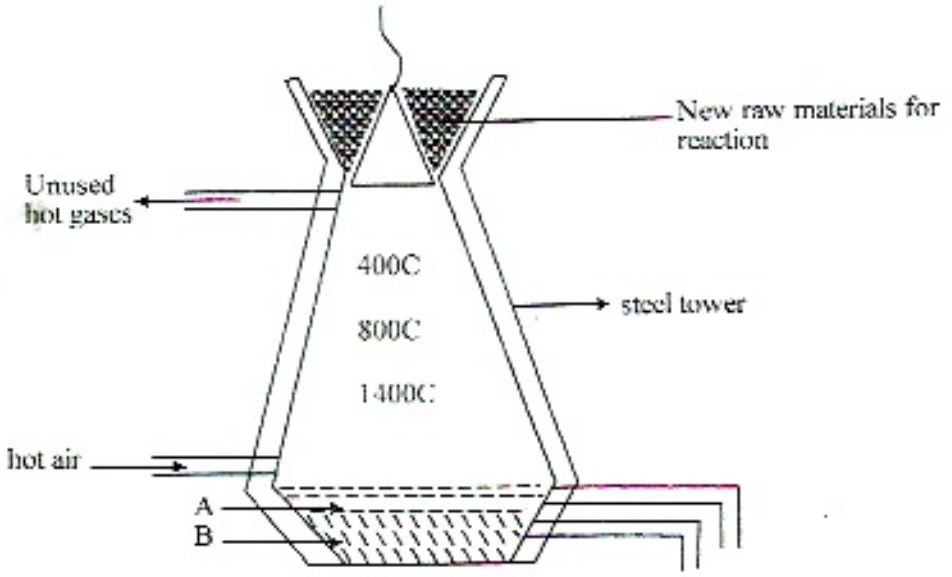
Take note:

- *The difference between magnetite and heamatite is in the composition of the iron with oxygen. Fe_3O_4 and Fe_2O_3 respectively.*

- *Coke (a form of carbon made from coal) is the reducing agent in the blast furnace. Coke reacts with oxygen to form carbon monoxide which reduces the iron. See notes below.*

Question 8

Study the diagram below for the extraction of iron, and answer the questions that follow.



(a)

i) Apart from iron ore name the two other materials that are fed into the reaction chamber. [1]

ii) Show the chemical equations in which the named raw materials in (a) (i) take part.

iii) What are the identities of substances A and B? [1]

(b) What is the use of the 'unused hot gases' in the diagram? [1]

[SCIENCE - 5124/P3/Z2005]

WORKED SOLUTIONS

(a) (i) coke and limestone

Take note:

The charge fed in the furnace consists of iron ore, coke and limestone. The purpose of coke and limestone are highlighted below (concise information – Extraction of iron).

(ii) 1. Reaction involving coke

$C + O_2 \rightarrow CO_2$

$CO_2 + C \rightarrow 2CO$

3. Reaction involving limestone

$CaCO_3 \rightleftharpoons CaO + CO_2$

$CaO + SiO_2 \rightarrow CaSiO_3$

(iii) Substance A is slag

Substance B is iron

TAKE NOTE: slag is less dense than the iron, therefore, it float on top of iron and is tapped off separately.

(b) Unused hot air gases are used in heat exchangers to heat the incoming air.

TAKE NOTE: This helps to reduce the energy costs of the process.

CONCISE INFROMATION (EXTRACTION OF IRON)

✓ *The main ore of iron is hematite (Fe_2O_3). The iron is obtained by reduction in the blast furnace.*

- *The furnace is loaded with the 'charge' consisting of iron ore, coke (a form of carbon made from coal) and limestone (calcium carbonate).*
- *Blast of hot air is sent through holes near the bottom of the furnace. The carbon burn in the air blast and the furnace gets very hot.*

✓ **CHEMISTRY OF REACTIONS IN THE BLAST FURNACE**

1. *Coke burns in host air to form carbon dioxide*

   $C(s) + O_2(g) \rightarrow CO_2(g)$
2. *In insufficient supply of oxygen carbon dioxide react with hot coke and is reduced to carbon monoxide.*

   $CO2(g) + C(s) \rightarrow 2CO(g)$
3. *Carbon monoxide at high temperature reduces iron ore to iron metal.*
4. $Fe_2O_3(s) + 3CO(g)$ ..... $3Fe(s) + 3CO(g)$

✓ **ACTION OF LIMESTONE**

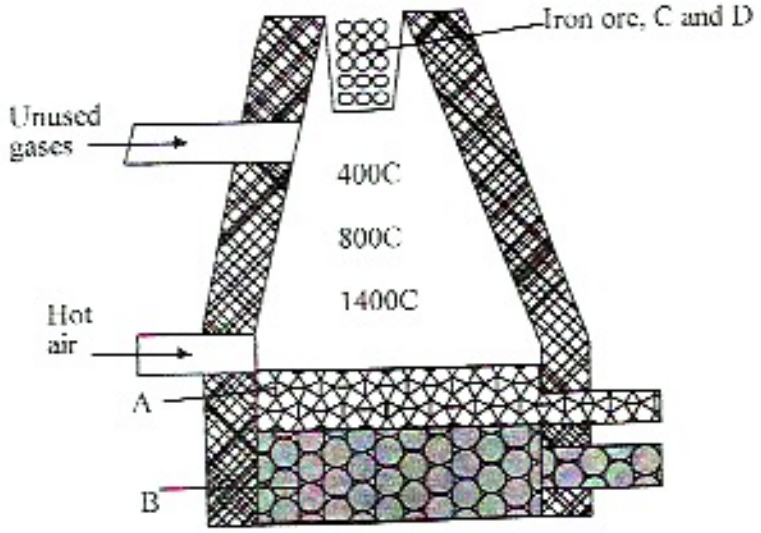
The limestone added to the furnace helps to remove silicate, SiO2 as follows:

1. $CaCO_3(s)$ ..... $CaO + CO(g)$
2. $CaO(s) + SiO_2 \rightarrow CaSiO_3(l)$

   Molten calcium silicate forms a molten layer of slag on top of the iron.

Question 9

Study the diagram below on extraction of iron.



(a) (i) Apart from iron ore, name two other materials (C and D) that are fed into the reaction chamber. [2]

(ii) Write the balanced chemical equation for the reduction reaction of iron ore to iron metal. [2]

(b) Name substance A and B. [2]

(c) State one physical characteristic of the brick lining in the furnace. [1]

[SCEINCE - 5124/P3/Z2011]

WORKED SOLUTIONS

(a) (i) coke and limestone

*TAKE NOTE: *The furnace is loaded with the 'charge' consisting of iron ore, coke and limestone.*

(iii) Fe_2O_3 (s) + 3CO (g) → 2Fe (s) + $3CO_2$ (g)

(b) Substance A is slag

Substance B is iron metal

*TAKE NOTE: *Slag is less dense than iron and float on top of iron.*

(c) It is heat resistant

TAKE NOTE:

The furnace is made of steel but normally line with refractory (heat resistant) bricks of magnesium oxide which are cooled by water.

Question 10

(a) Zinc is extracted from its ore, Zinc blende. The Zinc blende is heated in air to form the oxide and an acidic gas. The zinc oxide is then reduced to zinc.

(i) Name the acidic gas. [1]

(ii) What is the chemical name of Zinc blende? [1]

(iii) Write down the chemical equations for two processes involved in the extraction of Zinc from Zinc blende. [2]

(iv) Why is it not possible to reduce aluminium oxide to aluminium using carbon?

(b) Important uses of zinc are galvanizing steel, making alloys and manufacturing dry cells.

(i) Why is steel galvanized? [1]

(ii) Name an alloy containing Zinc metal. State one physical property of the alloy. [2]

[SCEICNE - 5124/P3/Z2008]

WORKED SOLUTIONS

(a) (i) sulphur dioxide

Take note: check the equation to understand how the acid comes about.

(iii) Zinc sulphide

(iv) 1. $ZnS\ (s) + 3O_2\ (g)$ ..... $2ZnO\ (s) + 2SO_2\ (g)$

2. $ZnO\ (s) + CO\ (g)$ ..... $Zn\ (g) + CO_2\ (g)$

(v) aluminium has a high affinity for oxygen and this makes it difficult for carbon to reduce the aluminum oxide.

TAKE NOTE:

aluminium reacts with oxygen to from a layer of oxide around the metal. The ionic compound is so strong and the only economic way of extracting the metal is by electrolysis.

(b) (i) in order to prevent rusting

TAKE NOTE:

zinc can easily react with oxygen in the air to form Zinc oxide (rust). To prevent this zinc is galvanized.

(ii) Brass

Brass is harder than the constituent metals.

TAKE NOTE: *Brass consists of 70% copper and 30% zinc.*

CONCISE INFROMATION (EXTRACTION OF ZINC)

The extraction of zinc from zinc blend (Zinc sulphide, ZnS) involves a two step reactions.

1. *Zinc blend is roasted in air to form zinc oxide.*
   $ZnS\ (s) + 3O_2 \rightarrow 2\ ZnO\ (s) + 2SO_2\ (s)$
2. *Zinc oxide is reduced to zinc metal by coke in the blast furnace.*
   $ZnO\ (s) + C$ ..... $Zn\ (s) + CO\ (g)$

- *The sulphur dioxide produced can be used to make sulphuric acid.*
- *Zinc is used in alloys such as brass and for galvanizing iron.*

NOTE: *extraction of lead (from lead sulphide, PbS) takes the similar course to the extraction of Zinc.*

✓ EXTRACTION OF COPPER

MOST COPPER IS extracted from copper pyrites, $CuFeS_2$. In the extraction process the ore is initially concentrated by a process of floatation, and hen it is roasted in air to produce copper(I) sulphide.

$2CuFeSO_2\ (s) + O_2\ (g) \rightarrow 2Cu_2S\ (s) + 3SO_2\ (g) + 2FeO\ (s)$

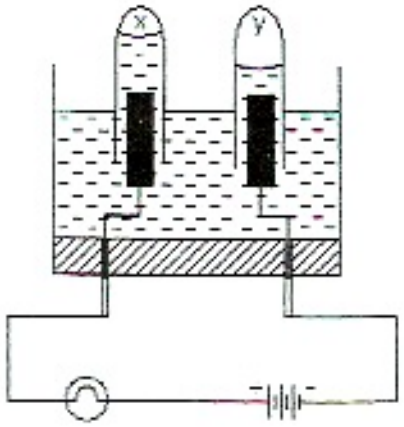
A silica is added and the mixture heated to remove the iron(II)oxide as iron(II)silicate (slag). The copper sulphide is reduced to the metal by heating in a regulated supply of air.

$CuS\ (g) + O_2\ (g) \rightleftharpoons 2Cu\ (s) + SO_2\ (g)$

NOTE: The copper produced by this method is suitable for piping and boilers. When it is to be used for electrical wiring, it must be refined. This is so because impurities increase the electrical resistance of the metal.

Question 1

Aqueous sodium chloride was electrolysed in the apparatus shown below.



(a) i) Name the gas x. [1]

ii) How can gas x be identified?

Test _____ [1]

Results _____ [1]

(b) i) Name the gas y. [1]

ii) Write the equation for the half reaction in which y is produced. [2]

(c) Why is the volume of x smaller than that of y? [1]

(d) The electrolysis of aqueous sodium chloride is used to manufacture important chemicals in an industry. Name the major product of this electrolysis. [1]

[CHEMISTRY – 5070/P2/Q6/2006]

WORKED SOLUTIONS

(a) i) Oxygen

***TAKE NOTE**

Two gases are produced in this reaction, oxygen and hydrogen gas. Oxide ions (O^{2-}) are negative, so they move to the anode(positive), whereas hydrogen ions (H^+) are positive and hence move to the cathode (negative) [positive and negative attract]. Therefore, gas x is oxygen and gas y is hydrogen.

ii) Test: introduce a glowing splint of wood into the test tube with gas x.
Result: the glowing splint relights.

(b) i) hydrogen

ii) $2H^+ + 2e^- \longrightarrow H_2$

***TAKE NOTE**

Two atoms of hydrogen combine to form a molecule of hydrogen. Two electrons are gained to give the neutral situation on the left side.

(c) Hydrogen gas (y) was produced in a larger amount than oxygen gas since electrolysis of aqueous sodium chloride implies the electrolysis of water in which hydrogen and oxygen are in the ratio 2:1.

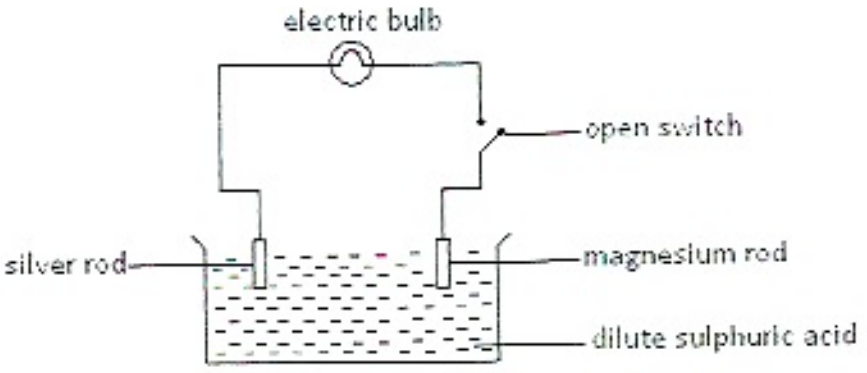
***TAKE NOTE**

Ideally, this is electrolysis of water and confirms that water is a compound of hydrogen and oxygen in the ratio of atoms 2:1 respectively.

(d) Hydrogen gas.

Question 2

An electrochemical cell converts chemical energy to electrical energy. A sample electrochemical cell was set up using silver and magnesium rods, dipped in dilute sulphuric acid according to the diagram below.



When the switch was closed, bubbles of gas were seen at the silver rod and the electric bulb was lit.

(a) Explain how an electric current is produced by the simple cell shown. [1]

(b) Which of the rods is acting as;

i) The cathode? [1]

ii) The anode? [1]

iii) The positive pole? [1]

(c) Write the ionic equation for the reaction which occurs at the

i) Magnesium rod. [1]

ii) Silver rod. [1]

(d) What device can be used in place of the electric bulb to measure the amount of electricity produced? [1]

(e) Predict what would happen if the silver rod is replaced by a copper rod. [1]

[CHEMISTRY - 5070/2/2008]

WORKED SOLUTIONS

(a) In the cell shown, magnesium ionizes by electron loss. The electron passes to silver through the wire creating electron flow. The chemical energy is then converted to electrical energy as electrons flow from magnesium to silver through the connecting wire.

***TAKE NOTE**

In an electric cell, the more electropositive of the two metals ionizes by electron loss passing the electron to the less electropositive through the wire. This creates a flow of electrons which correspond to the chemical change. Much of the chemical energy is converted to electrical energy as electrons flow.

(b) i) Magnesium rod

ii) Silver rod

iii) Silver rod

***TAKE NOTE**

The more electropositive metal loses electrons to the less electropositive; however, it also acts as the cathode (negatively charged). The less electropositive acts as the anode (positively charged.) Role: Anode (+) receives electrons

Cathode (-) loses electrons

(c) i) $Mg \longrightarrow Mg^{2+} + 2e^-$

ii) $2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$

*** TAKE NOTE**

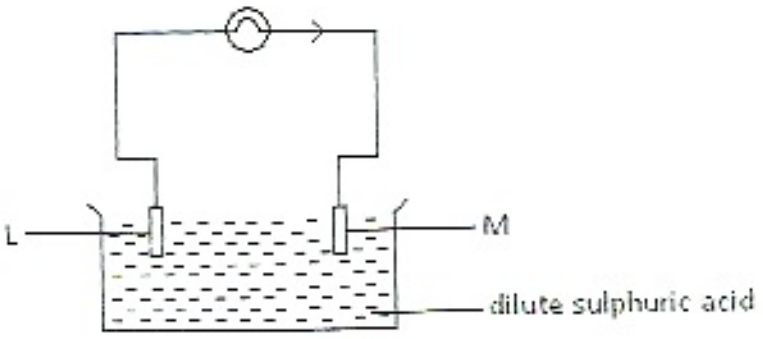
Magnesium goes into solution, (ionises) losing electrons and forms Mg^{2+}. These electrons from magnesium electrode flow to the silver electrode through the wire. At the same time, at the silver electrode, hydrogen ions ($H^{+}_{(aq)}$) from sulphuric acid (electrolyte) gain these electrons and liberate hydrogen gas.

(d) Voltmeter

(e) The voltage produced will be reduced as magnesium and copper are closer in the reactivity series than magnesium and silver.

Question 3

Two metal rods, L and M, dipped in a beaker containing dilute sulphuric acid are connected to an electric bulb. The bulb lights up within a few seconds.



(a) Describe how electricity is produced in the device. [3]

(b) What term is used to describe such a device? [1]

(c) If the current flowing in the direction indicated by the arrow, which metal rod is made from the more reactive metal? [1]

(d) i) If M is magnesium metal, state a possible metal for L? [1]

ii) Write the half reaction equations for the reactions occurring at the metal rods L and M. [1]

iii) Which rod is the anode and which is the cathode? [1]

(e) What chemical changes occur in the device? [1]

(f) If the metal rod L is copper and voltages are measured when the metals iron, lead and zinc were placed in turn as the metal rod M. Complete the table below by entering the metals in the correct order. [3]

Voltmeter reading/V	Metal
1.10	
0.78	
0.21	

[CHEMISTRY 5070/2/2010]

WORKED SOLUTIONS

(a) Metal L ionizes by electron loss, passing the electrons to metal M through the wire. This creates electron flow producing chemical energy. The chemical energy is converted to electrical energy as electrons flow.

(b) Electrochemical cell.

(c) Metal L

TAKE NOTE

The rod made from the more reactive metal loses electrons to the rod made from the less reactive metal.

(d) i) Potassium (or Na, or Calcium)

TAKE NOTE

In the electrochemical series, the metals more reactive than magnesium which are potassium, calcium and sodium can be used.

ii) Half reaction at L

$L \longrightarrow L^+ + e^-$

Half reaction at M

$2H^+_{(aq)} + 2e^- \longrightarrow H_2$

TAKE NOTE

L is losing electrons, therefore electrons are at the right of the equation.

iii) L is the cathode.

M is the anode

*** TAKE NOTE**

Anode (+) receives electrons

Cathode (-) loses electrons

(e) Chemical energy ⟶ electrical energy

(f)

Voltmeter reading/V	Metal
1.10	Zinc
0.78	Iron
0.21	Lead

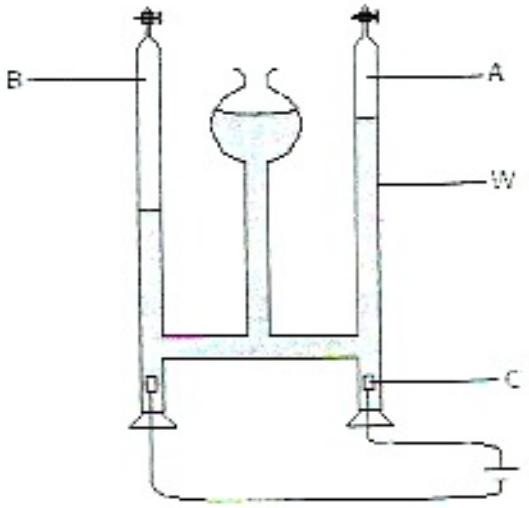
CONCISE

INFORMATION (IONIC THEORY)

- ✓ *In their reactions, metals readily lose their electrons in water to form positively charged ions (e.g. Na ⟶ $Na^+ + e^-$). Metals which readily lose their electrons are said to be very electropositive and are thus very active chemically.*
- ✓ *Non-metals accept electrons to become negatively charged ions (e.g. $Cl + e^- \longrightarrow Cl^-$). These elements which accept electrons readily are the most electronegative and are therefore very chemically reactive.*

Question 4.

The diagram below shows an experiment carried out to investigate the conductivity of solutions. Pure water was used by, followed by acidified water.



(a) i) What is the name of apparatus W? [1]

ii) Explain why no reaction is observed when the liquid in apparatus W is pure. [1]

(b) A few drops of concentrated sulphuric acid are added to the pure water. Two gases A and B are collected after 5 minutes.

i) Name the gas A and B collected after 5 minutes. [2]

ii) Write down the ionic equations to show the formation of the gases A and B. [2]

iii) What would be the best material for C? Give reason for your answer. [1]

(c) A current of 0.5A is passed through the acidified water in 5 minutes of the experiment. (1 faraday = 95 500 C)

i) Calculate the number of moles of electrons that passed through the acidified water during this time. [1]

ii) Calculate the volumes of the gases A and B formed in the 5 minutes interval. [2]

(d) Potassium chloride is used in place of the acidified water in the apparatus W and the experiment is repeated.

i) What would you see at the anode? [1]

ii) What would you see at the cathode? [1]

iii) How does the pH of the solution change as the reaction proceeds? [1]

[CHEMISTRY 5070/2/2007]

WORKED SOLUTIONS

(a) i) Holfmans voltameter

ii) Pure water does not easily decompose as it is a poor conductor of electricity.

***TAKE NOTE**

Pure water is a poor conductor of electricity. It can therefore be made to decompose by some addition of dilute sulphuric acid.

(b) i) Gas A is oxygen

Gas B is hydrogen

ii) Gas A: $4OH^-_{(aq)} \longrightarrow 2H_2O + O_2 + 4e^-$

Gas B: $2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$

iii) Platinuml; this is because it is unreactive and would thus not dissolve in the electrolyte and would not react with the electrode products.

(c) (i)

$$No.\ of\ moles\ of\ e^- = \frac{charge\ (Q)}{Faraday\ constant\ (F)}$$

$$Q\ is\ calculated\ as\ Q = current\ (I) \times time\ (t)\ in\ seconds$$

$$\therefore No.\ of\ moles\ of\ e^- = \frac{I \times t}{F} = \frac{0.5 \times 300}{96500} = 0.0016\ moles\ of\ e^-$$

(ii) Gas A (O_2)

Volume of gas = no. of moles of gas x molar volume of gas

Since we know the number of moles of e^- passed in acidified water, we can use the mole ratio in the balanced equation to find moles of gas O_2 as follows:

$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$

Mole ratio of O_2 to e^- is 1 : 4

Moles of electrons passed in acidified water is 0.0016, so making moles of O_2 to be *x*, *hence* we can find moles of O_2 as

$$\begin{array}{ccc} 1 & : & 4 \\ x & : & 0.0016 \end{array}$$

x = 0.0004 moles of O_2

$\therefore$ Volume of O_2 = 0.0004 mol x 24 mol/dm^3

= <u>0.0096 dm^3</u>

Gas B is H_2

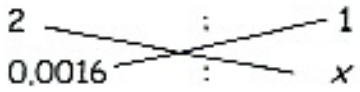
Volume = mole x gas molar volume

number of moles are calculated from the balanced equation:

$2H^+ + 2e \rightarrow H_2$

Mole ratio of e^- to H_2 is 2 : 1

Since the mole ratio of e^- passed in acidified water is 0.0016, then moles of H_2 is calculated as



$$x = \frac{0.0016}{2} = 0.0008$$

TAKE NOTE

No of moles of e = charge (Q) / faraday constant

Charge (Q) = It: where I is current and t is time in seconds

Faradays constant = 96 500 C/mol

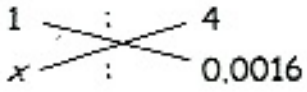
(ii) Calculation of volume of the two gases

Gas A (O_2)

Volume of gas = no. of moles of gas x molar volume of gas
Since we know the number of moles of e^- passed in acidified water, we can use the mole ratio in the balanced equation to find moles of gas O_2 as follows:

$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$
Mole ratio of O_2 to e^- is 1 : 4

Moles of electrons passed in acidified water is 0.0016, so making moles of O_2 to be *x* we can find moles of O_2 a



x = 0.0004 moles of O_2

∴ Volume of O_2 = 0.0004 mole x 24 mole/dm^3
= <u>0.0096 dm^3</u>

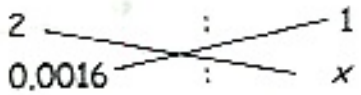
Gas B is H_2

Volume = mole x gas molar volume number of moles are calculated from the balanced equation:

$2H^+ + 2e^- \rightarrow H_2$

Mole ratio of e to H_2 is 2 : 1

Since the mole ratio of e^- passed in acidified water is 0.0016, then moles of H_2 is calculated as



$$x = \frac{0.0016}{2} = 0.0008$$

Volume of H_2 = 0.0008 mol x 24 dm^3/mol = 0.0192 dm^3

(d) i) At the anode chlorine gas will be produced.

ii) Hydrogen gas will be produced at the cathode.

iii) The pH of the solution becomes increasingly alkaline. (KOH)

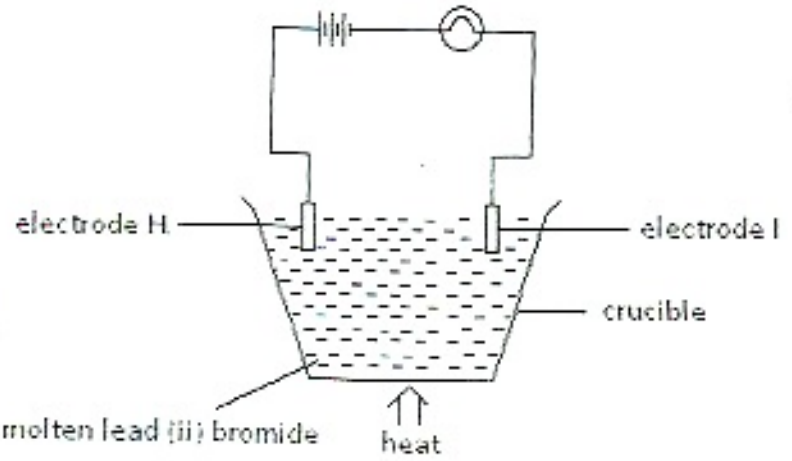
TAKE NOTE

Both Cl^- and OH^- move towards the anode. Cl^- is discharged because it is present in much greater concentration than OH^-. On the other hand both K^+ and H^+ move towards the cathode. H^+ being lower in the electrochemical series is discharged in preference to K^+.

The relative concentration of OH^- and K^+ in the remaining solution increases as H^+ and Cl^- are removed. so the remaining solution increases in alkalinity (KOH).

Question 5

The diagram below, shows an apparatus which was used to electrolyse a sample of molten lead (II) bromide.



(a) Name the products formed at the electrodes H and I. [1]

(b) Write the ionic equations for the reactions occurring at electrodes H and I. [1]

(c) State what you would see at the anode during electrolysis. [1]

(d) State one precaution when carrying out the electrolysis of molten lead (II) bromide. [1]

[CHEMISTRY 5070/2010]

WORKED SOLUTIONS

(a) The product at electrode;

H = bromine

I = Lead

***TAKE NOTE:** Br^- and Pb^{2+} are discharged at the anode and cathode respectively.*

(b) At electrode H; $2Br^-_{(l)} \longrightarrow Br_{2\,(g)} + 2e^-$

At electrode I; $Pb^{2+}_{(l)} + 2e^- \longrightarrow Pb_{(l)}$

TAKE NOTE

During electrolysis the positive ions are attracted to the cathode (-) where they gain electrons to form neutral atoms

$M^{n+} + e \longrightarrow M$

The negative ions go to the anode (+) where they lose electrons to form neutral atoms

$X^{n-} \longrightarrow X + e^-$

(c) Reddish-brown bubbles of gas.

TAKE NOTE

At the temperature of the molten lead (II) bromide electrolyte, bromine will be liberated as a gas, though at room temperature and pressure it is a liquid.

(d) The experiment should be carried out in a fume hood or a water free space.

Question 6

There are several methods that can be used to prevent rusting. The commonest one involves coating the iron or steel object with a suitable substance.

(a) Name three conditions necessary for rusting to occur. [3]

(b) Electroplating and galvanising are two of the methods used to 'coat' the iron or steel. What is meant by

(i) Electroplating; [1]

(ii) Galvanizing? [1]

(c) (i) Describe how you would electroplate an iron ring with silver. Draw a labeled diagram of an apparatus that can be used. [5]

(iii) Write equations for the reactions occurring at the electrodes. [2]

[CHEMISTRY – 5070/P2/Q9/2009]

WORKED SOLUTIONS

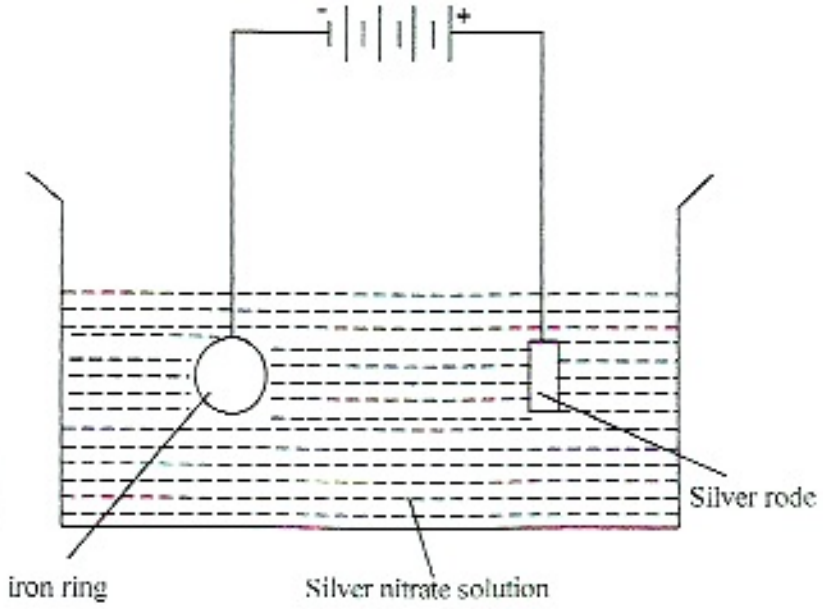
(a) Conditions for rusting to occur are

1. Moisture
2. Air (oxygen)
3. Iron metal

(b) Electroplating is is a process of depositing a thin coating of one metal on top of a different metal by electrolysis.

Galvanizing is the coating of steel or iron with zinc.

(c) Iron ring can be electroplated with silver by making the iron a cathode and making the silver rode an anode in a complete electrolysis cell. The electrolyte is made of the salts of silver, e.g. silver nitrate.



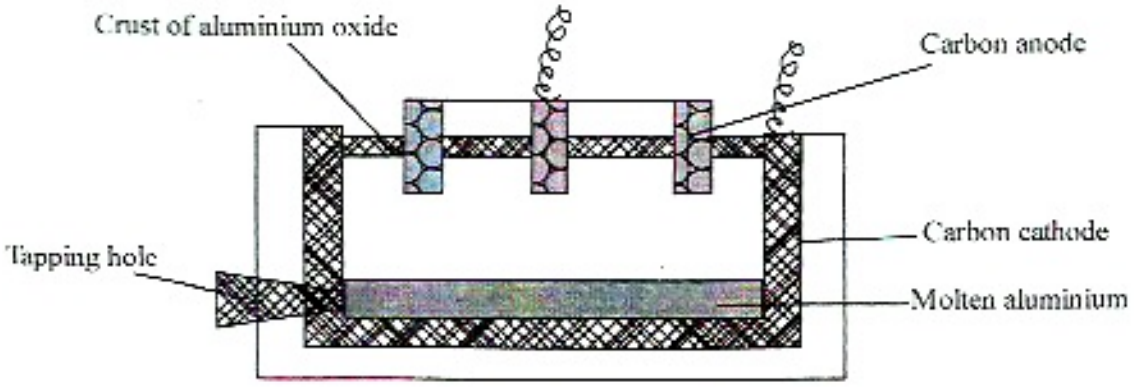
TAKE NOTE:

The basic rules for electroplating an object with a desired metal are as follows:

- *The object to be coated must be made the cathode.*
- *The anode is made of a strip of the desired metal.*
- *The electrolyte must be a solution of salt of the desired metal.*

Question 7

The diagram below is a representation of a Hall Herouit cell used for the extraction of aluminium from hydrated oxide, also known as bauxite.



Some of the processes involved in the extraction are listed below:

1. Bauxite is crashed.
2. Concentrated sodium hydroxide solution is added.
3. Filtration.
4. Dissolved in molten substance P to form the electrolyte.
5. A huge electric current is supplied.

(a) Explain the importance of each of the five (5) listed processes. [5]

(b) (i) the electrolyte is a solution of bauxite and another substance P. Name substance P. [1]

(c) What time, in hours, would it take to deposit 135g of aluminium, if a current of 5.0 amperes was allowed to flow through the circuit? [3]

(d) What test would you use to distinguish between the ions of aluminium, Al^{3+} and zinc, zn^{2+}? [1]

(e) Metals are non-renewable resources. Explain briefly what you understand by this.

(f) (i) Give two ways by which land is degraded. [2]

(ii) Suggest one practical way of reducing land degradation. [1]

[CHEMISTRY – 5070/P2/Q9/2011]

WORKED SOLUTIONS

(a) The importance of the five (5) processes are as follows:

1. Crushed to increase the surface area foe reaction
2. Concentrated sodium hydroxide purifies bauxite by removing impurities such as oxides of iron, silicon and titanium.
3. Filtration separates insoluble impurities from the molten ore.. note that the impurities are insoluble in sodium hydroxide.
4. To lower the melting point of the electrolyte
5. Electric current induces the electrolysis 9 or decomposition) of aluminium oxide.

(b) Substance P is cryolyte

(c)

Data provided in the question

- Mass of aluminium = 135g
- Current = 5.0 amperes
- Time = ?

STEPS TO FOLLOW

1. Find number of mols of aluminium

   Mol = mass/molar mass

   = 135g/27g

   = 5mol

2. Moles of electron needed:

   Al^{3+} + 3e- ⟶ Al

   1mol 3oml

   5 x

   x = 15 mol of Al

   the equation tells us that 1mol of Al ion reacts with 3mol of electron, therefore, 5 mol of Al^{3+} reacts with 15 mol of electrons.

3. Convert moles of electrons to coulomb

   1mol of e- = 96 500 of electric charge, therefore, 15 mol of e- = 1447, 500C

4. Using the equation $Q = It$ you can calculate time, t.

   t = Q/I

   = 1447, 500/5

   = 289,500 sec

   = 4825min

   = 80hrs

(d) Testing Al^{3+} and Zn^{2+} with aqueous ammonia

- Both Al^{3+} and Zn^{2+} forms white precipitate in aqueous ammonia, however, the precipitates of Al^{3+} are insoluble in excess ammonia while those of Zn^{2+} are soluble in excess ammonia.

(e) Metals cannot be naturally replaced or regenerated after they have been used.

(f) (i) Land is degraded by

1. Extreme weather conditions such as drought
2. Human activities such as cutting down trees

(ii) afforestation

CONCISE INFORMATION (REACTIVITY SERIES)

- ✓ *In their reactions, metals readily lose their electrons in water to form positively charged ions (e.g. $Na \longrightarrow Na^+ + e^-$). Metals which readily lose their electrons are said to be very electropositive and are thus very active chemically.*
- ✓ *Non-metals accept electrons to become negatively charged ions (e.g. $Cl + e \longrightarrow Cl^-$). These elements which accept electrons readily are the most electronegative and vice versa. Elements which are very electronegative are also very chemically active.*
- ✓ *Preferential discharge*

When two or more ions of similar charge are present under similar conditions, in a solution, one is preferentially selected for discharge. Selection depends on;

a. *Position of the element in the electrochemical series- ions will be discharged in preference to those above it.*

b. *Concentration- increase in concentration tends to promote an elements discharge*

c. *Nature of the electrodes.*

✓ *Table: part of the electrochemical series is shown below.*

Cations		Anions
K^+	most active	SO^{2-}_4
Ca^{2+}		NO_3^-
Na^+		Cl^-
Mg^{2+}		Br^-
Zn^{2+}		I^-
Fe^{2+}		OH^-
Pb^{4+}		
H^+		
Cu^{2+}		
Ag^{2+}	least reactive	

✓ *Electrolysis reactions*

During electrolysis the positive metal ions are attracted to the oppositely charged (negative) cathode where they gain electrons to form neutral atoms. The negative non- metal ions are attracted to the oppositely charged (positive) anode where they lose electrons to form neutral atoms.

✓ *Steps of analysing electrolysis reactions.*

1. *Determine the ions present in the solution.*
2. *Determine which ions move to either the cathode or anode.*
3. *Determine which ion will be preferentially discharged, (in case of solutions- both dilute and moderately concentrated) and ;*
4. *Finally determine the status of the remaining solution.*

Question 1

(a) Organic compounds form homologous series.

Give two characteristics of members of any homologous series. [2]

(b) Draw the structure of an alkane with two carbon atoms in the molecule. [2]

(c) Calculate the percentage by mass of hydrogen in this alkane. [2]

[SCEINCE – 5124/P3/Q6/2012]

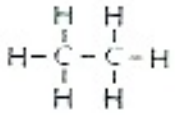
WORKED SOLUTIONS

(a)

1. They conform to a general molecular formula
2. Each member differs in molecular, from the next by CH_2

(b)

(i) structure



(ii) % by mass of hydrogen = 14.3%

Calculation

- The alkane has four hydrogens, therefore, the mass of hydrogen is 4g
- The total formula mass of the alkane is 28g (mole concept)
- % by mass = mass of hydrogen/total mass of alkane

= 4g/28g X100

= 14.3%

CONCISE INFORMATION (HOMOLOGOUS SERIES)

A series of compounds related to each other as the alkanes are is called a homologous series. Such a series has the following characteristics:

- *All members conform to a general molecular formula e.g. for alkanes, C_nH_{2n+2}.*
- *Each member differs, in molecular, from the next by CH_2, for example alkanes are CH_4, C_2H_6 and so forth.*
- *All members show similar chemical reactions, though varying in vigour. For example, all alkanes burn in air and give substitution reactions with chlorine.*
- *The physical properties of members change gradually in the same direction along the series, for example, in the alkanes, boiling points and freezing points rise (CH_4- a gas, C_5H_{12}- a liquid, $C_{20}H_{42}$- a solid at ordinary temperature and pressure.*

Question 2

(a) i) What is meant by the term unsaturated hydrocarbon? [1]

ii) Name one **unsaturated** hydrocarbon and draw its structural formula. [1]

iii) Name or write the chemical of the product formed when bromine and the named unsaturated hydrocarbon combine. [1]

iv) Name one **saturated** hydrocarbon and draw its structural formula. [2]

(b) i) Which of the two named hydrocarbons in a(ii) or (iv) can be converted to a Polymer? [1]

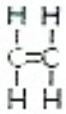
ii) Name the polymer and draw its structure. [2]

iii) State on environmental disadvantage of the polymer named in b(ii) . [1]

[SCIENCE - 5124/P3/2008]

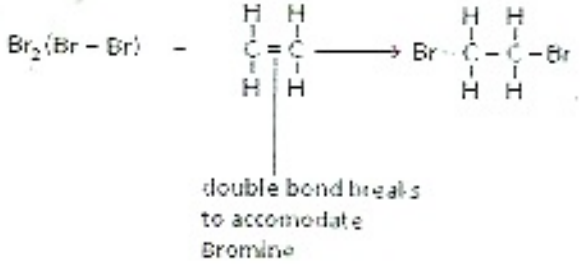
(a) i) The term unsaturated hydrocarbon means a hydrocarbon containing at least a multiple bond between two carbon atoms in its carbon chain (e.g. C=C).

ii) Ethene



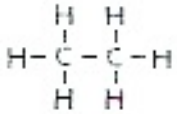
iii) Dibromoethane.

***TAKE NOTE** Formation of dibromoethane is as follows:*



The bond on the alkene is broken, creating space for two bromine atoms.

iv) Ethane

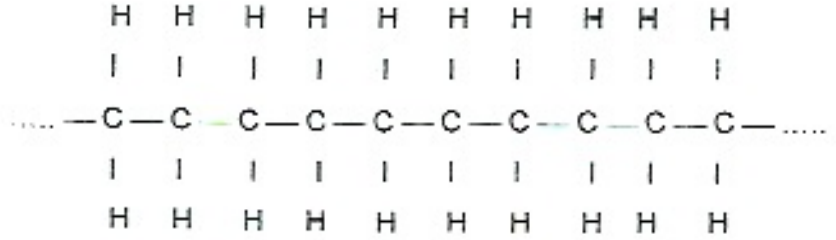


b. i) Ethene

TAKE NOTE

The C=C double bond of alkenes allow them to take part in addition reactions. The double bond is broken and other atoms attach to the carbons.

ii) Polyethene

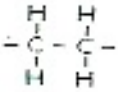


*** TAKE NOTE**

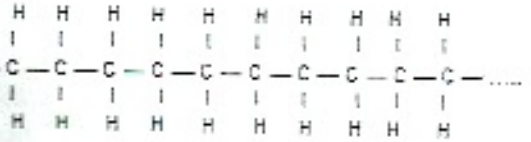
The double bond in ethene enables many molecules of ethene to join and form a large molecule (polymer), polythene/

monomer, ethene

double bond breaks



polymer(polythene) is formed by joining of many ethene molecules



iii) The environmental disadvantage of polythene is that it is non-biodegradable, hence when discarded causes land and water pollution.

CONCISE INFORMATION (REACTIONS OF HYDROCARBONS)

- ✓ *Hydrocarbons*
  - *A hydrocarbon is a compound that contains carbon and hydrogen atoms only*
- ✓ *The main classes of hydrocarbons include the Alkanes and Alkenes.*
- ✓ *Alkanes*
  - *These are saturated hydrocarbons that contain only single covalent bonds between carbon atoms.*
  - *The general formula for alkanes is $C_n H_{2n+2}$; where n is the no of carbon atoms present.*
- ✓ *Alkenes*
  - *These are unsaturated hydrocarbons that contain at least one C=C double bond amongst its carbon atoms somewhere in its chain structure.*
  - *The general formula for alkenes is $C_n H_{2n}$; where n is the no of carbon atoms present.*
- ✓ *Bromination*
  - *Bromine reacts with ethene to produce dibromoethene (colourless compound);*

$$C_2H_{4\,(g)} + Br_{2\,(l)} \longrightarrow C_2H_4Br_{2\,(l)}$$

The double bond in ethene breaks open and forms new bonds to the bromine atoms. The type of reaction, where a double bond breaks and two new atoms are added is known as an addition reaction. Other addition reactions include;

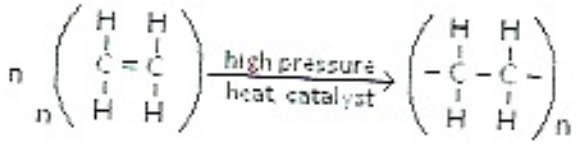
Hydrogenation

Hydration

Chlorination

✓ *Polymerization*

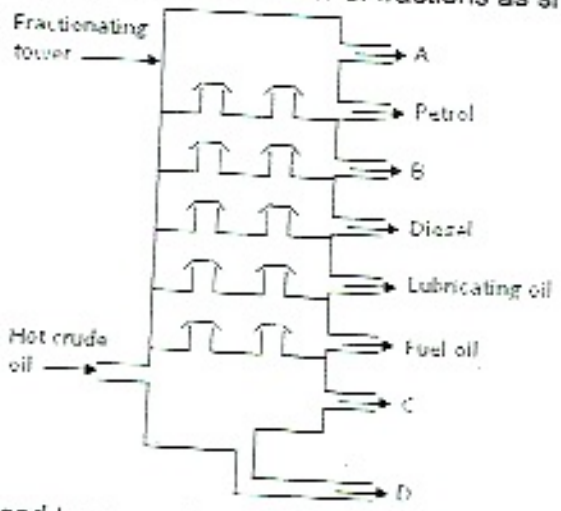
- *Polymerization is the chemical reaction in which a macromolecule known as a polymer is formed from many, small, identical reactive molecules (monomers).*
- *The joining of identical monomers, thereby making a chain of carbon atoms is called addition polymerization e.g. the double bond in ethene when broken, makes it possible for many other ethene molecules to join and form a large molecule. (polyethene)*
- *Various conditions can be used to produce different types of polyethene. Generally a high pressure, temperature at or above room temperature and a catalyst are needed. This can be summarised as shown below;*



where n is a very large number

Question 3

Crude oil is an important raw material that we need in modern life. Engineers process and refine crude oil in a tower to produce a number of fractions as shown in the diagram below.



(a) Name the process used to separate the fractions of crude oil. [1]

(b) Name two major elements that are found in crude oil. [2]

(c) State <u>two</u> differences in physical properties between fractions extracted at C and B. [2]

(d) A large proportion of fraction A has the molecular formula CH_4. Write a balanced chemical equation for the complete combustion of the compound with the chemical formula CH_4. [1]

(e) Crude oil is a non-renewable energy source. Explain what is meant by a 'non- renewable energy source'. [1]

(f) Give <u>two</u> reasons why the sun is a better source of energy than crude oil. [2]

[SCIENCE - 5124/3/2/2011]

WORKED SOLUTIONS

(a) Fractional distillation.

TAKE NOTE

Separation by fractional distillation takes advantage of the difference in the boiling points of the fractions in crude oil.

(b) Hydrogen and Carbon.

TAKE NOTE

Crude oil is mainly made up of hydrocarbons and hydrocarbons are defined as compounds having only the elements carbon and hydrogen.

(c) – Fraction C has a higher boiling point than fraction B.

- Fraction B has a lower viscosity (thickness) than fraction C.

***TAKE NOTE** The fractions that are released at the top are lighter while those collected at the bottom are heavier.*

(d) $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

***TAKE NOTE:** All hydrocarbons burning in air (O_2) produce carbon dioxide (CO_2) and water (H_2O) only.*

(e) A non-renewable source is one that is of limited supply and cannot be replaced once used.

TAKE NOTE

Natural resources are grouped into two categories renewable and non-renewable. Renewable ones are those that do not run out and may be replaced over time such as vegetation or are inexhaustible such as solar energy. Non-renewable ones are those that are of limited supply and cannot be replaced once used. Such include fossil fuels and mineral deposits such as copper.

(f) i) The sun is inexhaustible (cannot run out) where as crude oil is exhaustible.

ii) The use of solar energy is a clean process while that of crude oil causes pollution

Question 4

The chemical equation below is a reaction in which glucose is changed to ethanol.

$$C_6H_{12}O_{6\,(aq)} \xrightarrow{\text{yeast}} 2CH_3CH_2OH_{\,(aq)} + 2CO_{2\,(g)}$$

(a) What term is used to describe this type of reaction? [1]

(b) What is the purpose of the yeast? [1]

(c) Draw the structural formula of ethanol. [1]

(d) To which homologous series does ethanol belong? [1]

(e) When ethanol is exposed to air, it becomes 'sour'. Explain what happens. [2]

(f) Draw the structural formula of the compound formed when ethanol is dehydrated. [1]

[CHEMISTRY 5070/2/2010]

WORKED SOLUTIONS

(a) Fermentation.

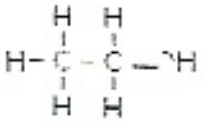
***TAKE NOTE**

Fermentation is the production of ethanol from sugar by the action of yeast or bacteria on it.

(b) Produces enzymes that catalyse the breakdown of glucose into ethanol and carbon dioxide.

***TAKE NOTE:** The enzymes of yeast or bacteria serve as catalysts for the transformation of sugar to alcohol.*

(c)



(d) Alkanols or Alcohols.

***TAKE NOTE**

A group of compounds related to each other with members conforming to a general molecular formula is called a homologous series. The alcohols are a homologous series of compounds which contain a hydroxyl (OH, as a functional group.

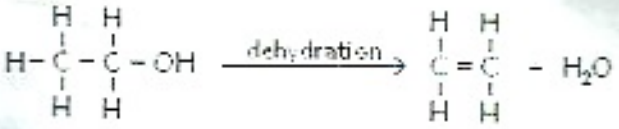
(e) Oxidation occurs which leads to the formation of carboxylic acid (i.e. ethanoic or acetic acid), which has a sour taste.

TAKE NOTE

Oxidation reactions that cause formation of carboxylic acid occur when ethanol is exposed to milder conditions such as a bottle of wine being left open for a long time.

$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$

(f)



Dehydration is the process of removing water from a compound. Ethanol can be dehydrated to produce ethene.

CONCISE INFORMATION (ALCOHOLS)

✓ *Alcohols*

- *The alcohols are a homologous series of compounds which contain a hydroxyl OH as a functional group. A functional group is a group of atoms in a structure that determines the characteristic reactions of a compound.*
- *The alcohols form a homologous series of a general molecular formulae, $C_nH_{2n+1}OH$, $n \geq 1$*

✓ *Formation of Alcohols*

i) Addition reactions

Ethene + steam $\xrightarrow[\text{at 300°C}]{\text{Phosphoric (V) acid}}$ *ethanol*

$C_2H_{4\,(g)} + H_2O_{\,(g)} \xrightarrow[300°c]{H_3PO_4} C_2H_5OH_{\,(aq)}$

ii) Fermentation

$C_6H_{12}O_{6\,(aq)} \xrightarrow{yeast} 2CH_3CH_2OH_{\,(aq)} + 2CO_{2\,(g)}$

✓ *Chemical reactions of Alcohols.*

i) Oxidation

Like all other hydrocarbons, alcohols can be burnt in the presence of oxygen releasing enough heat for it to be used as a fuel. This is known as oxidation.

$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$

A further type of oxidation occurs when ethanol is exposed to milder conditions such as a bottle of wine being left open for a long time, this will cause the formation of a carboxylic acid.

$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$

ii) Esterification

Alcohols react with organic acids to form sweet smelling oily liquids called esters.

E.g. ethanol + ethanoic acid ⟶ *ethyl ethanoate + water*

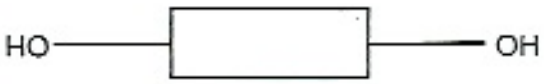
$CH_3CH_2OH + CH_3COOH \longrightarrow CH_3COOCH_2CH_3 + H_2O$

iii) Dehydration

Ethanol can be dehydrated to produce ethene. This is one method used in the preparation of ethene in the laboratory. Ethanol vapour is passed over a heated catalyst. The catalyst used can be aluminium oxide or broken pieces of porous pot.

Question 5

A carbohydrate is formed from the reaction of many small molecules, one of which is represented by the diagram below.



(a)

i. What is the general name of the small molecules which combine to form very large molecules?

ii. Show how two of the small molecules like the one drawn above would join together to form a bond. [2]

(b) Starch is hydrolysed to glucose by the enzymes in yeast and the glucose is then converted to an alcohol by a second process. Name:

(i) The second process

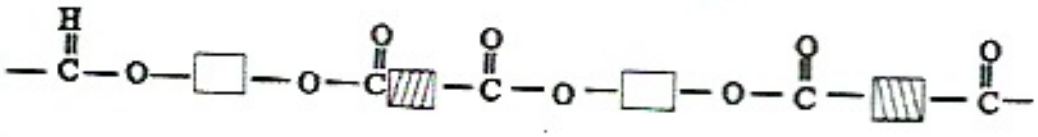
(ii) The alcohol produced. [2]

(c) State two uses of alcohol named in (b)(ii) above

(d) Terylene is an ester.

(i) State one use of terylene. [1]

The structure of terylene is represented in the diagram below.



(ii) Draw a box around a repeating unit in this structure. [1]

(iii) Why does terylene cause pollution? [1]

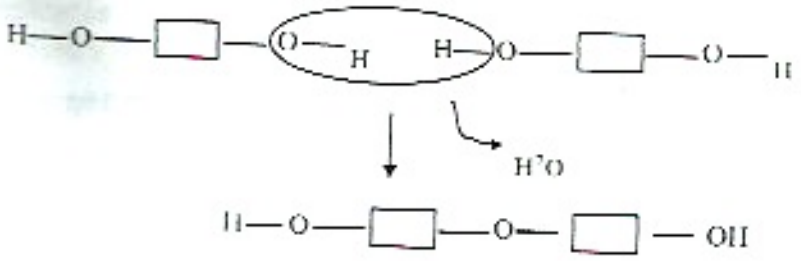
[SCIENCE – 5124/P3/Q9/2010]

WORKED SOLUTIONS

(a)

(i) Monomer

(ii)



(b)

(i) Fermentation

(ii) Ethanol

(c) – used in making esters which are used in perfumes

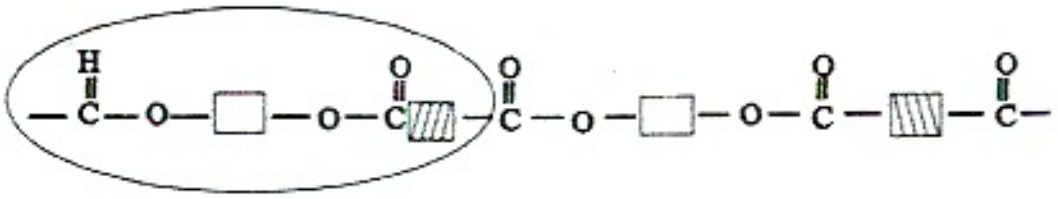
- Used in beverages such as wine and liquor

N.B. check concise information on estarification)

(d)

(i) Used in perfumes (responsible for sweet smell)

(ii)



(iii) Terylene causes pollution because it is non-biodegradable

Question 6

Organic acids are homologous series of compounds having the carboxylic group –COOH joined to an alkyl radical.

(a) What is the general formula for organic acids? [1]

(b) Draw the structure of butanoic acid

(c) A reaction between and alcohol and an organic acid is described as esterification and this is similar to neutralisation.

(i) Ehtylethanoate is an ester. Name two reagents used to prepare it. [2]

(ii) State two ways in which esterification is different from neutralisation. [2]

(iii) Write a balanced chemical equation for the esterification of ehtylethanoate. [2]

(d) Calculate the mass of ehtylethanoate formed from 15g of the organic acid. [2]

[SCIENCE – 5124/P3/Q11/2012]

(a) Carboxylic acids general molecular formula, $C_nH_{2n+1}CCOH$

(b) (structure)

TAKE NOTE:

When naming carboxylic acids, the carbon atom of the –COOH group is include. So formula for butanoic acid is C_3H_7COOH.

(c)

(i) Ethanol and ethanoinc acid are reagents

(ii)

- esterification involves the reaction between an acid (organic acid) and alcohol where as in neutralization the reaction is between an acid and a base.
- In esterification an ester is formed while in neutralisation a salt is formed.

(III) $CH_3CH_2OH + CH_3COOH \rightarrow CH_3COOCH_2CH_3 + H_2O$

(d)

- moles of organic acid = 15g/60(formula mass)
  = 0.25mol
- the mole ratio organic acid to ester is 1:1, therefore moles of ester is 0.25mol
- mass of ester = moles X formula mass
  = 0.25 X88
  = 22g

CONCISE INFORMATION (ESTERIFICATION)

✓ *Esters*

- *Esters are organic compounds formed by the reaction of acids and alcohols. An ester is formed by replacing ionisable hydrogen (of the COOH group) by the organic alkyl group from the ethanol.*
- *The esters usually have pleasant smell and find uses as flavouring materials and in perfumes*
- *Some esters occur naturally and these are also sweet smelling, they include;*
  a) Vegetable oils – palm oil, groundnut oil, e.t.c
  b) Animal fats

✓ *Formation of an ester.*

- *Reaction: carboxylic acid and alcohol*

  $CH_3COOH_{(aq)} + C_2H_5OH_{(aq)} \rightleftharpoons CH_3COOC_2H_{5(aq)} + H_2O_{(l)}$

  The above reaction is reversible. Hydrolysis (addition of water), recovers the acid and alcohol. In practice, the acid and alcohol are recovered by boiling with dilute mineral acid (HCl or H_2SO_4) or with an aqueous alkali (KOH or NaOH) as catalysts.

  $CH_3COOC_2H_{5(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COOH_{(aq)} + C_2H_5OH_{(aq)}$

- *When an alkaline is used, the above reaction is followed by the production of the sodium salt of the acid*

  $CH_3COOH_{(aq)} + NaOH_{(aq)} \longrightarrow CH_3COONa_{(aq)} + H_2O_{(l)}$

Question 7

One of the hydrocarbons found in crude oil is undecane, $C_{11}H_{24}$.

(a) Under suitable conditions, undecane undergoes the reaction below;

$$C_{11}H_{24} \longrightarrow C_7H_{16} + C_4H_8$$

i) What term is used to describe the type of reaction in the petroleum industry? [1]

ii) State two conditions necessary for the reaction to take place. [2]

iii) When 1.0 mol of undecane is used in the reaction, 21.2g of heptane C_7H_{16} is produced. Calculate the percentage yield of heptane. [2]

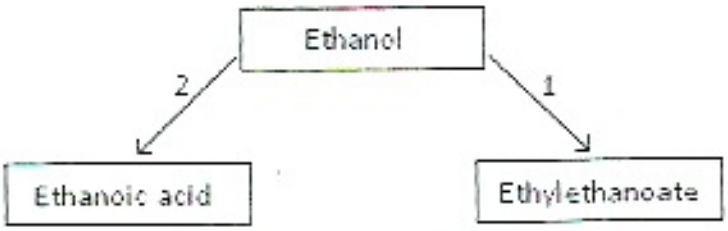
(b) Butene, C_4H_8 can exist as isomers.

i) Draw the structural formulae of the two isomers. [2]

ii) What is meant by the term 'isomer'? [1]

iii) Suggest a suitable name for the macromolecule formed when butene is polymerized [1]

(c) The following reaction shows the reactions involving ethanol.



i) Name the reactions 1 and 2. [2]

ii) Name the reagent solution that should bring about change 2. [1]

iii) Draw the structure formulae of ethylethanoate showing all the bonds. [2]

iv) What physical property of ethylethanoate distinguishes it from other compounds? [1]

[CHEMISTRY 5070/2/2006]

WORKED SOLUTIONS

(a) i) Catalytic cracking

** TAKE NOTE: Cracking is a process where large hydrocarbon molecules break into smaller molecules.*

ii) - Presence of a catalyst
- high temperature (around 500°c)

iii) $C_{11}H_{24} \longrightarrow C_7H_{16} + C_4H_8$

0.1mol ? mol

Mole ratio between $C_{11}H_{24}$ and C_7H_{16} is 1 : 1, therefore no of moles of C_7H_{16} is 1.0 moles

Expected mass of C_7H_{16} = moles x molar mass

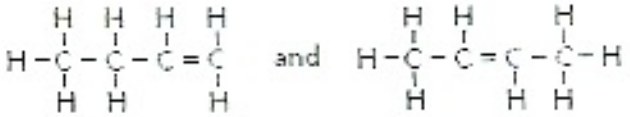
= 1.0 mol x 100g/mol

= 100g

% yield = $^{\text{actual mass}}/_{\text{expected mass}}$ x 100

= $^{21.2g}/_{100g}$ x 100

= 21.2%

(b)  and

ii) Isomers are two or more compounds with the same molecular formula but different molecular structure.

iii) Polybutene

*** TAKE NOTE**

Polybutene is formed when numerous butene molecules join together in an addition reaction. This is called addition polymerisation.

(c) i) reaction 1 is esterification

*** TAKE NOTE**

Ethanol (an alcohol) combines with ethanoic acid (a carboxylic acid) to generate ethylethanoate. an ester. This process is called esterification.

$CH_3CH_2OH + CH_3COOH \longrightarrow CH_3COOCH_2CH_3 + H_2O$

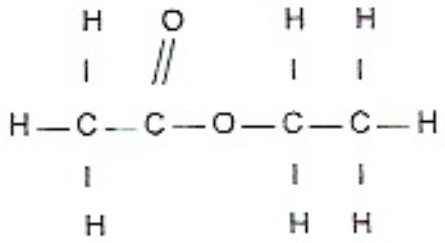
Reaction 2 is oxidation.

*** TAKE NOTE**

$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$

ii) acidified potassium dichromate (VI)

iii)



iv) Ethylethanoate has a sweet/pleasant smell.

*** TAKE NOTE**

The esters usually have a pleasant fruity smell and are used as flavouring materials in perfumes.

CONCISE INFORMATION (ATALYTIC CRACKING)

✓ *Catalytic cracking*

- *Large molecules from heavier fractions of petroleum can be broken into smaller, more valuable, molecules. This process is called cracking.*
- *In cracking reactions, particles of catalysts (made up of powdered minerals such as silica, alumina and zeolites) are mixed with the hydrocarbons fractions at around 500°c*

  The following is an example of a cracking reaction;

  $C_{10}H_{22} \longrightarrow C_8H_{18} + C_2H_4$
- *All cracking reactions give two types of products;*

  - An alkane with a shorter chain than the original, and

  - A short chain alkene molecule.

✓ *Isomerism*

- *Isomerism is the occurrence of two or more compounds with the same molecular formula, but different molecular structure. Isomers of butane are as follows;*

Question 8

(a) **Plastics** are organic polymers. The table below describes two types of plastics. Complete the table. Part of the table has been completed for you as an example.

name	Repeating unit	use	Type of polymerization used in manufacture
Poly(ethane)		Making plastic bags	
			Condensation polymerisation

[4]

[SCIENCE – 5124/P3/Q8/2011]

name	Repeating unit	use	Type of polymerization used in manufacture
Poly(ethane)	DIAGRAM	Making plastic bags	Additional polymerisation
Polyamide	DIAGRAM	Used in textiles for clothing, e.g. nylon	Condensation polymerisation

TAKE NOTE:

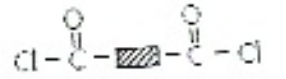
Polymerization is the chemical reaction in which a compound is made into a polymer by the addition or condensation of smaller molecules.

- *Joining identical monomers to make carbon chains is called addition polymerization.*
- *the joining of two or more different monomers of varying length with the elimination of water (or other polymers) is called Condensation polymerization*

Question 9

The diagram below shows the two monomers which are used to make nylon in the laboratory.

1, 6 diaminohexane



hexanedioyl chloride

(a) What name is used to describe the type of reaction in which nylon is formed from the two monomers?(1)

(b) Apart from nylon, name another compound formed by the reaction of the two monomers to form nylon. [1]

(c) Draw the structure of nylon showing four(4) monomer ends. [2]

(d) Draw a circle around the simplest repeating unit in the structure you have drawn above. [1]

(e) Name a naturally occurring macromolecule which has similar linkages to those found in nylon. What is the name given to this type of linkage? [2]

(f) State one use of Nylon. [1]

[CHEMISTRY 5070/2/2008]

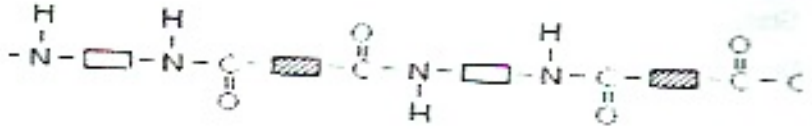
WORKED SOLUTIONS

(a) Condensation polymerisation.

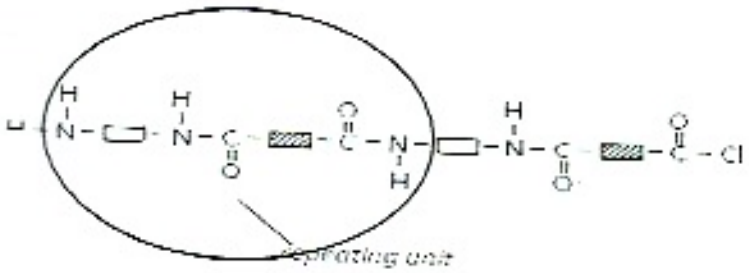
(b) Hydrogen chloride.

***TAKE NOTE**

Hydrogen is coming from 1, 6 diaminohexane and chlorine from hexanedioyl chloride thus forming hydrogen chloride



(c)

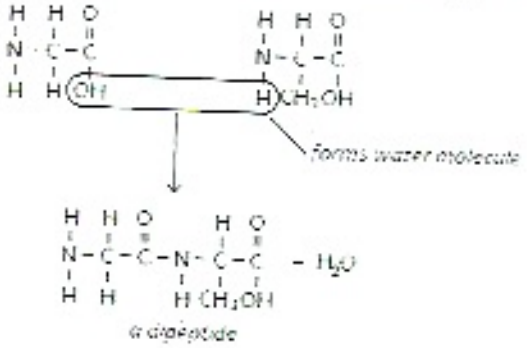


(d) Name of macromolecule: Protein

Type of linkage: amide (peptide) linkage

***TAKE NOTE**

Proteins are built from amino acid monomers. All amino acids contain two functional groups, $-NH_2$ and $-COOH$. When amino acids react with each other, an amide linkage is formed to produce a dipeptide.



When this is repeated many times using different amino acids, a polymer is formed. Chains involving more than 100 amino acids are called proteins.

(e) Nylon is used as a synthetic fibre in clothing, carpets, rubber reinforcement, sail cloth, computer ribbons and sewing threads.

Question 10

(a) A gaseous organic compound, K contains 85.7% carbon and 14.3% hydrogen by mass. 28g of the compound occupy 24 000cm^3 measured at r.t.p.

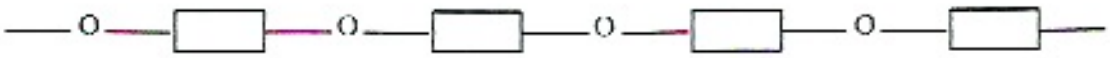
(i) Work out the empirical and molecular formula of the compound. [4]

(ii) The organic compound is an unsaturated hydrocarbon. What do you understand by the terms 'unsaturated' and 'hydrocarbon'? [2]

(iii) State the products of the complete combustion of any hydrocarbon. [2]

(iv) Draw the full structural formula of K. [1]

(b) The structural formula of a macromolecule is shown below.



(i) What is meant by the term 'macromolecule'? [1]

(ii) Name the macromolecule represented above. [1]

(iii) Draw the structural formula of the monomer from which the macromolecule is made. [1]

(iv) The macromolecule shown above can be broken down into the simpler molecules from which it is made. What name is given to this type of reaction? State the conditions under which the reaction occurs. [3]

[CHEMISTRY/5070/2/2010]

(a) .

(i) Empirical formula is CH_2

Calculations of empirical formula involve 4 steps as follows:

		Carbon	Hydrogen
1	Mass	85.7	14.3
2	Molar mass	12	1
3	Moles	7.14	14.3
4	Mole ratio	1	2

Therefore the empirical formula is CH_2

Molecular formula = (empirical formula) X n

$= (CH_2) \times 2$

$= C_2H_4$

n. is calculated as:

n. = relative formula mass/ relative empirical formula mass

= 28/14

= 2

(ii) Unsaturated means the carbon atoms contains at least one c=c double bond in the molecule

Hydrocarbon means the compound contains only C and H atoms.

(iii) Products of combustion of hydrocarbons are **carbon dioxide** and **water** only.

(iv)

(b)

(i) Large/giant molecule consisting of many structural units joined together, e.g. protein, fat, polymer, etc.

(ii) Carbohydrate (starch)

(iii) Hydrolysis

(iv)

- Heating

Use of Hydrochloric acid and enzymes(*hydrochloric acid acts as a catalyst*)

Tests for anions

Anion	*Test*	*Test result*
carbonate (CO_3^{2-})	add dilute acid	effervescence, carbon dioxide produce
chloride (Cl^-) [in solution]	acidify with dilute nitric acid, then add aqueous silver nitrate	white ppt.
iodide (I–) [in solution]	acidify with dilute nitric acid, then add aqueous lead(II) nitrate	yellow ppt.
nitrate (NO_3^-) [in solution]	add aqueous sodium hydroxide then aluminium foil; warm carefully	ammonia produced
sulphate (SO_4^{2-}) [in solution]	acidify with dilute nitric acid, then add aqueous barium nitrate	white ppt.

Tests for aqueous cations

Cation	*effect of aqueous sodium hydroxide*	*effect of aqueous ammonia*
Aluminium (Al^{3+})	white ppt., soluble in excess giving a colourless solution	white ppt., insoluble in excess
ammonium (NH_4^+)	ammonia produced on warming	-
calcium (Ca^{2+})	white ppt., insoluble in excess	no ppt. or very slight white ppt.
copper(II) (Cu^{2+})	light blue ppt., insoluble in excess	light blue ppt., soluble in excess giving a dark blue solution
iron(II) (Fe^{2+})	green ppt., insoluble in excess	green ppt., insoluble in excess
iron(III) (Fe^{3+})	red-brown ppt., insoluble in excess	red-brown ppt., insoluble in excess
zinc (Zn^{2+})	white ppt., soluble in excess giving a colourless solution	white ppt., soluble in excess giving a colourless solution

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