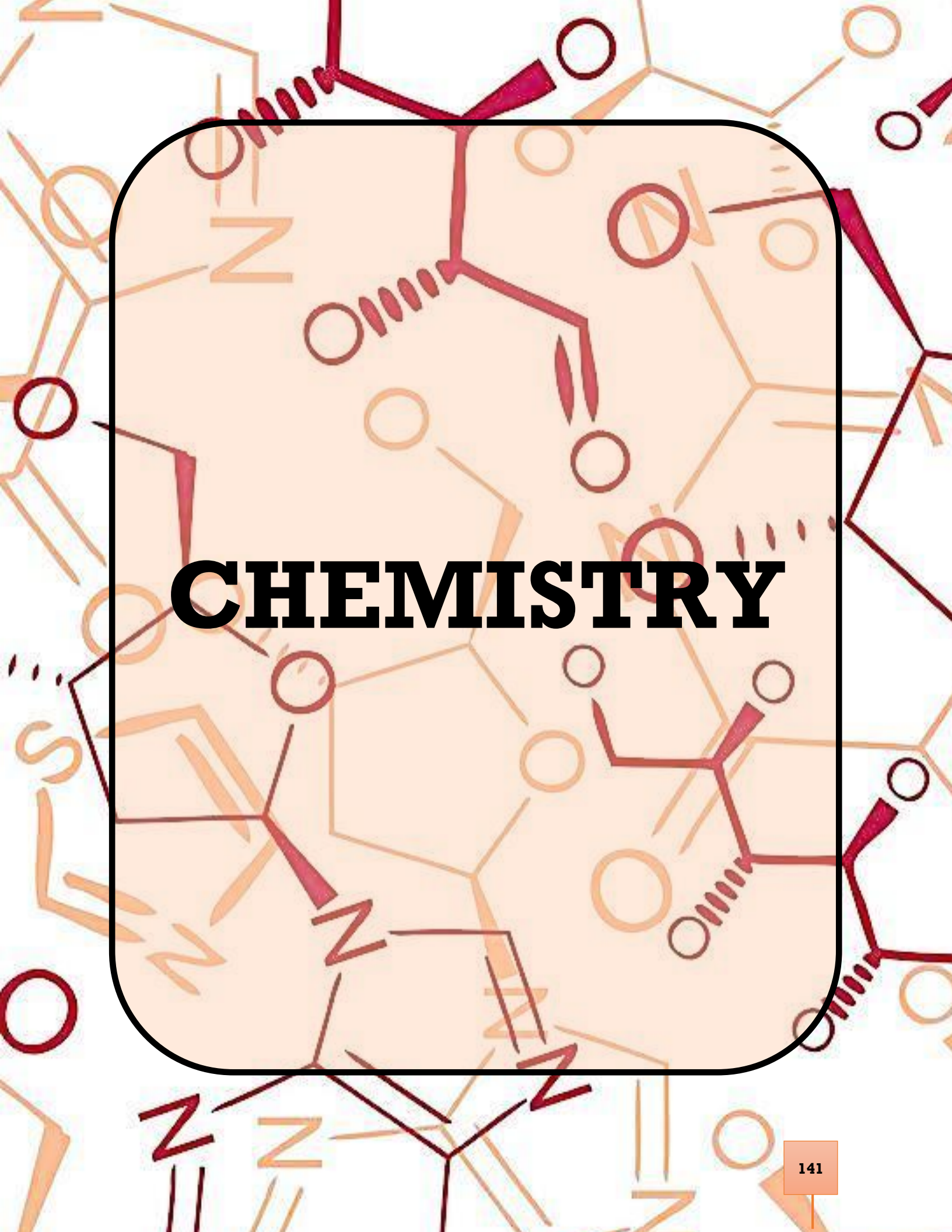

CHEMISTRY

JANUARY 2013 PAPER 2

1. (a) This is the study of the speed at which reactions occur. The rate of a reaction can be found by measuring the change in concentration of reactants or products per unit time.

(b) TABLE 1: DATA FOR EXPERIMENTS

Experiment	[HCl] (mol dm^{-3})	Form of Zinc	Temperature (^oC)	Volume (cm^3)
1	0.1	granules	30	89
2	0.2	granules	30	171
3	0.1	powder	30	187
4	0.1	granules	20	46

(c) **(i)** $Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$

(ii) An oxidizing agent causes an element/compound to lose electrons. HCl is the oxidizing agent. Oxidizing agents gain electrons.

$2H^+_{(aq)} \longrightarrow H_{2(g)}$

$+ \quad \longrightarrow \quad 0$

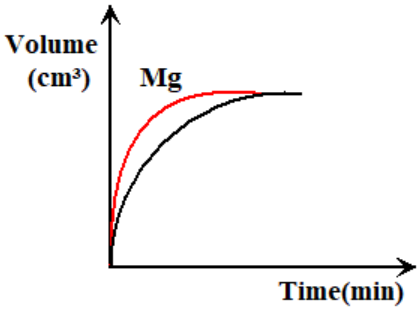
(iii) Step 1: Convert mass of zinc to moles, $\frac{1}{65} = 0.015$ moles of Zn.

Step 2: Refer to mole ratio of Zinc and H_2 in balanced equation $= 1:1$.
From the mole ratio 0.015 moles of H_2 will be produced.
Step 3: Convert number of moles of H_2 to volume by multiplying 0.015 by 24 dm^3 = 0.36 dm^3 of $H_{2(g)}$.

(d) Experiment 2: This experiment produces more gas than experiment #1 because the concentration of reactant molecules is greater therefore the chances of collision is more frequent.
Experiment 3: This produces the most because of increase surface area. More molecules can react at the same time and this increases the rate of reaction.
Experiment 4: At lower temperature molecules have less energy to move and collide therefore the volume of gas is lowered with decrease rate of reaction.

(e) **(i)** Magnesium granules (more reactive than zinc in the reactivity series)

(ii)



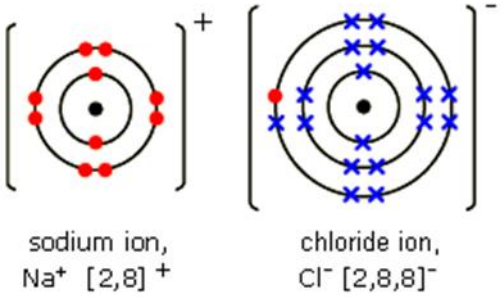
(f) **(i)** Construction of a simple electric cell using a conductivity meter, power supply, measuring cylinder, beaker and test reagents:
1- Place an equal volume of diluted sodium chloride, hydrochloric acid and acetic acid using a measuring cylinder into separate beakers.
2- Place each beaker one at a time into the electric cell and measure the conductivity of the solution. Barium sulphate is a solid.

(ii) Sodium chloride solution and hydrochloric acid are both strong conductors of electricity and are strong electrolytes. They would give a high reading on the conductivity meter. However, acetic is a weak electrolyte and will not give a high reading and Barium sulphate is insoluble in solution, that is it has no mobile electrons and will not conduct electricity.

2. **(a)** **(i)** Sublimation

(ii) Light purple gas from the mixture of Iodine and sodium chloride will emerge and condense on the outer cool surface of the beaker with water.

(iii)

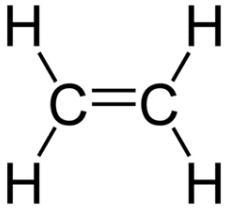


(iv) The intermolecular force of attraction in NaCl (ionic compound) is much stronger than simple molecules where the force of attraction is weaker in covalent bonds. The lattice structure in NaCl is giant sized and made up of thousands of molecules while I_2 has a smaller structure with weak intermolecular forces of attraction therefore gently heating will vapourise I_2 molecules.

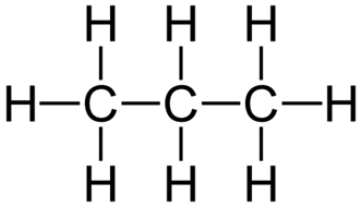
(b) **(i)** This method is not suitable for separating the Fe from NaCl.

(ii) The force of attraction within a Fe molecule is very strong. Fe has metallic bonding where strong intermolecular forces of attraction occur just like NaCl. Therefore, both of them need high temperatures to break up their structure. A magnet can be used to remove the iron fillings.

3. **(a)** **(i)**



Compound A
Name: Ethene



Compound B
Name: Propane

(ii) Compound A burns in air with a sooty flame.
N.B. alkenes contain fewer hydrogen atoms per molecule that results in a smokey flame.

(iii) Equation: $C_2H_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$

(b) **(i)** Compound C is ethanoic acid. It is soluble in water because it contains a hydroxyl group (OH) that has a polar H or hydrophilic group that bonds to water easily/. Therefore making it very soluble in water.

(ii) $2CH_3COOH_{(aq)} + Ca_{(s)} \longrightarrow (CH_3COO)_2Ca_{(aq)} + H_{2(g)}$

(c) **(i)** A polymer is a compound that is made up of many smaller units forming a long chain-like molecule. Polymers can consist of thousands of single units joined together.

(ii) **a)** Addition polymerization

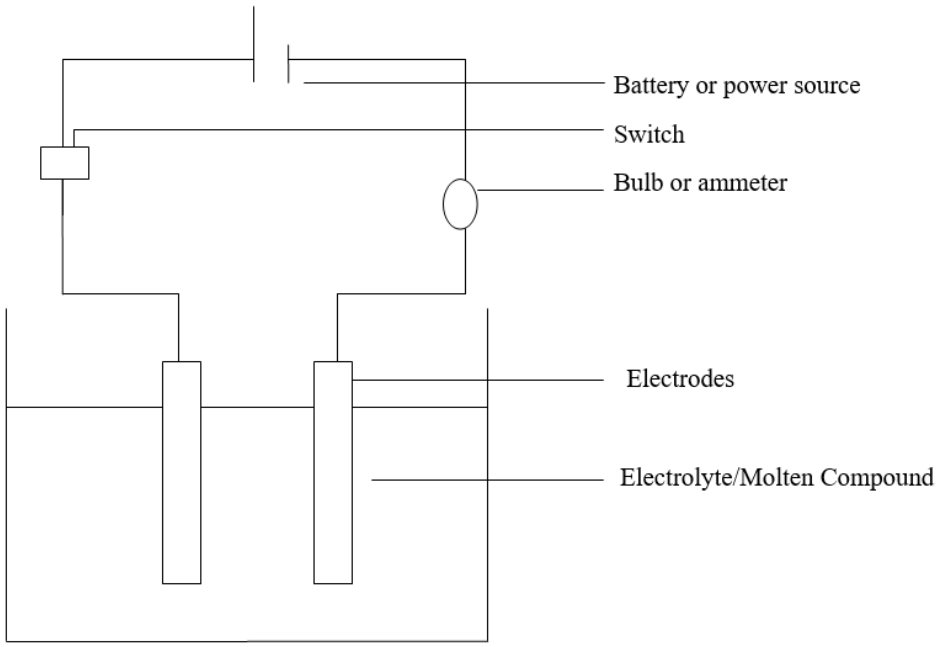
b) Polypropene

c) Plastics

4. **(a)** Magnesium conducts electricity when solid because it has free (available) mobile electrons. Metallic bonding is present in magnesium. Here the metal has a neat arrangement of positive ions held together in a sea of free moving electrons. However, MgI_2 bonding is ionic and the electrons are locked in a crystal lattice and are not free or mobile therefore it cannot conduct electricity. However, when MgI_2 is molten or in solution it conducts electricity as the molecule separates into positive cations and negative anions. The cation can move towards the cathode

and accept electrons, the anion will move towards the anode and release electrons. This allows the solution or molten MgI_2 to conduct electricity.

(b) **(i)**



(ii) At the cathode: $Mg^{2+}_{(aq)} + 2e^- \longrightarrow Mg_{(s)}$

At the anode: $2I^-_{(aq)} \longrightarrow I_{2(g)} + 2e^-$

(c) Current $(I) = 5A$ Time $= 10$ mins or 600 secs

$Q = It$

$= 5 \times 600$

$= 3000$ Coulombs

From the equation for the discharge of Magnesium: $Mg^{2+} + 2e^- \longrightarrow Mg$

2 moles of electrons are required for the formation of 1 mole of Magnesium.

That is, 2×96500 C 24g of Magnesium.

Convert Coulombs produced to moles then convert moles produced to mass by multiplying by its (Mg) RAM.

$$\text{Moles produced to mass} = \frac{3000}{2 \times 96500} \times 24$$

$$= 0.37 \text{ g Magnesium}$$

5. (a) **(i)** In process X Carbon dioxide dissolved in rain water and falls as carbonic acid. Process X is called precipitation (rainfall). Process Y is called photosynthesis. Here plants absorb carbon dioxide from the atmosphere

and combine it with water and minerals to make carbohydrates which is stored in plants and used when needed to release energy.

(ii) Process Z is combustion. An example of a fossil fuel is natural gas, methane CH_4. Methane undergoes combustion as shown by the following equation:

$CH_{4(g)} + O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)}$.

When fossil fuels burn or combust carbon dioxide is given off. Excess amounts or quantities of gas pollute the air by trapping heat causing the atmosphere to be hotter than its normal temperature. This warmer atmosphere causes a global phenomenon called global warming. Global warming is the direct cause of harmful effects such as melting of the ice caps and climate change, which results in excessive flooding and drought.

(b) **(i)** **a)** Since the formula of the oxide of metal R is RO, R cation is R^{2+} then the formula for R carbonate is $RCO_{3(s)}$.

$RCO_{3(s)} \longrightarrow RO + CO_2$

N.B. If R was more reactive than aluminum it could have been potassium or magnesium. Potassium and sodium carbonate undergo no reaction with heat. However, Mg will react to give oxide and carbon dioxide.

b) $3M_{(s)} + 2Al^{3+}_{(aq)} \longrightarrow 3M^{2+}_{(aq)} + 2Al_{(s)}$

e.g. $3M_{(s)} + 2AlCl_{3(aq)} \longrightarrow 3MCl_{2(aq)} + 2Al_{(s)}$

Displacement reaction. Metal M is more reactive than Aluminum therefore it will displace Aluminum from solution.

(ii) M is more reactive than R because it can displace Aluminum from solution therefore it will react more vigorously with dilute acid than with R. M is higher up the reactivity series than R which means it is more reactive.

(iii) Both of them are metals. They have high melting and boiling points and a chemical property is that they react with acids to produce salt and hydrogen gas.

6. **(a)** **(i)** Source of chlorofluorocarbons - refrigerants, aerosols. Source of phosphates – Fertilizers, detergents, weathering of rocks.

(ii) Chlorofluorocarbons destroy the ozone layer in the stratosphere that protect living organisms from the sun's dangerous ultraviolet radiation (U.V.) This harmful radiation causes cancer. The chlorofluorocarbons break up the O_3 (ozone) molecule to O_2 and a free radical oxygen, O^*. Phosphate is a nutrient that algae feeds on. Excessive phosphate can cause eutrophication or algae bloom. This excessive algae growth consumes all

the oxygen in the water, leaving none for other aquatic organisms. This can result in fish kills.

(b) One advantage of landfills is all refuse or garbage that can cause disease and pollution can be contained in one area for neutralization or breakdown to harmless compounds. Some disadvantages of landfills are leachate of toxic pollutants and compounds can contaminate underground water supply and the mixing of pollutants can cause a new potent compound (synergistic effect). Also, the release of methane gas causes global warming and the landfill can harbor disease-causing organisms like rodents and pathogens.

An advantage of an incinerator is that the heat produced can be used to heat water to steam, then to steam turbines for electricity generation. Disadvantages of incinerators are it produces large amounts of ash that has to be disposed of in landfills and it releases atmospheric pollutants like carbon dioxide and volatile organic compounds. Therefore, it not only causes land pollution but will also cause air pollution.

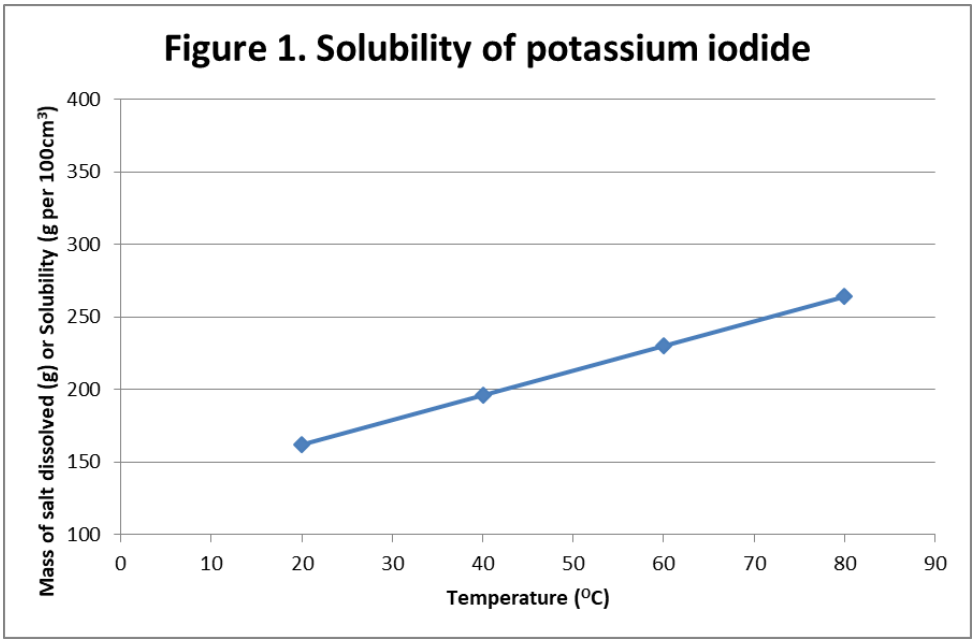
Recycling reduces the need for raw material for the manufacture of new products. Therefore it reduces the strain of exploration and extraction of new raw materials. Disadvantages associated with recycling include the high start-up cost and large amounts of recyclable material needed for the process to be economically viable and a large area needed for collecting, storing and processing of recyclable materials. Valuable productive forested and agricultural land can be lost for building of recycling plants.

JUNE 2013 PAPER 2

1. (a) (i) TABLE 1: MASS OF POTASSIUM IODIDE SOLUTION AT VARYING TEMPERATURES

Temperature (°C)	Mass of Beaker and 100cm^3 of Water (g)	Mass of Beaker and Salt Solution (g)	Mass of Salt Dissolved (g)
20	243	405	162
40	249	445	196
60	245	475	230
80	247	511	264

(ii)



(iii) 247 gcm^{-3}

(iv) At 70°C mass of KI = 247 g
At 30°C mass of KI = 177 g
Mass of KI that will precipitate out from solution at 30°C = 247 g − 177 g
= 70 g

(v) Step 1: Find the number of moles of KI present at 30 ^{o}C i.e. in the mass calculated above, divide by its RMM. (RMM of KI = 166)

$$\text{Number of moles of KI in 177 g} = \frac{177 \text{ g}}{166}$$
$$= 1.067 \text{ moles}$$

Step 2: 1.067 moles of KI are present in 177g in 100 cm^3. (Find the amount of moles in 1000 cm^3 to find the molarity.)

$$100 \text{ cm}^3 \text{ of KI} = 1.067 \text{ moles}$$
$$1 \text{ cm}^3 \text{ of KI} = \frac{1.067}{100} \text{ moles}$$
$$\therefore 1000 \text{ cm}^3 \text{ of KI} = \frac{1.067}{100} \times 1000$$
$$= 10.67 \text{ moles}$$

(b) Potassium Iodide is an ionic compound that is polar. Polar solvents will dissolve in polar solutes. Water and potassium iodide is polar so the potassium iodide will dissolve in water. Ethanol however, is polar but not as polar as water therefore the potassium iodide is only slightly soluble in ethanol.

(c) **(i)** Barium Nitrate or silver nitrate, beaker, Bunsen burner, retort stand, evaporating dish, filter paper, filter funnel and conical flask.

(ii) Dissolve both salts in water as both of them are soluble. To this mixture add a spatula of Barium Nitrate. This will react to give barium sulphate which is insoluble. The barium sulphate can be removed by simple filtration while the sodium chloride left in the solution can be obtained by recrystallisation. Another method is to dissolve both soluble salts in water. Then add silver nitrate to it. The silver nitrate will react to remove the chloride leaving behind barium nitrate in solution that can be obtained by recrystallisation.

(iii) Both salts will dissolve to give a clear solution – Upon adding the reagent (barium nitrate or silver nitrate) a white precipitate will be seen.

(d) TABLE 2: TEST FOR IONS PRESENT IN Q

Test		Observation	Inference
(i)	A small amount of solid Q was placed in a test tube and heated over a Bunsen burner.	• A brown gas was produced. • Damp blue litmus changed to red.	• Nitrogen gas was given off. NO_3^- ions present. • Acidic gas given off.
(ii)	A solution of potassium iodide was added to a solution of Q.	• A bright yellow precipitate was formed.	• This indicates that $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \longrightarrow PbI_{2(s)}$(yellow)

2. (a) (i) X is more easily ionized than Mg or those above it in the periodic table. The ease of ionization increases down the group II.

Explanation: As you go down group II metals, the atom is getting bigger as more filled shells are added. The force of attraction between the outermost electron and inner protons is getting weaker as the filled shells shield or reduce the attractive force of the valence electron and the nucleus therefore the outer electron is lost easily.

(ii) Cl has a stronger oxidizing power than Y.

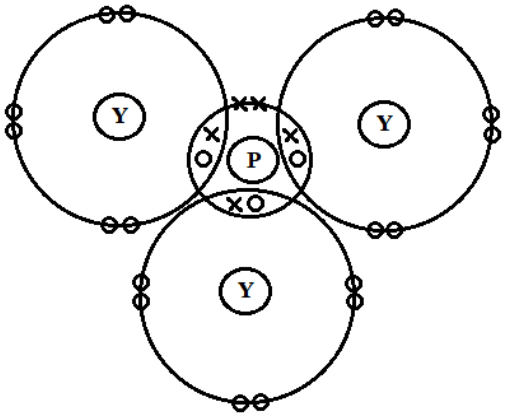
Explanation: Chlorine has a stronger oxidizing power than Y because it has less filled shells than Y and the shield effect is less. The force of attraction between the outer valence electrons and the nucleus is very strong. Chlorine will gain electrons and it will cause other atoms to lose electrons therefore chlorine is a powerful oxidizing agent.

(b) (i) Both X and Y is solids.

(ii) X is a metal it is hard (metallic bonding), has a high melting and boiling point while Y (non-metal) has covalent bonding and has a lower melting and boiling point.

(c) (i) Covalent bonding

(ii)



(iii) PY_3 is the chemical formula. This covalent compound has a low melting point and boiling point. It does not dissolve in polar solvents e.g. water and it does not conduct electricity in solution. It is soluble in non-polar organic solvents.

3. (a) This is the breaking up of long chain hydrocarbons into small ones by the use of heat or catalysts or by both. Shorter chains of lower molecular mass hydrocarbons are produced.

(b) **(i)** OH—□—OH where □ = $C_6H_{10}O_4$

(ii) OH—□—OH + OH—□—OH + OH—□—

OH ⟶ OH—□—O—□—O—□—OH

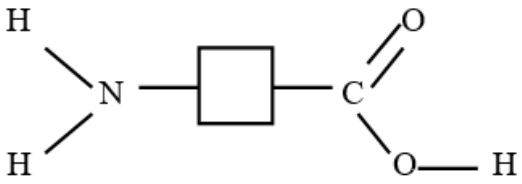
For continuous linkage and larger molecules:

(—□—O—□—O—□—)$_n$, where $n \geq 1$

(iii) Type of polymerization: Condensation polymerization
Family of polymers: Polysaccharides

(c) **(i)** Acid hydrolysis will break up the peptide bond releasing smaller units called amino acids.

(ii)



H is added to the NH part to form the amide part while OH is added to the CO part to form the carboxylic acid.

(d) **(i)** **a)** P and R

b) Q or S

(ii) Polyesters

4. **(a)** Four factors that influence the rate of reaction are: surface area, temperature, catalyst and concentration of reactants. For some reactions: light intensity and pressure.

(b) **(i)** The total volume of CO_2 produced is $124cm^3$. N.B. each small block represents $4cm^3$ of CO_2.

(ii) To find the mass of $CaCO_3$ used you must convert the volume of Carbon dioxide produced to moles then use the balanced equation to find the equivalent number of moles of $CaCO_3$ used. Finally, convert moles of $CaCO_3$ to mass by multiplying the number of moles by its RMM.

Step 1: Convert volume of CO_2 to Moles $= \dfrac{\text{Volume of } CO_2 \text{ produced}}{\text{R.T.P.}}$

$= \dfrac{124}{24000}$

$= 0.0052 \text{ moles of } CO_2$

R.T.P $= 24\ dm^3$ but since CO_2 produced in cm^3 convert to cm^3 by multiplying by 1000.

Step 2: Use balanced equation to find the number of moles of $CaCO_3$ required 1:1 mole ratio between $CaCO_3$ and CO_2. This means 0.0052 moles of $CaCO_3$ is needed to produce 0.0052 moles of CO_2.

Step 3: Convert moles of $CaCO_3$ to mass by multiplying number of moles of $CaCO_3$ by RMM.

RMM of $CaCO_3$ = 100 g

Mass of $CaCO_3$ $= 100\ g \times 0.0052 \text{ moles}$

$= 0.52\ g$

(iii) Using powdered Calcium carbonate instead of chipped will reduce the reaction time for the experiment. This will occur because the surface area in powdered Calcium carbonate is increased. This means that more particles can react or are exposed for reaction at any given time when compared to the chip.

(c) **(i)** Metals are often combined to make alloys because this combination produces improved and more durable properties than the individual metals.

(ii) Metals high in the reactivity series will react and displace those lower from solution. Manganese is higher than hydrogen therefore it will react with dilute acids but copper is lower than hydrogen and it will not react will dilute acids.

Step 1: React the mixture (alloy) with dilute acids, the manganese will react but not copper.
Step 2: Filter the resulting mixture and collect the residue (this is copper.)
Step 3: Wash the residue with water and dry to collect sample of copper.

5. (a) **(i)** The name of the electrolyte is brine (concentrated sodium chloride.) The ions present is $Na^{+}_{(aq)}$, $Cl^{-}_{(aq)}$ and $H^{+}_{(aq)}$, $OH^{-}_{(aq)}$.

(ii) At the cathode, H^{+} ions from the water are preferentially discharged, because it is lower in the electrochemical series than the Na^{+} ions.

At the anode the Cl^{-} ions are preferentially discharged because they are in a high concentration. N.B. For positive ions the least reactive metal/element will get discharged because they have the tendency to become atoms while more reactive metals have a greater tendency to become ions.

(iii) At the anode: $2Cl^{-}_{(aq)} \longrightarrow Cl_{2(g)} + 2e^{-}$
At the cathode: $2H^{+}_{(aq)} + 2e^{-} \longrightarrow H_{2(g)}$

(iv) The ion exchange membrane is to prevent the $Cl^{-}_{(aq)}$ and $OH^{-}_{(aq)}$ ions from mixing. It allows the Na^{+} ion to pass through to react with OH^{-} from water to get NaOH solution (sodium hydroxide.) It prevents the H^{+} from reacting with Cl^{-} to produce HCl (hydrochloric acid).

(b) **(i)** The anode will decrease its size, it will become thinner as the solid $Cu_{(s)}$ will go into solution $Cu_{(aq)}$.

(ii) The ionic equation at the cathode:
$Cu_{(aq)} + 2e^{-} \longrightarrow Cu_{(s)}$

One mole of $Cu_{(s)}$ requires 2 moles of e^{-}.
One mole of e^{-} = Faraday's constant
= 96500 C

Two moles of e^- $= 96500 \times 2$

$= 193000$ C

1 mole of $Cu_{(s)} = 193000$ C

Step 1: Find the amount of coulombs produced

$I = 5$ A, $t = 30 \times 60 = 1800$ s

$Q = It$

$= 5 \times 1800$

$= 9000$ C

Step 2: Convert coulombs produced to moles by dividing by 19 3000 C.

Number of moles of $Cu_{(s)}$ produced $= \frac{9000 \text{ C}}{193000}$

$= 0.0466$ moles of Cu

Step 3: Convert moles of Cu to mass by multiplying by RAM.

$0.0466 \text{ moles} \times 64 \text{ g} = 2.98 \text{ g}$

6. (a) (i) Ozone depletion – main pollutant is Ozone depleting substances such as CFCs.
Global warming – main pollutant is carbon dioxide.

(ii) Harmful effects of Ozone depletion are:

- Increase in skin cancer
- Increase in cataract of the eyes
- lower crop yield
- lower productivity of the ocean

(iii) Harmful effects of global warming:

- climate change (more hurricanes/drought)
- melting of ice caps/loss of habitat for polar bears
- heat waves
- rise in sea level
- lower crop yield and ocean productivity
- death to plants and animals that cannot adapt to warmer temperatures

(b) Hoteliers going green can assist by:

(i) Water use – use waste water to water plants and lawn

- washing of towel and sheets in large wash only
- have signs indicating to reuse towels and place to wash only when dirty
- have signs in rooms to turn off taps when not in use e.g. while brushing of teeth
- taps with timers to wash hands can be installed in bathrooms

(ii) Garbage disposal – recycling bins around hotels and in rooms

- all biodegradable waste to be disposed of in compost heap
- use less plastic in hotel restaurants, use washable utensils

(iii) Energy use – special keys to enter room that will power it (AC/lights) and which is removed when locking and leaving the room. This will ensure that the utilities are not left on after leaving rooms

- Use solar water heaters on roof for hot water
- Use energy saving light bulbs (led and fluorescent) throughout hotel
- Motion sensor lights

(c) I totally agree with the statement because it sets limits on how much one country can pollute without damaging the environment. It sets a fair playing field for all countries as excessive pollutants from one country can affect others and even globally. If these standards are not followed, the country which violated it should not be able to trade goods and services with countries who abide with the standards. In order to maintain a clean, healthy environment for all forms of life to live and flourish all countries must follow common rules and standards that will allow life to survive.

JANUARY 2014 PAPER 2

1. (a) (i) Salts are formed when metal ions or ammonium ions take the place of the replaceable hydrogen(s) of an acid. A normal salt is formed if all the replaceable hydrogen of the acid is removed.

(ii) Type of salt: An acid salt – only part of the replaceable hydrogen is removed.

Chemical Formula: $H_2SO_{4(aq)} + NaOH_{(aq)} \longrightarrow NaHSO_{4(aq)} + H_2O_{(l)}$

(iii) $H_3PO_{4(aq)}$ acid salts produced are Na_2PO_4 – sodium hydrogen phosphate
NaH_2PO_4 – sodium dihydrogen phosphate

(b) (i) TABLE 1: TITRATION RESULTS

	Titration Number		
	1	**2**	**3**
Final Volume (cm^3)	25.5	37.3	40.5
Initial Volume (cm^3)	0.5	12.2	15.5
Volume Used (cm^3)	25.0	25.1	25.0

(ii) Volume of acid $= \frac{25.1 + 25.0}{2}$

$= 25.05\ cm^3$

(iii) Indicators are used to identify the end point. In part A the end point was identified therefore in part B there was no need to add indicator as the end point in A is the volume used in B.

(iv) Collect the filtrate and evaporate the water. The solution of the salt must be evaporated to dryness over a beaker of boiling water. N.B. in the preparation of a hydrated salt, the solution of the salt must not be evaporated to dryness, but left to crystallize.

(v) $2NaOH_{(aq)} + H_2SO_{4(aq)} \longrightarrow NaSO_{4(aq)} + 2H_2O_{(l)}$

Sodium hydroxide sulphuric acid sodium sulphate

(vi) Convert gdm^{-3} to moles by ÷ by its RMM = 98g.

$$\text{Moles } dm^{-3} = \frac{gdm^{-3}}{RMM}$$

$$= \frac{4.9}{98}$$

$$= 0.05 \text{ moles } dm^{-3}$$

$1000\ cm^3 = 0.05$ moles of H_2SO_4

$$1cm^3 = \frac{0.05}{1000} \text{ moles}$$

$25.05\ cm^3$ of H_2SO_4 was used

$$25.05\ cm^3 = \frac{0.05}{1000} \times 25.05$$

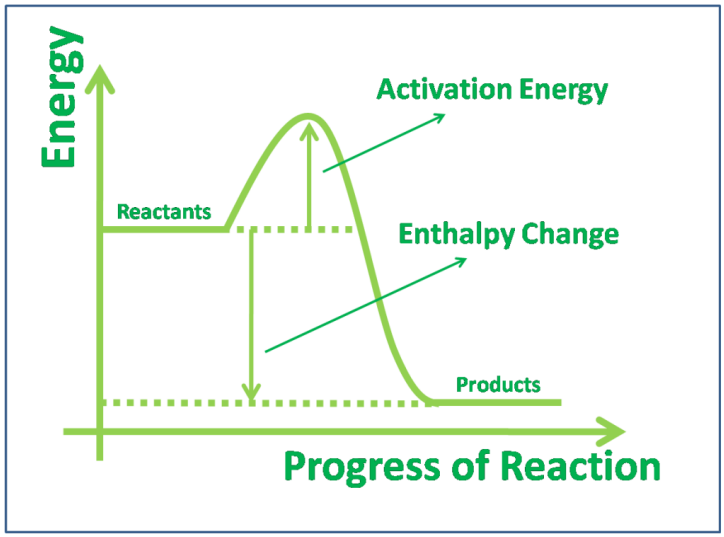
$$= 0.00125 \text{ moles of } H_2SO_4 \text{ reacted}$$

(vii) From the balanced equation:
1 mole of H_2SO_4 will react to give 1 mole of Na_2SO_4.
0.00125 moles of H_2SO_4 will react to give 0.00125 moles of Na_2SO_4.
$\therefore$ 0.00125 moles of Na_2SO_4 are produced.

Convert moles to mass by multiplying number of moles by its RMM.
RMM of Na_2SO_4 = 142g
0.00125moles of $Na_2SO_4 = 0.00125 \times 142$ g
$= 0.1775$ g

(viii) Experimental errors by the student in weighing, mixing and reading the apparatus or inefficient method of preparation of the salt.

(ix) ENERGY PROFILE DIAGRAM FOR AN EXOTHERMIC REACTION



(c) TABLE 2: TESTS PERFORMED ON COMPOUND X

Test	Observation	Inference
A sample of X was heated in a dry test tube.	A brown gas evolved which turns damp blue litmus red but does not bleach it.	Acidic gas. The gas could be NO_2, nitrogen dioxide
To one portion of a solution of X, aqueous sodium hydroxide is added dropwise until in excess and then heated	• No precipitate formed. • Upon heating, a pungent gas evolves which turns moist red litmus blue	$NH_4^+{}_{(aq)} + OH^-{}_{(aq)} \rightarrow NH_{3(g)} + H_2O_{(l)}$ Ammonia gas given off.

2. (a) (i) Electrolysis is the process by which the passage of an electric current through a substance causes it to decompose.

(ii) Active anode

(b) (i) Electrode 2

(ii) $Br^-{}_{(l)}$

(iii) $Pb^{2+}{}_{(l)} + 2e^- \longrightarrow Pb_{(s)}$

(iv) Current $= 5$ A Time in seconds $= 5 \times 60$
$= 300$ seconds

$$Q = It$$
$$= 5 \times 300$$
$$= 1500 \text{ C}$$

Calculate the number of moles of electrons this is equivalent to:
96500 C $= 1$ mole of electrons

$$\therefore \quad 1 \text{ C} = \frac{1}{96500} \text{ C}$$

$$\text{And } 1500 \ C = \frac{1}{96500} \times 1500 \text{ mole of electrons}$$
$$= 0.016 \text{ mole of electrons}$$

From the reaction, 2 mol of electrons produce 1 mol of Pb.
1mol of electrons produce 0.5 mol of Pb.
0.016 mol of electrons produces $0.5 \times 0.016 = 0.008$ mols of Pb

Convert mols of Pb to mass:
$\therefore\ 0.008 \times 207\ \text{g} = 1.656\ \text{g}$ of Pb

(c) Experiment 1: magnesium is more reactive than zinc in the reactivity series therefore zinc cannot displace magnesium from solution. The more reactive metal can displace the less reactive metal from solution.

Experiment 2: Zinc is higher than copper in the reactivity series therefore it will displace it from solution. The copper is deposited at the bottom of the beaker. In addition to this as the copper gets displaced the blue solution slowly fades away.

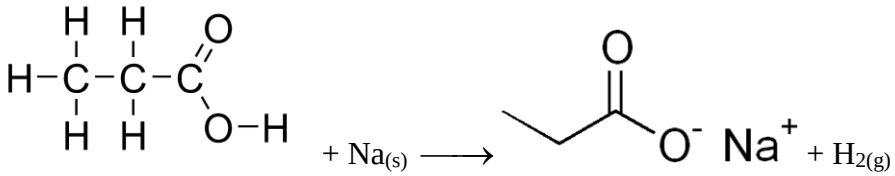
3. (a) Compound B: Alkanes
Compound C: Carboxylic acids/organic acid

(b) $C_2H_6O_{(l)} + 3O_2(g) \longrightarrow 2CO_{2(g)} + 3H_2O_{(l)}$

(c) More soluble compound: A
Reason: Compound A contains a polar OH that is hydrophilic i.e. a water loving group. N.B. the small alcohols like methanol and ethanol are completely soluble in water owing to the polar nature of the OH group. However, solubility decreases as the number of carbon atoms in the alcohol increases.

(d) More reactive compound: C
Reason: Compound C is a weak acid that dissociates to give H^+ ions that will readily react with sodium metal to give salt and hydrogen gas. The OH in the acid is more reactive than the OH in alcohol.

(e) Equation:

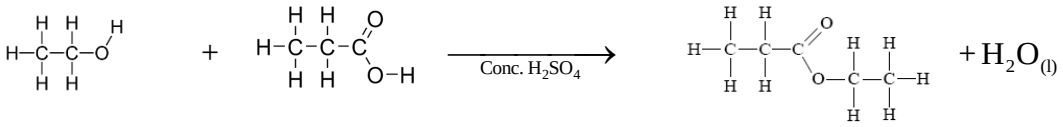


Propanoic acid Sodium propanoate

$2C_2H_5COOH_{(aq)} + 2Na_{(s)} \longrightarrow 2C_2H_5COONa + H_{2(g)}$

(f) Use a glowing splint. The gas given off will relight it.

(g) Name of catalyst: Concentrated sulphuric acid, conc.H_2SO_4



Ethyl propanoate

N.B. when naming esters the alcohol name comes first.

4. (a) (i) The chloride $= MCl_2 = 159g$

$M + 71\ g = 159\ g$

$\therefore \quad M = (159 - 71)\ g$

$= 88\ g$

$M =$ Strontium

(ii) $M_{(s)} + Cl_{2(g)} \longrightarrow MCl_{2(s)}$

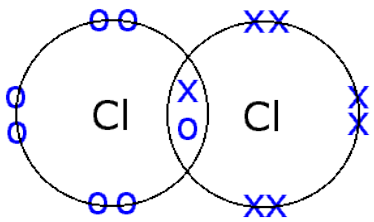
$Sr_{(s)} + Cl_{2(g)} \longrightarrow SrCl_{2(g)}$

(iii) a) The type of bonding in element M is metallic bonding the core of positive cations are surrounded by a sea of mobile e^- (electrons).

b) The bonding in the chloride of element M is ionic bonding. The element M will give up two electrons to two chloride atoms. The element M will be positively charged (+2) while each chlorine atom on accepting the electrons will turn to chloride ion anion (-ve) negatively charged. The difference in charges will attach the molecules together in a bond.

(b) (i) Graphite is a made of carbon only and belongs to group IV. Graphite bonding is unique as it has mobile e^- (electrons) that can conduct an electric current. Graphite is an excellent electrode as it conduct an electric current and does not take part in the chemical reactions, it is inert. While element M is in group 2 and it is a metal that is fairly reactive. If element M is used as an electrode it can take part in the chemical reaction as it acts as an active electrode. It can break down during electrolysis process.

(ii) BONDING IN CHLORINE



5. (a) (i) $H_{2(g)}$ hydrogen gas and $NaOH_{(aq)}$ sodium hydroxide

(ii) a) $2Cl^-_{(aq)} \longrightarrow Cl_{2(g)} + 2e^-$

b) $2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$

(b) (i) Water enters the atmosphere by evaporation or respiration by plants and animals. Water leaves the atmosphere by rain (precipitation), snow, fog, mist, hail.

(ii) Trees absorb water from the environment in liquid form and return it, transfer or convert it to vapour form back to the environment and return pure water vapour to the atmosphere where it will condense and fall as rain. Building of homes by removal of trees will greatly hamper the process and decrease the flow in the water cycle.

(c) (i) $R(OH)_2 \longrightarrow$ stable, no decomposition

(ii) The carbonate of R is stable and no decomposition. The carbonate of T will yield oxide and carbon dioxide.

(iii) R is more reactive than T it will bond faster to other elements or substances in nature to form stable compounds.

6. (a) (i) Pollution is the contamination of land, air or water environment by harmful or poisonous substances. These harmful substances are called pollutants. Once something is contaminated with harmful pollutants it is unfit for human use.

(ii) The environment refers to the natural surroundings of living organisms including living things (biotic component) and non-living (abiotic components) that affect the organisms.

(b) The main pollutants responsible for global warming are carbon dioxide and methane. The pollutants responsible for acid rain are nitrogen oxide and sulphur dioxide.

Carbon dioxide comes from the combustion of fossil fuel while methane comes from the decomposition of dead organic matter. Nitrogen oxide and sulphur dioxide comes from the combustion of fossil fuel in factories, power plants and motor vehicles.

Fossil fuel methane, natural gas, $CH_{4(g)} + 2O_{2(g)} \longrightarrow CO_{2(g)} + 2H_2O_{(g)}$

$2NO_{2(g)} + H_2O_{(l)} \longrightarrow HNO_{2(aq)} + HNO_{3(aq)}$

Nitrous acid nitric acid

$$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(aq)}$$

Sulphurous acid

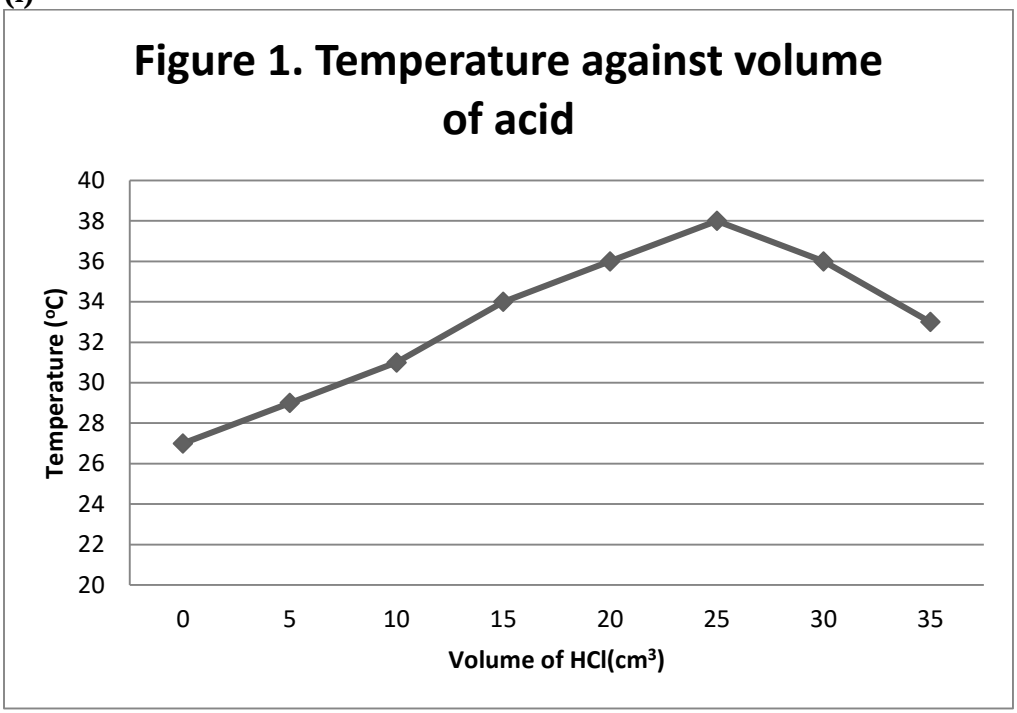
Global warming can lower agriculture yield/increase pest infestation, increase in temperature destroys eco-tourism in the ocean by destroying coral reefs (bleaching). Increase chances of acquiring skin cancer due to hotter temperatures.

Acid rain kills crops, and microbes in soil which decreases productivity. It makes lakes and streams acidic, killing aquatic life like fish and shell fish that is an important food source from agriculture.
Acid rain changes the pH of soil, leaves acid droplets that may damage crops and harm animals that eat vegetation. It can also cause corrosion of buildings and machinery. Global warming results in melting of the polar ice caps, increase flooding and changes in the weather (climate change). This unpredicted weather is dangerous as hurricanes and other natural disasters can destroy agriculture, wildlife, homes and endanger lives.
Acid rain destroys monuments and historic sites that tourists visit making the site unattractive.

These pollutants can be reduced by burning less fossil fuels and developing more efficient conversion methods in obtaining energy from fossil fuel and switching to alternative, less polluting energy sources like solar and wind.

JUNE 2014 PAPER 2

1. (a) (i)



(ii) 25 cm^3 of acid is needed to neutralize 25 cm^3 of KOH.

(iii) Temperature difference $=$ Final temperature $-$ Initial temperature

$= 38 - 27$

$= 11°C$

(iv) $c = 42\ kJ\,kg^{-1}\,°C^{-1}$

Assuming $1\ cm^3 = 1\ g$

$25 + 25 = 50\ cm^3$

$50\ cm^3 = 50\ g$

$m = 50$ g or 0.05 kg

$\Delta H = 11 \times 0.05 \times 4.2$

$= 2.31$ kJ

(b) **(i)** To investigate the rate of reaction between magnesium ribbon and iron III chloride using different surface area.

(ii) The reaction is a displacement reaction. The Mg ribbon is more reactive than Fe in solution. The Mg will displace Fe from solution and Fe will be deposited on the bottom of the beaker as a reddish solid.

(iii) $3Mg_{(s)} + 2FeCl_{3(aq)} \longrightarrow 3MgCl_{2(aq)} + 2Fe_{(s)}$

(iv) The contents of beaker A will change to a lighter yellowish colour than beaker B because the reaction is occurring at a much faster rate while more Fe will be deposited in beaker A than B.

(v) The greater the surface area of a Mg ribbon means more molecules of Mg is exposed to the solution to react. Therefore the surface area of beaker A is greater and will react faster, displacing Fe from $FeCl_3$ solution faster than beaker B so the yellowish solution of $FeCl_3$ will fade faster in A and slower in B.

(c) **(i)** Acidified Potassium dichromate or acidified potassium permanganate.

(ii) The acidified potassium dichromate will change from orange to green while acidified potassium permanganate will change from purple to colourless.

Explanation: When dilute acid reacts with sulphite, sulphur dioxide gas is produced. This gas is a reducing agent and will reduce acidified potassium dichromate or potassium permanganate to the colour seen above.

$2MnO_4^-{}_{(aq)} + 5SO_{2(aq)} + 2H_2O_{(l)} \longrightarrow SO_4^{2-}{}_{(aq)} + 2MnSO_{4(aq)} + 2H_2SO_{4(aq)}$
purple colourless

$Cr_2O_7^{2-}{}_{(aq)} + 3SO_{2(aq)} + 8H^+{}_{(aq)} \longrightarrow 2Cr^{3+}{}_{(aq)} + 3H_2SO_{4(aq)} + H_2O_{(l)}$
orange green

(iii) Solution Y will be Calcium hydroxide. The CO_2 produced will turn it milky white.

2. **(a)** **(i)** Element X will react with water more vigorously than K.

(ii) The solution formed from this reaction will be basic.
When X reacts with water the hydroxide of X is produced. X is a metal. Metal oxides and hydroxides are basic while non-metals form acid solutions.

(b) **(i)** 2,8,2

(ii) QCO_3

(iii) $QCO_{3(s)} + HCl_{(aq)} \longrightarrow QCl_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$

N.B. Q and Mg belongs to the same group therefore they will react the same way.

(c) When metals react with a non-metal the bonding is ionic. The metal ion will give up one of the electron to become Na^+ cation while the non-metal Z will accept two electrons to become Z^{2-} anion. Since Z needs two electrons, two Na atoms will each give up one electron. The electrostatic force of attraction between the two oppositely charged ions causes the ions to form a strong ionic bond.

$2Na^+ + Z^{2-} \longrightarrow Na_2Z$

(d) **(i)** A reddish brown gas will be given off. The gas is $NO_{2(g)}$. If a glowing splint is placed at the mouth of the test tube it will relight, indicating that $O_{2(g)}$ is given off.

N.B. K, Na nitrate will decompose to give nitrate of metal and oxygen gas while Ca to Cu nitrate will decompose to give metal oxide, nitrogen dioxide and oxygen gas.

(ii) Step 1: Convert given mass of $Ca(NO_3)_2$ to moles. This can be done by dividing the given mass by its RMM.

$\frac{5}{64} = 0.030$ moles of Calcium nitrate reacted

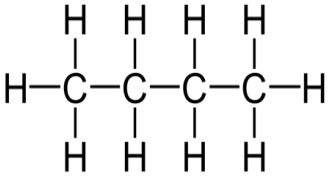
Step 2: Using the balanced equation given in (d) calculate the number of moles of $NO_{2(g)}$ produced using its proportional ratio.
2 moles of $Ca(NO_3)_{2(S)}$ will produce 4 moles of $NO_{2(g)}$.
1:2
Therefore, 0.030moles of calcium nitrate will produce 0.060moles of $NO_{2(g)}$.

Step 3: Convert moles of $NO_{2(g)}$ produced to volume by multiplying it by RTP i.e.
0.060moles of $NO_{2(g)}$ $\times 24000\,cm^3 = 1440\,cm^3$ of $NO_{2(g)}$ produced.

3. (a) (i) This is where organic molecules have the same molecular formula but differently arranged molecules or orientation of molecules in its structure.

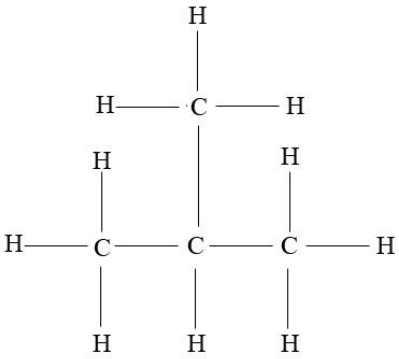
(ii)

Isomer 1



Butane

Isomer 2



2-methylpropane

(b) (i) Test: You can bubble the two gases separately in a solution of acidified potassium permanganate or bromine water.

Observation: Compound A will decolourise both reagents. Acidified potassium permanganate will turn colourless from a purple solution while bromine water will turn colourless from a brown liquid.

(ii) Equation: $C_3H_{8(g)} + 5O_{2(g)} \longrightarrow 3CO_{2(g)} + 4H_2O_{(l)}$

(iii) Use for Compound A: This compound can be used in polymerization to make plastics such as polypropene.

Use for Compound B: This can be used as a fuel, when it burns it releases a large amount of energy.

(c) (i) X is water as steam.

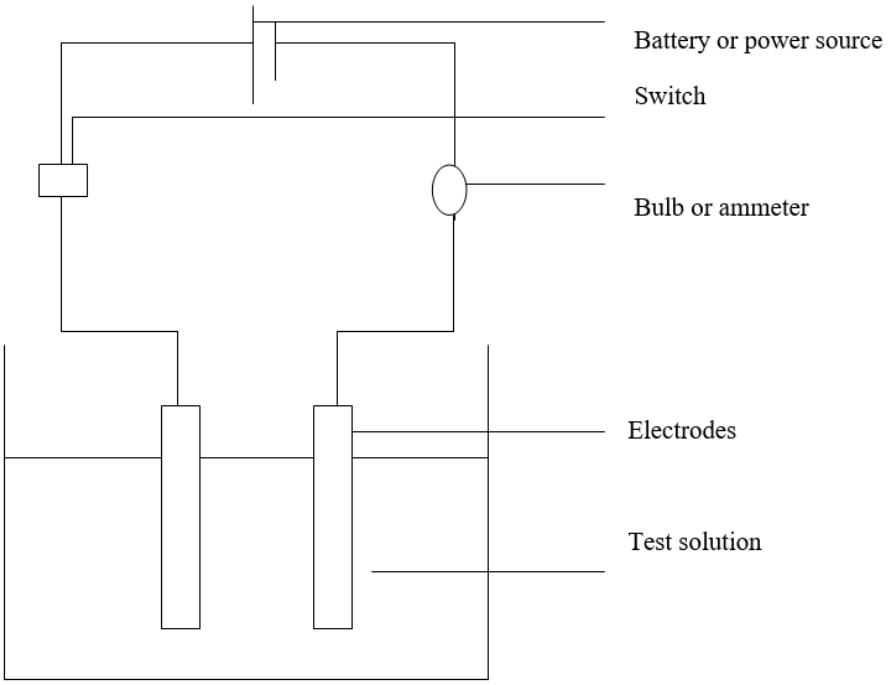
(ii) Name: propan-2-ol N.B. OH is on Carbon atom number 2.
Homologous series: Alcohols.

4. (a) (i) Magnesium oxide is a solid with a high melting point because the bond is ionic due to the strong electrostatic force of attraction between the two oppositely charged ions which causes the ions to form a strong bond. The ions are pulled closer to each other to form a solid in a lattice structure. A large amount of energy is needed to break this strong bond therefore the melting point is very high. Oxygen and sulphur are both non-metals. The bonding is much weaker than those of Magnesium and oxygen. The bond between sulphur and oxygen is covalent, forming sulphur dioxide gas. The molecules are held together by weak Van der waals' forces of attraction that are easily broken hence its low melting point.

(ii) Oxides of sulphur will not conduct electricity as there are no mobile electrons to share electrons in a molten or ionic aqueous solution. However, MgO is an ionic compound and will conduct electricity in a molten state as it will have mobile and free electrons available to conduct electricity.

(b) (i) This circuit is not suitable for this experiment since there is no container or vessel to put the test solution in with the electrodes and there is no indicator that will detect if the test solution will conduct electricity or not like a bulb or ammeter.

(ii)



(iii)

Conductors	Non-Conductors
Aqueous lead II nitrate	Ethanol
Aqueous ammonia	

5. (a) (i) $Zn_{(s)} + CuSO_{4(aq)} \longrightarrow ZnSO_{4(aq)} + Cu_{(s)}$

(ii) Zinc foil will react with copper sulphate because Zinc is more reactive than copper in the reactivity series. Therefore, zinc will react with copper sulphate by displacing the copper from the sulphate. The zinc will react with the sulphate to form zinc sulphate while the copper metal will be precipitated out of solution as copper metal and be deposited at the bottom of the beaker. As the copper is being deposited the blue colour of copper sulphate will fade. Silver foil will not displace copper from copper sulphate because it is lower than copper in the reactivity series and it is less reactive. Metals higher in the reactivity series will displace metals in solution lower in the reactivity series.

(iii) Aluminium will displace copper from copper sulphate solution. Aluminium is higher than copper in the reactivity series and is more reactive than copper.

(b) (i) The conditions for iron to rust are moisture (H_2O) and oxygen.

(ii) Painting iron is important in preventing it from rusting as the paint coats the iron surface with an air and water repellent that forms a protective coating around the iron.

(c) Duralumin is an alloy of Aluminum. It is lighter and less dense than aluminum. This alloy is also more corrosion resistant than aluminum therefore it is preferred in the manufacture of aircraft.

6. (a) Suggestion: Two nutrients that can be added is nitrogen and magnesium.

Reason: The lack of essential nutrients to plants can lower its resistance to disease. The curling of the tips of leaves is an indication of disease caused by mites. Both nitrogen and magnesium are essential to healthy growth of plants as it is involved in the production of chlorophyll and many enzymatic reactions in plants. Green healthy leaves in plants indicate a lot of chlorophyll being produced.

(b) Advantage 1: Organic fertilizers contain a lot of microbes that is needed to break down organic matter into simple ions that the plants can absorb. These microbes such as bacteria and fungi are important in recycling of nutrients.

Advantage 2: Organic fertilizers also help maintain and build soil structure as it contains humus and micronutrients. Better soil structure with humus and organic matter retains moisture in the soil so that the plant does not wilt easily.

Advantage 3: Organic fertilizers do not leach its nutrients easily. It slowly releases nutrients to the soil so that the plants can absorb it. No excessive nutrients are added to the environment that can cause eutrophication.

(c) Disadvantage: The release of the nutrients is slow and as a result the plant growth can be slower than with commercial fertilizer.

(d) Test for soil acidity: A small sample of the soil is obtained. This sample is taken about from about 6cm below the surface. The sample is shaken with water and allowed to settle. The settled solution is tested with universal indicator paper or solution to determine its actual pH. The use of red or blue litmus will determine its actual pH. Modern tests use a pH probe that is inserted into the moist soil and a digital indicator is read.

(e) The chemical name for lime is calcium hydroxide and its chemical formula is $Ca(OH)_2$. Lime should be used when the soil is too acidic. It decreases the acidity of the soil i.e. it makes the soil less acidic.

$$Ca(OH)_{2(s)} + 2H^+_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + 2H_2O_{(l)}$$

(f) When lime is added to soil at the same time as ammonia fertilizers it reacts with each other to produce ammonia gas. This causes nitrogen to be lost from the soil and a nitrogen deficiency in plants could result. Ammonia gas can also be toxic to plants and microbes in the soil.

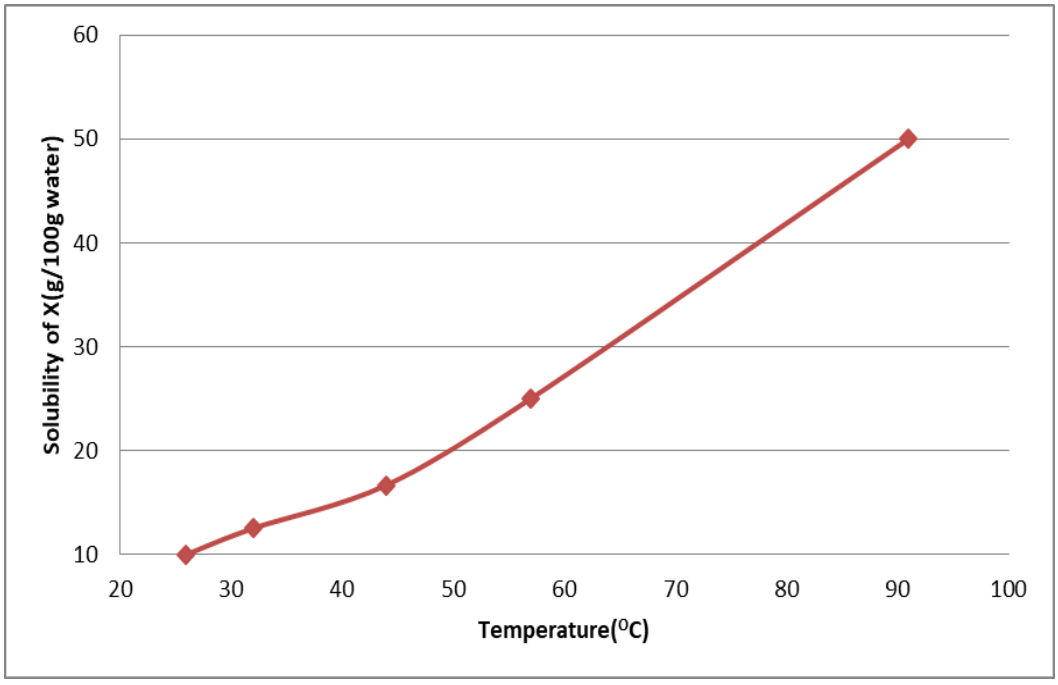
$$2OH^-_{(aq)} + NH_4^+{}_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + 2H_2O_{(l)} + 2NH_{3(g)}$$

JANUARY 2015 PAPER 2

1. (a) TABLE 1: DETERMINATION OF THE SOLUBILITY OF X AT VARIOUS TEMPERATURES

Experiment Number	Mass of X(g)	Volume of water(cm^3)	(i)Temperature at which crystals reappear (^oC)	(ii)Solubility of X (g/100g water)
1	2	4	91	50.00
2	2	8	57	25.00
3	2	12	44	16.67
4	2	16	32	12.50
5	2	20	26	10.00

(b)



(c) Solubility of X increases as Temperature increases.

(d) From the graph at 60 ^oC the solubility of X $= 27.5\ g/100\ g$ of water

Using the equation from 1 (a)(ii):

$$\frac{2}{\text{Mass of water}} \times 100 = 27.5 \text{ g}$$

$$\frac{200}{\text{Mass of water}} = 27.5$$

$$\text{Mass of water} = \frac{200}{27.5}$$

$$= 7.27 \text{ cm}^3$$

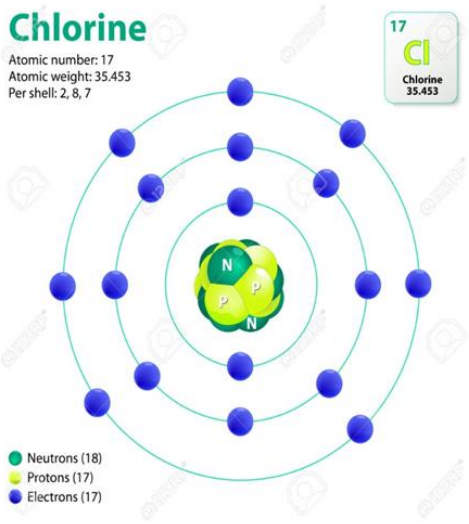
(e) In a solution a solute is completely dissolved in the solvent forming a uniform solution while in a suspension the solute partially dissolves in the solvent and particles can be seen suspended in the solvent. In suspension particles generally settle to the bottom of the solvent.

(f) Two other factors are pressure and particle size.

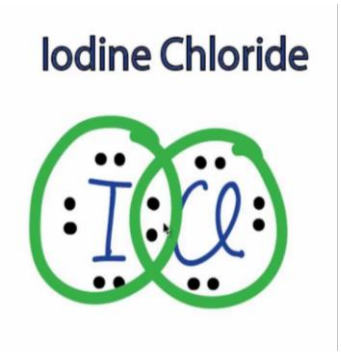
(g) TABLE 2: TESTS CARRIED OUT ON SOLUTION M

	Test	Observation	Inference
(i)	To a portion of M, add aqueous sodium hydroxide until in excess	• White precipitate • Soluble in excess	• Al^{3+} or Pb^{2+} or Zn^{2+} or Ca^{2+} possibly present • Al^{3+} or Pb^{2+} or Zn^{2+} possibly present
(ii)	To a second portion of M, add aqueous ammonia until in excess	• White precipitate formed • Precipitate soluble in excess aqueous ammonia	• Zn^{2+}, Pb^{2+}, Al^{3+} possibly present • Zn^{2+}present
(iii)	To a third portion of M, add aqueous sodium iodide	• Yellow precipitate formed	• $Pb^{2+}_{(aq)} + 2I^{-}_{(aq)} \longrightarrow PbI_{2(s)}$
(iv)	To a fourth portion of M, add aqueous silver nitrate followed by aqueous ammonia	• No observable change	• $NO_3^{-}{}_{(aq)}$ or $SO_4^{2-}{}_{(aq)}$) possibly present

2. (a) (i)



(ii)



(b) They have weak intermolecular bonds holding the molecules together. Secondly, the electronegativity of these two atoms is greatly different therefore they will not really want to share an electron pair. Chlorine would rather accept an electron than share.

(c) Both I and Cl can exist as isotopes. Isotopes are the same element but different forms have different mass number due to the different amount of neutrons. Therefore, isotopes have same atomic number but different mass number hence ICl sample can have different molar mass.

(d) $Cl_{2(}g) + 2KI_{(aq)} \longrightarrow 2KCl_{(aq)} + I_{2(aq)}$

(e) (i) $2I^-_{(aq)} + 2e^- \longrightarrow I_2{}^0{}_{(s)}$ $\quad -1 \longrightarrow 0$

$2I^-_{(aq)} \longrightarrow I_{2(s)} - 2e^-$

(ii) Chlorine is an oxidizing agent because it causes iodine to lose an electron and itself to gain an electron.

3. (a) Crude oil and natural gas (methane)

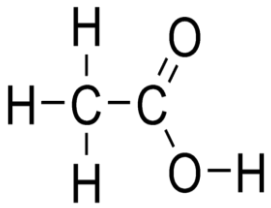
(b) (i)

Fraction Number	Fraction Name
1	Refinery gas
2	Kerosene
3	Lubricating oils and waxes

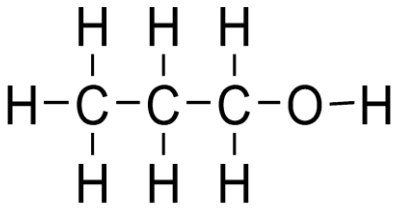
(ii) Lubricate mechanical parts in machinery and vehicle, polishing wax, wax paper, petroleum jelly and candles.

(c) (i) Esters

(ii)

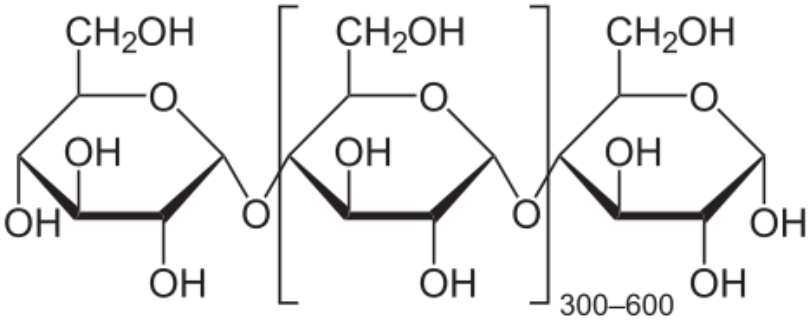


Structure A
Name: ethanoic acid



Structure B
Name: propanol

(d) (i) Starch



(ii) Glucose: The glucose is soluble in water and will be in the liquid.
Polymer: This is insoluble in water and will settle to the bottom.

(e) Type of polymer formed: Proteins, Nylon
Use: Muscles, rope

4. (a) (i) This is the passage of an electric current through an electrolyte resulting in a chemical change in the electrolyte.

(ii) During the electrolysis of molten sodium chloride, sodium metal will be discharge and chlorine gas given off.

Reaction at the cathode: $Na^{+}_{(l)} + e^{-} \longrightarrow Na_{(l)}$

Reaction at the anode: $2Cl^{-}_{(l)} \longrightarrow Cl_{2(g)} + 2e^{-}$

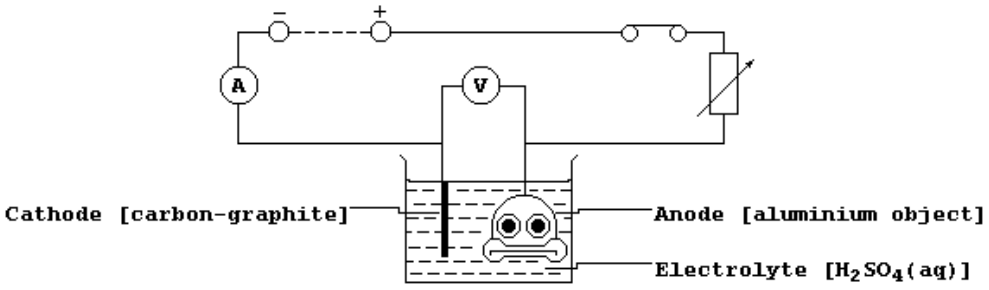
The Na^{+} ion will accept electrons from the cathode i.e. the sodium undergo reduction. The Cl^{-} ions give up their electrons to the anode i.e. Chlorine ions undergo oxidation.

(b) During electrolysis of aqueous sodium chloride the following ions are produced: Na^{+}, H^{+}, Cl^{-}, OH^{-}. At the anode OH^{-} ions are preferentially discharged because they are in a dilute solution and they are lower in the electrochemical series than Cl^{-} ions. At the cathode the H^{+} ions are preferentially discharged because they are in a dilute solution and they are lower in the electrochemical series than Na^{+}.

At the anode: $4OH^{-}_{(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^{-}$

At the cathode: $2H^{+}_{(aq)} + 2e^{-} \longrightarrow H_{2(g)}$

(c)



Anodising is a process where the thickness of this aluminium oxide layer is artificially increased. Firstly- the protective outer layer on a sheet of aluminium is removed by treating the aluminium with a sodium hydroxide solution. Secondly- the aluminium sheet is now placed in a dilute sulphuric acid solution as the anode in the electrolysis of sulphuric acid.

The reaction at the anode: $4OH^{-}_{(aq)} \longrightarrow 2H_2O + O_{2(g)} + 4e^{-}$. Thirdly, the oxygen formed reacts with the aluminium anode forming a thicker oxide layer.

$4Al_{(s)} + 3O_{2(g)} \longrightarrow 2Al_2O_{3(s)}$.

5. (a) (i) The acid anhydride is sulphur trioxide. Firstly sulphur burns to form sulphur dioxide.

$S_{(s)} + O_{2(g)} \longrightarrow SO_{2(g)}$. Secondly, when a mixture of sulphur dioxide and oxygen is passed over a catalyst of vanadium (v) oxide, at a temperature of about $500^{o}C$ and atmospheric pressure, sulphur trioxide is produced.

Increased pressure increases yield. $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$. The sulphur trioxide formed is dissolved in concentrated sulphuric acid to form oleum.

(ii) Anhydride. $SO_{3(g)} + H_2SO_{4(l)} \longrightarrow H_2S_2O_{7(l)}$. The sulphur trioxide is dissolved in sulphuric acid to form oleum or pyrosulphuric acid. The required concentration of sulphuric acid is obtained by diluting the oleum.
$H_2S_2O_{7(l)} + H_2O_{(l)} \longrightarrow 2H_2SO_{4(l)}$.

(iii) Sulphur trioxide is not dissolved in water because sulphur trioxide reacts with water vapour to form a mist a mist of acid.

(b) **(i)** The alloy stainless steel is preferred to pure iron in making cooking utensils because it does not corrode or break down and it does not rust like iron. Stainless steel also does not react with food while it is being cook. Stainless steel is inert to corrosion and unreactive to food.

(ii) The lack of iron in the human diet could result in anemia. This is caused by a shortage of iron in your blood. It can result in the low production of red blood cells. Therefore, the blood doesn't carry enough oxygen to the rest of your body, resulting in weariness, tiredness and weakness.

6. **(a)** **(i)** Phosphorus – a deficiency causes intense green colouration or reddening in leaves due to lack of chlorophyll.
Nitrogen- yellow leaf, slow growth, chlorosis
Potassium – wilting, brown spotting, higher chance of damage from heat and frost.

(ii) This experiment can be used to test for all nutrient deficiency. Example, for nitrogen:

i. Take 4 identical seedlings, plant each one in a pot of identical size and soil structure. 4 is used in case one dies.
ii. 2 seedlings will have all nutrients in the recommended dosage while 2 other seedlings will have a very low quantity of nitrogen.
iii. All seedlings will be given the same amount of water and exposure to light each day.
iv. The four seedlings will be placed in a green house in order to reduce attack by pests.
v. Monitor and observe plant growth for the next month.
vi. Make deductions based on observations.

(b) **(i)** Acidic soil kills microbes in soil that is needed in recycling of nutrients and breakdown of organic matter.

(ii) $OH^-_{(aq)} + H^+_{(aq)} \longrightarrow H_2O_{(l)}$
$Ca(OH)_{2(s)} + 2H^+_{(aq)} \longrightarrow Ca^{2+}_{(aq)} + 2H_2O_{(l)}$

(iii) When calcium hydroxide is used to neutralize acidic soil, ammonium fertilizers cannot be used at the same time. Calcium hydroxide being a base, reacts with the ammonium ions to produce ammonia gas. This causes nitrogen to be lost from the soil and a nitrogen deficiency in plants could result.

$2OH^-_{(aq)} + NH_4^+{}_{(aq)} \longrightarrow NH_{3(g)} + H_2O_{(l)}$.

From lime from fertilizer

(c) Disadvantages- Expensive to set up and retain, nutrient solutions must be closely monitored, workers need more technical knowledge.

To address these disadvantages:

1- Loan or government subsidy programme to start up.
2- Use test kits daily to monitor nutrients
3- Educate and read on hydroponic systems, go to courses that teach it.

JUNE 2015 PAPER 2

1. (a) (i) Petroleum (crude oil), methane(natural gas), peat, coals.

(ii) Ethanol, gasoline, diesel, methane.

(b) (i) TABLE 1: READINGS FROM FIGURE 2

Mass of conical flask and water (g)	326
Mass of conical flask (g)	125
Mass of water used (g)	201
Final temperature of water (^oC)	39
Initial temperature of water(^oC)	27
Temperature change(^oC)	12
Initial mass of candle and watch glass (g)	97.5
Final mass of candle and watch glass (g)	96
Mass of candle burnt (g)	1.5

(ii) Heat absorbed by conical flask $= 125\ g \times 0.816\ J\,g^{-1}\,°C^{-1} \times 12°C$
$= 1291.5\ J$

(iii) Heat absorbed by water in conical flask $= 201\ g \times 4.2\ J\,g^{-1}\,°C^{-1} \times 12°C$
$= 10130.4\ J$

(iv) Total heat absorbed by the calorimeter
= (heat absorbed by the conical flask) + (heat absorbed by water in the conical flask)
$= 10130.4\ J + 1291.5\ J$
$= 11421.9\ J$

(v) Heat of combustion of the candle wax
$$= \frac{\text{Total heat absorbed by calorimeter}}{\text{Mass of candle burnt}}$$
$$= \frac{11421.9\ J}{1.5\ g}$$
$$= 7614.6\ Jg^{-1}$$

(vi) The can prevented heat loss to the environment and insulated the conical flask with heat from the candle for maximum absorption.

(c) TABLE 2: OBSERVATIONS AND INFERENCES

Test	Observation	Inference
(i) Q is heated strongly in a boiling tube. A glowing splint is placed at the mouth of the boiling tube. The gases evolved are bubbled into aqueous calcium hydroxide.	Brown fumes are seen around the mouth of the boiling tube. The glowing splint is rekindled. A white precipitate if formed.	• Nitrogen dioxide gas is given off. $NO_{2(g).}$ Q is a nitrate. N.B. not potassium or sodium. • Oxygen gas is given off $O_{2(g)}$. • Compound Q contains a carbonate, the gas given off is $CO_{2(g)}$. $CO_{2(g)} + Ca(OH)2 \rightarrow CaCO3_{(s)} + H_2O_{(l).}$
(ii) Dilute HCl is added in excess to Q and the mixture warmed. To the resulting solution, aqueous NaOH is added until in excess.	A green precipitate is formed which is insoluble in excess NaOH.	• $Fe^{2+}{}_{(aq)} + 2OH^-{}_{(aq)} \rightarrow Fe(OH)_{2(s)}$ (green) Iron II present
(iii) Dilute nitric acid followed by a few drops of silver nitrate solution was added to Q. The test tube was left standing in light for 5 minutes. Ammonium hydroxide was then added to the resulting mixture.	• White precipitate • Precipitate turns grey • White precipitate is soluble in ammonium hydroxide	Cl^- ions present $Cl^-{}_{(aq)} + AgNO_{3(aq)} \rightarrow AgCl_{(s)} + NO_{3(aq)}$ $AgCl_{(s)} + 2NH_4OH_{(aq)} + Ag(NH_3)_2Cl_{(aq)} + 2H_2O_{(l)}$.

2. (a) (i) Solid, liquid, gas

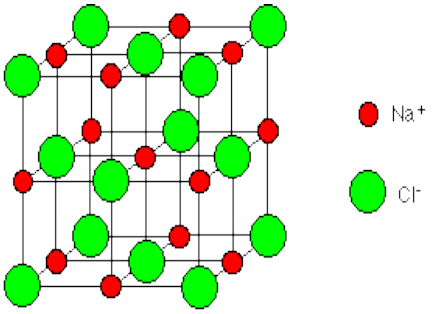
(ii) The particles in a solid are very closely packed with very strong intermolecular forces of attraction. These strong bonds hold the particles together while in liquids, the force of attraction between particles are weaker than a solid but stronger than a gas. In gas the force of attraction is weak Van der Waals forces that are easily broken which causes the particles to be scattered.

(iii) Iodine changes to a gas from a solid. This process is called sublimation.

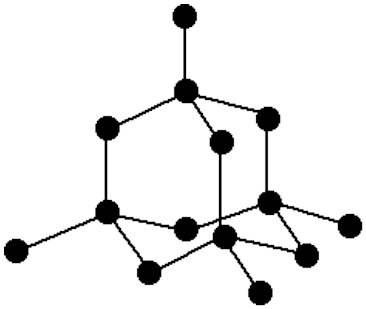
(iv) As iodine molecules sublimes it absorbs heat energy which excite the molecules which then vibrates and break loose of the bonding in its solid state and goes directly to a gas.

(b)

Sodium chloride



Diamond



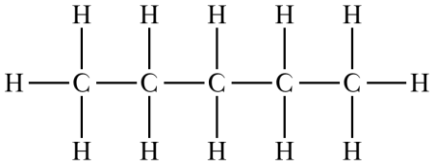
(c) Two tests for ionic solids are:
1- dissolve compound in water and it will conduct an electric. Ionic solids are soluble in water and are good conductors of electricity while molecular solids are not.
2- heat test – molecular solids have low melting and boiling points while ionic has much higher. Apply heat to the molecular solid and it will melt or vaporize easily while ionic solids need much more heat to melt.

3. (a) (i) Compound A: Alkanes
Compound B: Alkenes

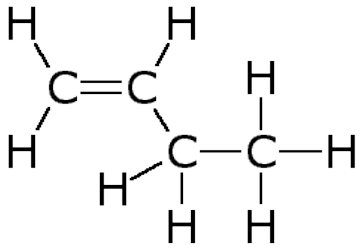
(ii) Compound A: 2-methylbutane
Compound B: but-2-ene

(b) (i) This is where hydrocarbons have the same molecular formula but different structural orientation.

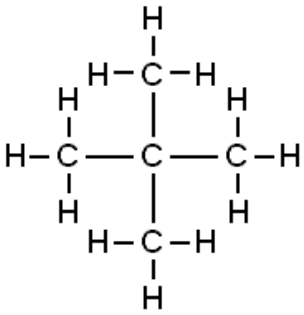
(ii)



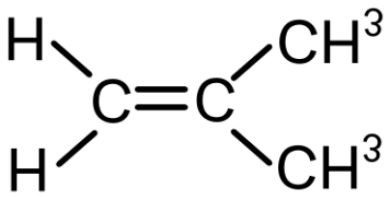
pentane



but-1-ene



2,2-dimethylpropane
Structural Isomer of Compound A



2-methylpropene
Structural Isomer of Compound B

(c) **(i)** Polymers are very long chain molecules or macromolecules made up of small repeated units called monomers.

(ii) Addition polymerization

(iii) Plastic bags, plastic films, bottles, packaging containers, buckets, plant pots

(iv) Nylon, carbohydrates, protein, Styrofoam, Teflon, epoxy, polyester, silk, wool, DNA, cellulose, rubber.

4. (a) **(i)** Calcium carbonate can be prepared by reacting 50mL of aqueous solution of calcium chloride with 50mL of aqueous sodium carbonate.

$CaCl_{2(aq)} + (Na)_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaCl_{(aq)}$

- Put on safety goggles then proceed.
- Weigh 2g of calcium chloride and 1g of sodium carbonate. Place this into separate beakers and add 50mL of water and dissolve.
- Pour the calcium chloride solution into the beaker with sodium carbonate and stir.
- Allow the mixture to react and settle. 5 minutes after filter the mixture. The solid calcium carbonate in the filter paper can be gently heated in an oven to obtain a dry sample.

(ii) A fertilizer for plants as it contains essential elements for healthy plant growth or soothe aches, remove odors, soften rough skin with a foot soak, reduces swelling.

(iii) Epsom salts ($MgSO_4$) can be dissolved in water molecules because it is an ionic compound that is very soluble in water or polar solvents. Its anhydrous form is very hydroscopic which means it has the ability to attract and hold water molecules.

(b) Permanent hardness in water is hardness due to the presence of the chlorides, nitrates and sulphates of calcium and magnesium. This cannot be removed by boiling. The lime scale can build up on the inside of the pipe restricting the flow of water or causing a blockage. Hard water is formed when water percolates through deposits of limestone and chalk which are largely made up of calcium and magnesium carbonates. These ions are dissolved in the rain water and are carried away to streams and lakes where water is extracted and purified for domestic and industrial use. Sodium carbonate can be used to remove permanent and temporary hardness in water.

$Na_2CO_{3(aq)} + Mg^{2+}_{(aq)} \longrightarrow MgCO_{3(s)} + 2Na^{+}_{(aq)}$.

On reaction with the sodium carbonate, dissolved magnesium or calcium ions are precipitated as the insoluble carbonate.

5. (a) (i) Process P: Clarification – the juice is neutralized by the addition of calcium hydroxide and heat. This causes insoluble salts to be formed by the reaction between the calcium hydroxide and sediment impurities.

Process Q: Precipitation/crystallization.

(ii) A mixture of crystals and molasses forms massecuite. The centrifugation process separates the molasses from the sugar crystals.

(iii) Molasses

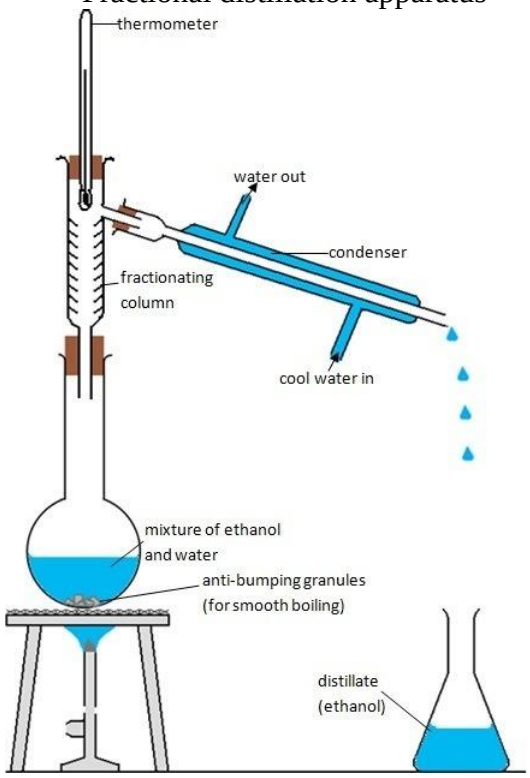
(iv) Bagasse in the factory is used in the boiler room as a fuel to heat water, to make steam to generate electricity for the factory or it can be used as a fuel to heat up and evaporate the water from the cane juice.

(b) (i) Ethanol formation can be derived from the anaerobic fermentation of sugar or molasses using a unicellular fungi, yeast, under the right conditions of pH and temperature.

$$C_6H_{12}O_{6(s)} \xrightarrow[37°C,\ \text{right pH in aqueous solution}]{\text{Enzymes supplied by yeast}} 2C_2H_5OH_{(l)} + 2CO_{2(g)}$$

Glucose Ethanol

(ii) Fractional distillation apparatus



(iii) This type of reaction is a neutralization reaction. The wine turned acidic hence the sour taste. The magnesium oxide is a base which will neutralize the acid. The ethanol is oxidized by oxygen in the air to form ethanoic acid.

$2CH_3COOH_{(aq)} + MgO_{(s)} \longrightarrow (CH_3COO)_2Mg_{(aq)} + H_2O_{(l)}$

Ethanoic acid magnesium oxide magnesium ethanoate

6. (a) (i) The soap may be producing more scum at Ann's house because the water is hard. The side of the island Ann lives contains a lot of limestone. The carbon dioxide dissolved in rain water makes it slightly acidic. This dissolves calcium and magnesium ions present in the limestone. Calcium and magnesium ions give rise to hardness in water and take a longer time to lather.

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

Limestone rain carbon dioxide hard water

(ii) No- soapless detergents are not affected by the presence of calcium ions in hard water.

Note: Hard water does not lather easily with soap (lather is a frothy white mass of bubbles). Soap can be represented as NaS^+ Sodium stearate when the water is hard i.e. contains Ca^{2+} from limestone.

$2NaS^+_{(aq)} + Ca^{2+}_{(aq)} \longrightarrow CaS^{2+}_{(s)} + 2Na^+_{(aq)}$

When all the Ca^{2+} is removed by the soap then the excess can lather.

(b) These second generation detergents have a high level of phosphates, which is a nutrient which cause rapid growth of algae. Encatchment areas such as ponds and lakes are quickly covered with these fast growing algae. This process is known as eutrophication. Phosphates also reduce the quality of water for drinking purposes. Detergents also contain additives such as perborates and enzymes that cause anxiety.

(c) **(i)** Green chemistry is an area of chemistry that focuses on the designing of products and processes that minimize the use of hazardous substances. It maximizes the use of recycling, reducing and reusing in order to prevent harm to our natural environment.

(ii) Some of the benefits involved in utilizing the principles involved in green chemistry are:

1- It help produces less waste in processes therefore there is less to clean up or treat or neutralized before releasing into the environment.
2- Chemical processes are designed to minimize the production of toxic substances that are harmful to the environment.
3- The designing of safer chemicals that are target oriented and not broad spectrum. It is designed to affect their desired function while minimizing their toxicity.
4- Safer solvent auxilliaries are manufactured and used only when necessary therefore, less harm to the environment when seldom used.
5- Energy efficiency design maximizes the use of energy produced and minimizes waste and economic impacts.
6- The use of renewable material reduces the strain and enhances sustainability of natural resources by reducing its demand. Hence, less natural resources have to be harvested or removed for manufacturing.
7- The use of catalysis saves time, speeds up reaction and reduces the need for natural resources. Therefore it minimizes the need for natural resources. Therefore, it minimizes the need for energy in the reaction processes, less energy reduces the need for extra fossil fuel.

JANUARY 2016 PAPER 2

1. (a) (i) This is the change in concentration of reactants consumed or change in concentration of products formed divided by the time taken for the change.

(ii) Temperature, catalyst, surface area or particle size, pressure and light for some reactions.

(b) (i) RAM $KIO_3 = 39.1 + 126.9 + (16 \times 3)$

$= 214$ g

1 mole of $KIO_3 = 214$ g

$\therefore 0.214$ g of $KIO_3 = \frac{1}{214} \times 0.214$

$= 0.001$ moles

Conc. in 100 cm^3 = 0.001mols

$\therefore \quad 1cm^3 = \frac{0.001}{100}$

$1000\ cm^3 = \frac{0.001}{100} \times 1000$

$= 0.01\ mol\,dm^{-3}$

(ii) $\frac{10}{50} \times \text{Concentration of solution} = 0.0008\ mol\,dm^{-3}$

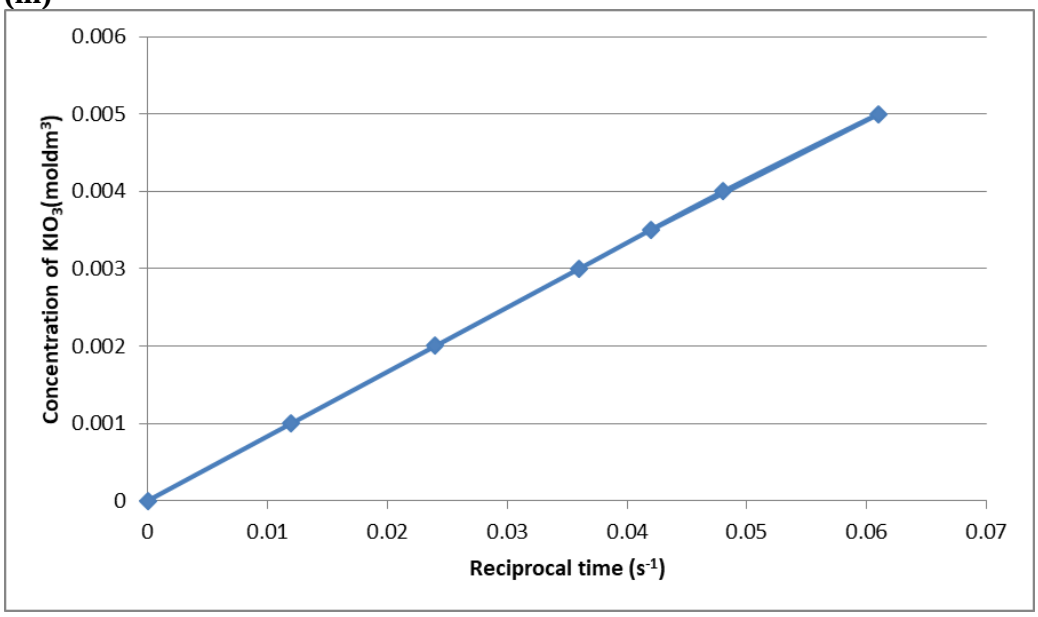
$\text{Concentra of solution} = 0.0008 \times \frac{50}{100}$

$= 0.004\ mol\,dm^{-3}$

(c)

Experiment	Solution 1 (cm^3)	Solution 2 (cm^3)	Distilled water (cm^3)	(i) Time taken for blue-black colour to appear (s)	(ii) Reciprocal time (s^{-1})	Concentration of KIO_3 after mixing ($moldm^3$)
1	5	10	35	83.5	0.012	0.0010
2	10	10	30	41.5	0.024	0.0020
3	15	10	25	28.0	0.036	0.0030
4	20	10	20	21.0	0.048	0.0040
5	25	10	15	16.5	0.061	0.0050
6	20 Solution X	10	20	24.0	0.042	0.0035

(iii)



(d) As the concentration of KIO_3 increases the time taken for the reaction decreases hence, rate of reaction increases.

(e) After mixing it is 0.0035 $moldm^{-3}$.

(f) **(i)** Time

(ii) Total volume of solution reacting. Concentration of sodium hydrogen sulphite ($NaHSO_3$)

2. **(a)** To remove stains, sanitation (kill bacteria)

(b) **(i)** Oxidizing agent causes oxidation by causing an atom to lose electrons while the oxidizing agent gain the electrons.

(ii) Oxidation is the loss of an electron from an ion, atom or molecule to another ion, atom or molecule. (Increase in oxidation state.)

(c) Na^{+}, Cl^{x}, $O^{2-} = 0$

$1 + x + (-2) = 0$

$Cl\ (x) = +1$

(d) **(i)** $Cl_2 \longrightarrow Cl^{-}$ $\qquad$ $0 \longrightarrow -1$

(ii) Reduction because it gained an electron to become -1.

(iii) It will turn damp blue litmus paper red then bleaches it white.
Chlorine makes damp starch iodide paper turn blue-black.

(e) The oxidation number of Oxygen in H_2O_2 is -1.
The oxidation number of oxygen in H_2O is -2. Oxygen is going from -1 to -2.
∴oxygen gains an electron and reduction is taking place.
N.B. oxygen's oxidation numbers are -1 in hydrogen peroxide, -2 in water and 0 in oxygen and hydrogen stays the same at +1.

3. **(a)** **(i)** Propanoic acid

(ii) Organic acids or carboxylic acids

(iii) It reacts with bases to give salt and water (neutralization reaction). It reacts with alcohols to give esters.

(b) **(i)** Butanol

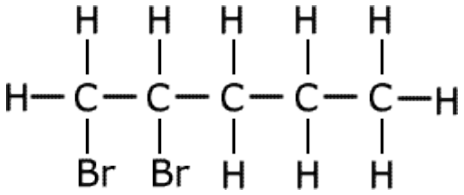
(ii) Alcohols

(iii) $C_nH_{2n+1}OH$

(c) **(i)** They are both colourless gases with low melting and boiling point and are very volatile and less dense than air.

(ii) G

(iii)



1,2-dibromobutane

(iv) Yes

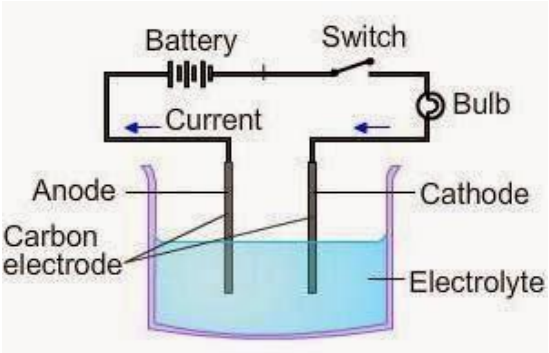
(v) $2C_4H_{10(g)} + 13O_{2(g)} \longrightarrow 8CO_{2(g)} + 10H_2O_{(g)}$

(vi) Easily transported and stored. Very flammable and give out a lot of heat energy, readily available and cheap.

4. (a) **(i)** This is a negatively charged atom that is attracted to the positive electrode, an anode.

(ii) $OH^-_{(aq)}$, $SO_4^{2-}{}_{(aq)}$

(iii)



(b) $Q = It$

Firstly calculate how much coulombs are produced.

$Q = (I \times 60 \times 60) \times 965$

$= 3474000$ C

Then, convert coulombs to moles of electrons. From the equation 2 moles of electrons are needed to liberate one mole of $H_{2(g)}$ i.e. (2 x 96500)C = 1 mole of $H_{2(g)}$

$$1\ \text{C} = \frac{1}{2 \times 96500}\ \text{moles of } H_{2(g)}$$

$$\therefore\ 3474000\ \text{C} = \frac{1}{2 \times 96500} \times 3474000$$

$$= 18\ \ \text{moles of } H_{2(g)}$$

Finally, convert the number of moles of $H_{2(g)}$ produced to Vol. by multiplying by 22.42:

$$\text{Volume} = 18 \times 22.42$$

$$= 403.2\ \text{L}$$

(c) This process is called electro-refining of nickel. The electrode must be an active electrode i.e. it must take part in the reaction. Impure nickel is made the anode and a strip of pure nickel is made the cathode. The electrolyte is a mixture of nickel sulphite or chloride and sulphuric acid. A large current is used during the electrolysis. During the reaction the anode will get thinner and the cathode will get thicker. This occurs because during electrolysis the nickel atoms will leave the anode and enter the solution as nickel ions while nickel ions are discharged at and deposited on the cathode.

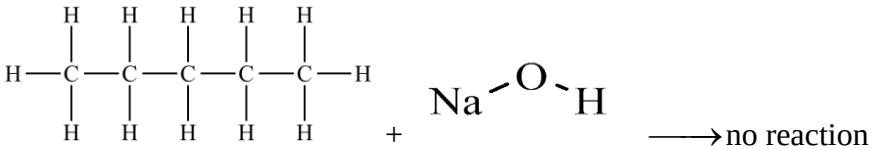
5. (a) Petroleum, Methane (natural gas), coals and peat.

(b) Fraction: Kerosene, diesel, gasoline
Use: Fuels
Fraction: Bitumen
Use: to make roads

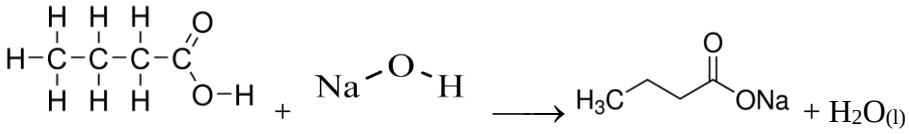
(c) **(i)** Breaking up of larger, long chain hydrocarbons into smaller chains or units.

(ii) Catalytic cracking uses a catalyst and relatively low temperatures while thermal cracking uses large amounts of heat.

(d) **(i)** Pentane + sodium hydroxide $\longrightarrow$ no reaction



Butanoic acid + sodium hydroxide $\longrightarrow$ sodium butanoate + water



(ii) $C_5H_{12(g)} + 8O_{2(g)} \longrightarrow 5CO_{2(g)} + 6H_2O_{(g)}$

6. (a) Calcium hydroxide $Ca(OH)_2$ and ammonium sulphate $(NH_4)_2SO_4$.

(b) Ammonia gas is a base. If sulphuric acid is used a neutralization reaction will occur. That is the sulphuric acid will react with the ammonia gas and you will not get dry ammonia.

$2NH_{3(g)} + H_2SO_{4(aq)} \longrightarrow (NH_4)_2SO_{4(aq)}$ ammonium sulphate

N.B. anhydrous calcium chloride will also react with ammonia gas.

(c) **(i)** Its density and solubility in water.

(ii) The method that is best suited is upward delivery. Downward delivery is not suited as ammonia is less dense than air and it will rise to the top and escape into the atmosphere. Displacement of water is not suited because ammonia gas is very soluble in water and will dissolve in it causing the pH to increase.

(d)

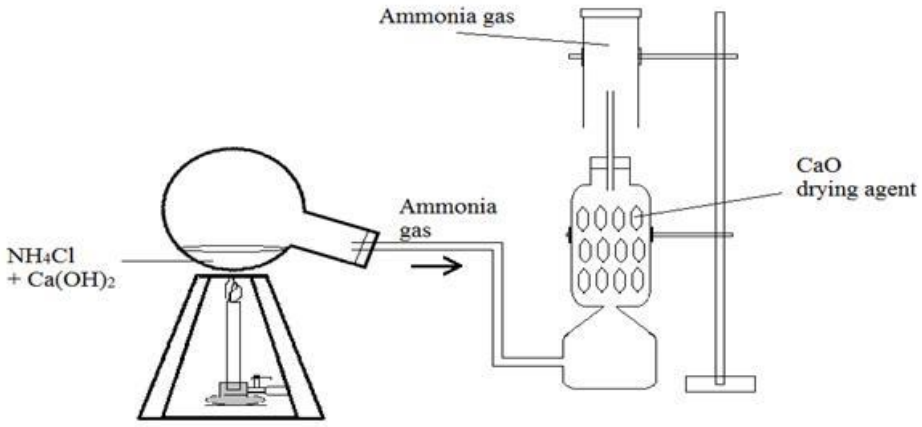


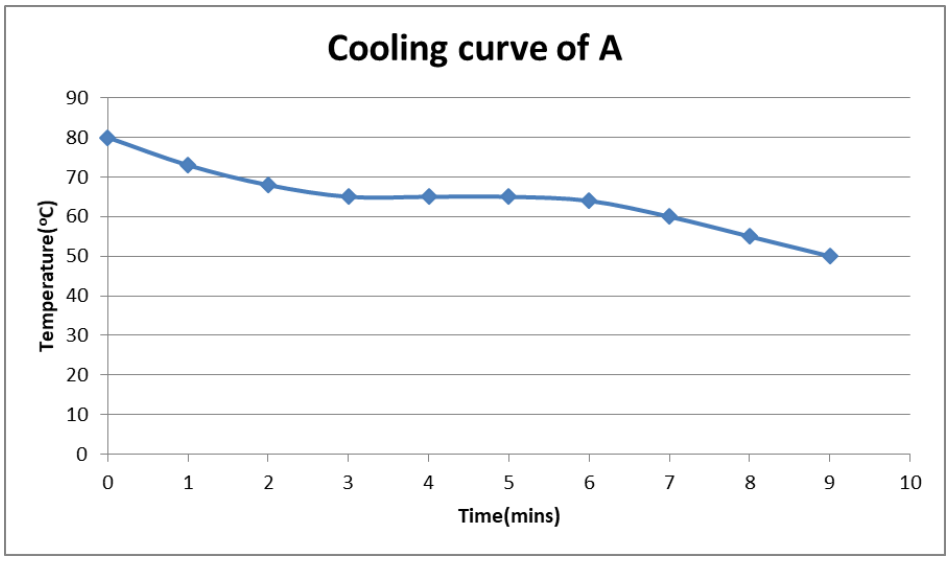
Diagram showing the laboratory preparation of dry ammonia

JUNE 2016 PAPER 2

1. (a) (i) TABLE 1: RESULTS OF EXPERIMENT

Time (min)	Temperature(°C)
0	80
1	73
2	68
3	65
4	65
5	65
6	64
7	60
8	55
9	50
10	48

(ii)



(iii) Solid, liquid, gas

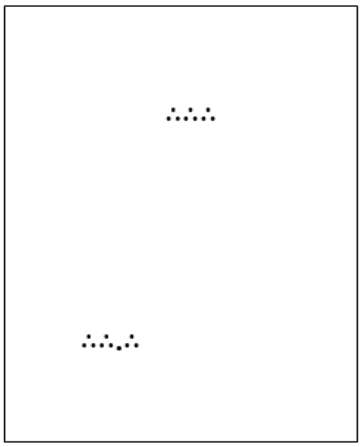
(iv) The constant temperature at which a solid changes from a solid to a liquid.

(v) 65 °C

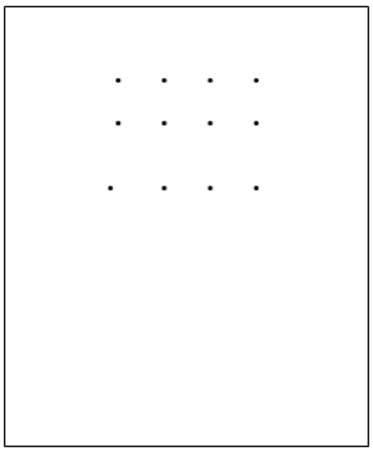
(vi) 3-5 minutes

(vii) Hold boiling tube away with wooden forceps and point away from body to avoid injury. Add anti-bumping granules into water bath for uniformed boiling.

(viii)



Particles of A at 0 minute



Particles of A at 10 minutes

(b)

	Test	Observation	Inference
(i)	Place a small portion of solid, B in a test tube and heat strongly using a Bunsen burner	• A reddish brown gas evolved	• NO_2, nitrogen dioxide gas
(ii)	Dissolve the remainder of B in about $10cm^3$ of distilled water, stir, then filter. Collect the filtrate and divide it into three equal portions for use in the following tests		
(iii)	To the first portion of the filtrate from (b)(ii), add aqueous NaOH solution slowly until in excess	• White precipitate formed • Soluble in excess	• Al^{3+}, Ca^{2+}, Pb^{2+}, Zn^{2+} • Al^{3+}, Pb^{2+}, Zn^{2+}
(iv)	To the second portion of the filtrate from (b)(ii) add aqueous NH_3 slowly until in excess	• White precipitate formed • Insoluble in excess	• Al^{3+}, Pb^{2+}, Zn^{2+} • Al^{3+}, Pb^{2+}
(v)	To the third portion of the filtrate from (b)(ii), add aqueous KI	• Yellow precipitate formed	• Pb^{2+} • $Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$

2. (a) An oxidizing agent causes a substance to lose electrons and itself gains electrons (reduced).
A reducing agent causes the substance to gain electrons and itself lose electrons (oxidized).

(b) **(i)** Acidified potassium dichromate (VI)/ acidified potassium manganate (VII)

(ii) Test 1: C is a reducing agent. N.B. manganate is an oxidizing agent.
Test 2: C is an oxidising agent. N.B. KI is a reducing agent.

(iii) Test 1: the colour change is from purple owing to the presence of the mangante (VII) ion (MnO_4^-) to colourless owing to the formation of the manganese (II) ion (Mn^{2+}). The mangante (VII) ion gains electrons from the reducing agent.

Test 2: the colour change is from colourless owing to the presence of the iodide ion (I^-) to brown owing to the formation of Iodine in solution.

(iv) $Fe_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Fe^{2+}_{(aq)} + Cu_{(s)}$

(v) In the electrochemical series the element higher in the series will displace the element lower. In test 3, iron is higher than copper in the electrochemical series, therefore iron will displace the copper in the solution. In test 4, no reaction took place because silver is lower than copper in the electrochemical series and therefore cannot displace the copper from the solution.

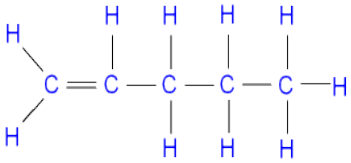
3. (a) Compounds that have the same molecular formula but their structure are oriented differently.

(b) **(i)** Pentene

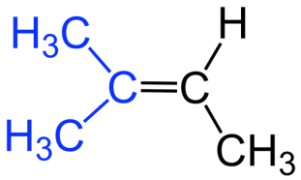
(ii) It is a gas. It has a low boiling point. It is less dense than air. It is volatile.

(iii) Decolourised acidified potassium mangante from purple to colourless. Decolourised bromine solution from red-brown to colourless.

(iv)

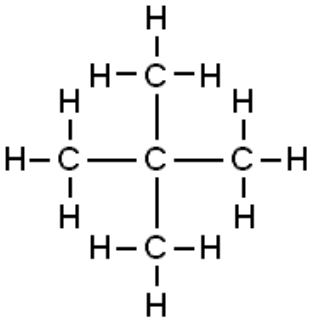


Pentene
Compound P



2-methyl-but-2-ene
Isomer of compound P

(c) **(i)**



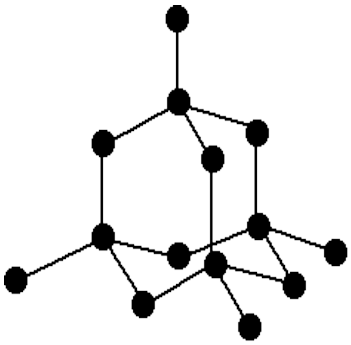
(ii) The properties of liquid. Volume and density (low).

(d) Pent-2-ol

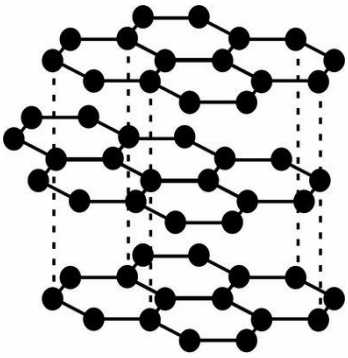
(e) 170^{o}C, concentrated sulphuric acid

4. (a) An allotrope is different forms of the same element in the same physical state.

Diamond



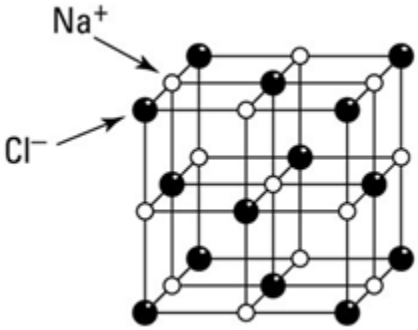
Graphite



(b) (i) Atoms in metals are tightly packed together and as a result the valence electrons become delocalized and cations are formed. This sea of cations and electrons are held together by strong forces of electrons.

(ii) In graphite the 4th electron of carbon atom becomes delocalized allowing electricity to move through it.

(c)



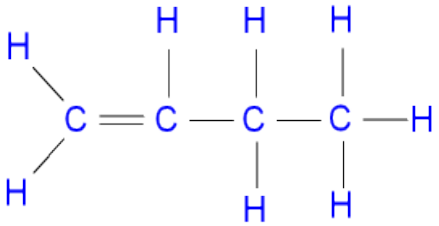
Bonds in Ca^{2+} is stronger therefore it requires more energy to breakdown than Na^{+} which only has one bond which requires less energy to breakdown. Since Ca^{2+} and O^{2-} have relatively higher charges than Na^{+} and Cl^{-}, there is a stronger force of attraction.

5. (a) Covalent bonding because they are both non-metals by which carbon has 4 valence electrons and would rather share than gain or give up electrons.

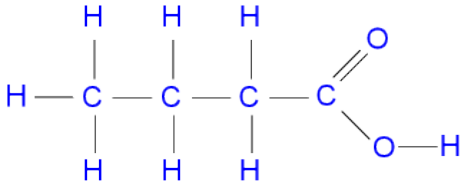
(b) (i) $CH_4 + 4Cl_2 \longrightarrow CCl_4 + 4HCl$

(ii) Substitution reaction, UV light, sunlight.

(c)



Alkene: C_4H_8



Acid: $C_4H_8O_2$

(d) **(i)** Lighting splint: alkanes burn with a clean, blue flame while alkenes burn with with a smoky orange-red flame.

An alkene will decolourize $KMnO_4$ (VII) rapidly while an alkane will not.

(ii) Carboxylic acids react with alcohols to produce esters in a process called esterification whereas alkanes do not.

6. **(a)** **(i)** Extraction of the mined bauxite ore in Jamaica occurs through the Bayer process which involves treating the crushed bauxite with moderately concentrated sodium hydroxide solution. This results in a white product called alumina or aluminium oxide. This is then taken to another processing plant to be converted into aluminium via electrolysis, which is conducted in a large tank lined with carbon which acts as the negative electrode. Huge blocks of carbon are hung above the middle of the tank acting as the positive electrode. In order to reduce the melting point of the pure alumina it is dissolved in molten cryolite (Na_3AlF_6) which has a much lower melting point. Once dissolved, its ions are free to move. At the cathode Al^{3+} ions undergo reduction and gain electrons.

$Al^{3+}_{(l)} + 3e^- \longrightarrow Al_{(l)}$

(ii) Since the majority of the Caribbean islands are relatively small, it is difficult to extract aluminium mainly because there is not enough space on the island. The waste size of aluminum is large and its extraction must take place somewhere where it is able to be absorbed like forests with a lot of trees.

(b) Duralumin is better to use because it is strong, lightweight and able to withstand greater stress than pure aluminum. Magnalium is better because it is stronger, harder and more corrosion resistant than pure aluminium. It has a lower density thus it is also lighter than aluminium.

(c) Though metals such as mercury are useful in the manufacturing of many products (thermometers, car batteries etc.) it poses a threat to the environment. It can damage the CNS of the body causing degenerative neurological disorders and death.

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1. (a) This is a solution of known concentration. It is made by dissolving a known weight of solute in a specific volume.

(b)

Mass of beaker and sample (g)	17.11
Mass of beaker (g)	13.95
Mass of sample (g)	3.16

(c)

	Burette Readings(cm^3)	**Titration 1**	**Titration 2**	**Titration 3**
(i)	Final volume	25.6	26.3	24.5
	Initial volume	1.00	2.05	0.15
(ii)	Volume used	24.6	24.25	24.35

(iii) Average volume of $KMnO_4$ used in the titrations $= \dfrac{(24.5 + 24.35)\ cm^3}{2}$

$= 24.3\ cm^3$

(iv) 0.01 moles of $KMnO_4$ in 1000 cm^3

No. of moles in $1cm^3 = \dfrac{0.01}{1000}$

$= 0.000\,01$ moles

No. of moles in 24.3 cm^3 $KMnO_4 = 0.000\,01 \times 24.3$

$= 0.000\,243$ moles

(d) (i) According to the balanced equation 1:5 mole ratio

25 cm^3 of Fe^{2+} will contain $5 \times 0.000\,243 = 0.001215$ moles of Fe^{2+}

(ii) In 25c m^3 of $Fe^{2+} = 0.001215$ moles

In $1cm^3$ of $Fe^{2+} = \dfrac{0.001215}{25}$

$= 0.000\,048\,6$ moles

$\therefore$ 250 cm^3 of $Fe^{2+} = 0.000\,048\,6 \times 250$

$= 0.01215$ moles

(e) Mass of anhydrous $FeSO_4$ $= 152 \times 0.01215$
$= 1.8468$ g

(f) Mass of water in the hydrated $FeSO_4$ $= 3.16\text{ g} - 1.8468\text{ g}$
$= 1.3132$ g

(g) No. of moles of water in the hydrated sample $= \dfrac{1.3132}{18}$
$= 0.0730$ moles

(h) $n = \dfrac{0.073}{0.01215}$
$= 6$

(i) The colour change at the endpoint is from purple to colourless/light pink.

(j) One of the reagent or reactant is coloured. $KMnO_4$ is purple. On addition to $FeSO_4$ the colour of the solution changes to pink.

(k)

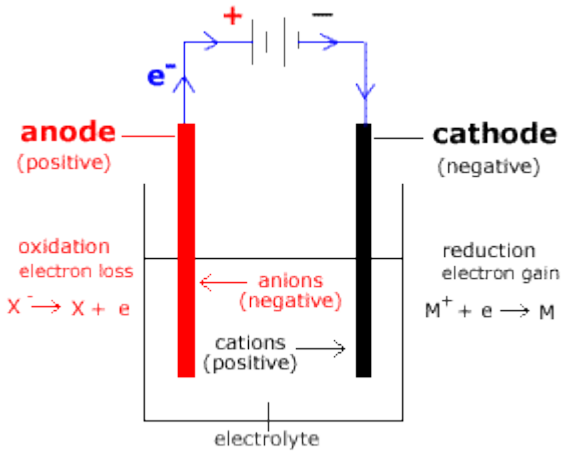
	Test	**Observation**	**Inference**
(i)	• Aqueous sodium hydroxide was added dropwise • And then in excess	• Dirty green precipitate • Insoluble in excess	Fe^{2+} ions present
(ii)	• The resulting mixture from (i) was left to stand in air	• Turns brown on exposure to air	Fe^{2+} ions oxidized to Fe^{3+}
(iii)	• Aqueous barium nitrate was added • Followed by dilute nitric acid	• White precipitate • insoluble in acid	SO_4^{2-} ions present

2. (a) (i) This is the passage of an electric current through an electrolyte causing a chemical change such as decomposition.

(ii) This is the coating of or depositing a thin layer of one metal on top of another.

(iii) 1- Purification of metals eg. Copper
2- Anodising of metals eg. Aluminium
3- Extraction of metals from ores eg. Aluminium

(b) **(i)**



Both electrodes are made of carbon.

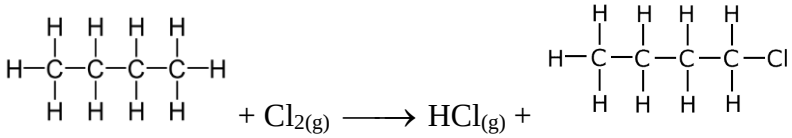
(ii) Equation at anode: $2Br^- \longrightarrow 2e^- + Br_{2\ (g)}$
Equation at Cathode: $Pb^{2+}_{(l)} + 2e^- \longrightarrow Pb_{\ (s)}$

3. **(a)** **(i)** Alkane

(ii) Fuel, Fuel in cigarette lighters, propellant in aerosols, a refrigerant

(iii) Sunlight or UV rays

(iv)



(v) It will react with ammonia gas to form ammonium chloride which is seen as white fumes.

(b) **(i)** A polymer is a long chain of combined smaller units called monomers. The monomers are attached to each other via their functional group to form larger molecules. Polymers can be made up of millions of smaller units.

(ii) Type of polymerization: Addition polymerization
Name of polymer: polypropane
Use of polymer: plastics

(c) **(i)** Ester linkage

(ii) Type of polymerization: condensation
Use of polymer: cosmetics, perfumes, synthetic flavor

(iii) Water

4. (a) Isotopes are elements that have the same atomic number but different mass number due to the different number of neutrons. Both carbons have the same atomic number, 6, i.e. they have six electrons and six protons ${}^{12}_{6}C$ has $12-6=6$ neutrons. ${}^{13}_{6}C$ has $13-6=7$ neutrons. Both ${}^{12}_{6}C$ and ${}^{13}_{6}C$ has the same atomic mass but different mass number. ${}^{13}_{6}C$ has one extra neutron.

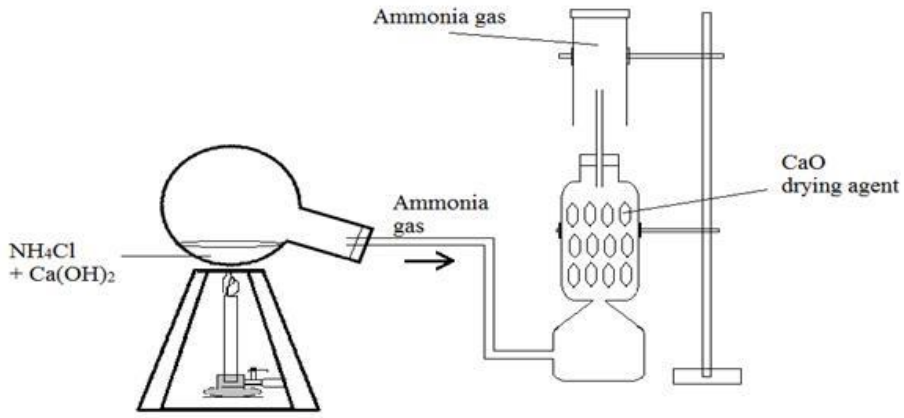
(b) Cobalt 60 is used to arrest the development of cancer.
Iodine 131 is used to treat hyperthyroidism.
Carbon 14 is used in breath test to detect the ulcer causing bacteria and in carbon dating eg. age of fossil.
Plutonium 238 is used to provide energy for heart pacemakers.
Thallium 99 is used to monitor heart disease. Sodium 24 is used to trace the flow of blood and to locate obstructions in the circulatory system.

(c) **(i)** W belongs to group 7 (halogen) period 2.
X belongs to group 2 (alkaline earth metals) period 3.
The type of bonding is ionic bonding. X^{2+}, W^{-}. XW_2, metal first followed by non-metal.

(ii) The compound above will dissolve in water. Ionic compounds are of high solubility in polar or ionic solvents. When the oppositely charged ions in the solid ionic lattice are surrounded by the opposite pole of a polar molecule, the solid ion is pulled out of the lattice and into the liquid.

5. (a) Colourless gas, less dense than air, boiling point is -33.3 ºC, freezing point is –77.7 °C, alkaline gas, pungent smell.

(b) **(i)**



(ii) $Ca(OH)_{2(s)} + 2NH_4Cl_{(s)} \longrightarrow CaCl_{2(s)} + 2H_2O_{(l)} + 2NH_{3(g)}$

(iii) Concentrated sulphuric acid will react with the ammonia gas in a neutralization reaction as the ammonia gas is alkaline to give ammonium sulphate.

$H_2SO_4 + NH_3 \longrightarrow NH_4SO_4$

Calcium oxide and ammonia are both basic compounds so they do not react with each other.

(c) Ammonia gas will turn red litmus paper blue and it will react with hydrogen chloride vapour to form a white dense gas, ammonium chloride which has a pungent smell.

(d) Eutrophication
Poison water which becomes hazardous to health and can lead to metheamoglobinemia or blue baby syndrome
Potential cancer risk (nitrates can react with amines or amides in the body to form nitrosamines which is known to cause cancer.
Anoxia- this is a lack of oxygen due to high levels of nutrients eg. Nitrates. It causes fish kills.

6. (a) High specific heat capacity - helps in the absorption of heat from the body and cools it via sweating and evaporation.
Lower density of ice causes lakes and rivers to freeze from the top which insulates the water below preventing it from freezing which allows life to persist below.
It is attracted to polar molecules. Cohesion causes surface tension that allows insects to walk on water (habitat). Adhesion – capillary action helps plants absorb water and nutrients from soil.
Water has a high polarity which helps to dissolve a wide range of solutes. It is an ideal solvent eg. Blood.

(b) **(i)** $Ca(HCO_3)_{2(aq)} + (Na)_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaHCO_{3(aq)}$

(ii) Water can be softened by ion exchange resins. Water is slowly passed through a column of ion exchange resins. The dissolved calcium and magnesium ions displace the sodium ions in the resin.

$Ca^{2+}_{(aq)} + Na_2Z_{(s)} \longrightarrow CaZ_{(s)} + 2Na^{+}_{(aq)}$

(c) Hard water does not lather with soap.
1- Place 100 cm^3 of water sample in a boiling tube with a small piece of soap.
2- Cork the boiling tube and shake for 1 minute.
3- Observe the content of the tube. If it lathers it is soft water. If it does not lather it is hard water. Lather is a frothy white mass of bubbles.

OR

1-Place 10 cm^3 of pure water in a test tube A and 10 cm^3 of hard water in another in B
2-Insert equal amounts of soap into each test tube and shake vigorously
3-Observe the test tubes. Test tube A should have lather while test tube B shouldn’t.

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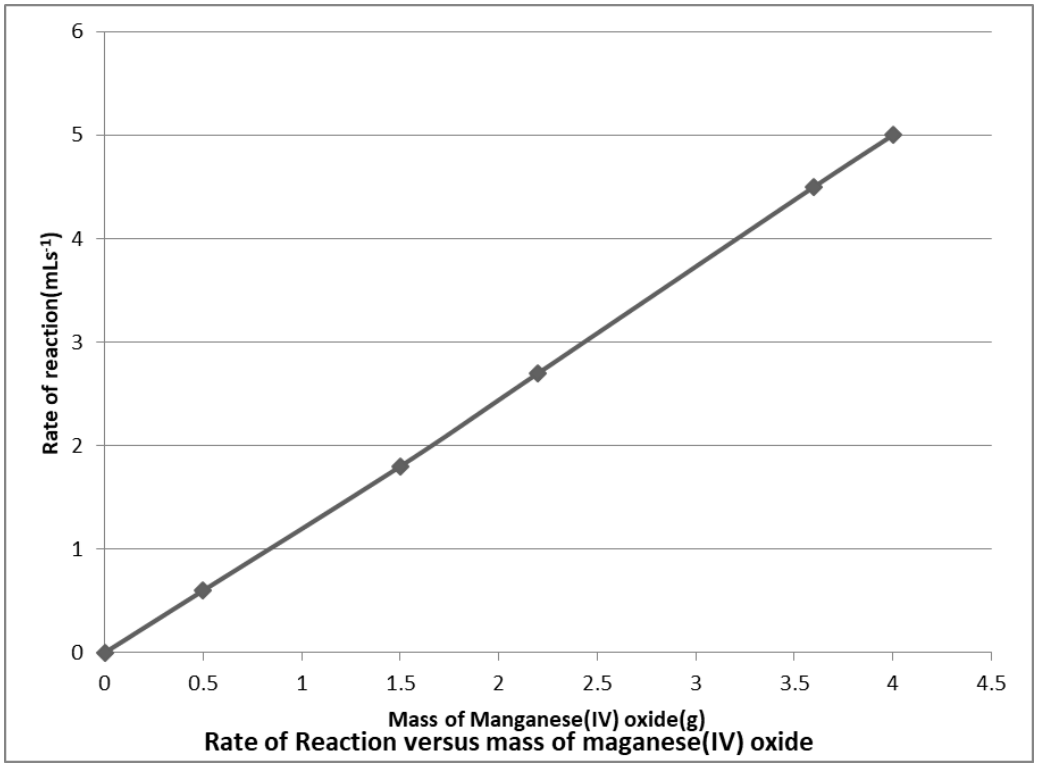
1. (a) TABLE 1: RATE OF REACTION BY MASS OF MAGANESE (IV) OXIDE

Experiment	Mass of Maganese (IV) oxide (g)	Rate of reaction (mLs^{-1})
1	0.0	0.0
2	0.5	0.6
3	1.5	1.8
4	2.2	2.7
5	3.6	4.5
6	4.0	5.0

(b) The rate of a reaction is given by either the change in concentration of reactants or products with time at a stated temperature.

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

(d)

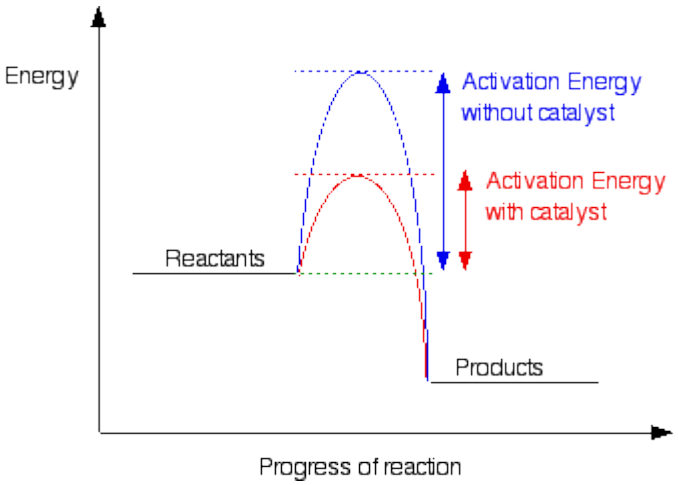


(e) **(i)** As the mass of the catalyst increases the rate of the reaction increase. More alternate pathway and orientation of successive collision for reactant to react occurs therefore the rate of the reaction increases. This implies that the mass of catalyst is directly proportional to the rate of reaction.

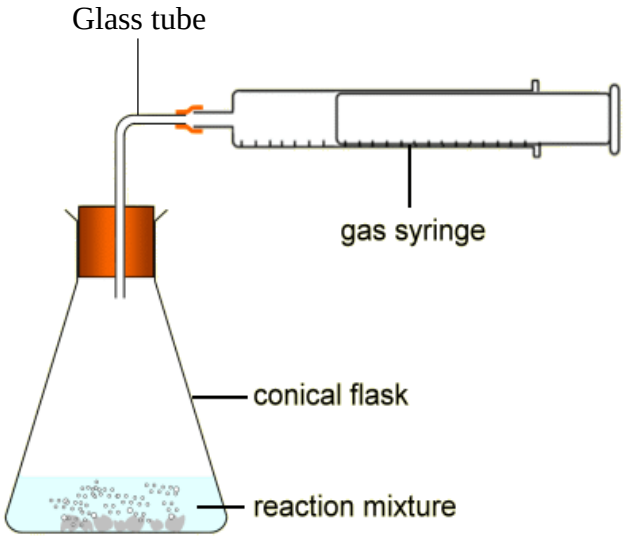
(ii) From the graph, 3.0 g of the catalyst will give a reaction rate of 3.7 mLs^{-1}.

(iii) Rate $= 3.7\ mLs^{-1}$
After 10 s the volume of oxygen produced is $3.7\ mL \times 10 = 37\ mL$

(f)



(g)



(h) Temperature, surface area, pressure, light

2. (a) (i) Mole: this is the amount of a substance which contains as many elementary entities (atoms, molecules, ions, electrons or protons) as there are carbon atoms in 12 g (0.012 kg) of Carbon-12.

Molar mass: this is the sum of all masses of each element in a molecule or compound and is expresses as g/mol or kg/mol OR the mass of 1 mole of any substance expressed in grams is called the molar mass and has units of $gmol^{-1}$.

(ii) 1 mole of aspirin $= 180$ g

0.2 moles of aspirin $= 180 \times 0.2$

$= 36$ g

(iii) 180 g of aspirin $= 1$mol

$$1 \text{ g} = \frac{1}{180} \text{ moles}$$

$$\therefore 18 \text{ g of aspirin} = \frac{1}{180} \times 18$$

$$= 0.1 \text{ moles}$$

(b) From the given equation, when one mole of aspirin is hydrolysed, one mole of ethanoic acid is produced i.e. 1:1 or 0.1 moles : 0.1 moles.

0.1 moles of ethanoic acid is produced.

1 mole of ethanoic acid $= 60$ g

$$0.1 \text{ moles of ethanoic acid} = \frac{60}{1} \times 0.1$$

$$= 6 \text{ g of ethanoic acid}$$

(c) (i) This is a substance that dissociates into mobile ions in a solution. It has mobile ions and can conduct an electric current.

(ii) $CH_3COO^-_{(aq)}$ and $H^+_{(aq)}$

(iii) This is the negatively charged electrode in an electrolytic cell. At this point e^- are discharged into the electrolyte solution. N.B. At the cathode positive ions called cations are attracted to it. They accept electrons from the cathode.

(iv) $H^+_{(aq)}$ cation

(v) This is a weak electrolyte because it partially dissociated in water.

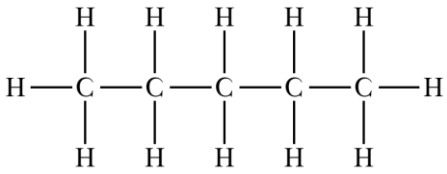
$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$$

3. (a) (i) Name of Homologous series: Alkanes
General formula: C_nH_{2n+2}, $n \geq 1$.

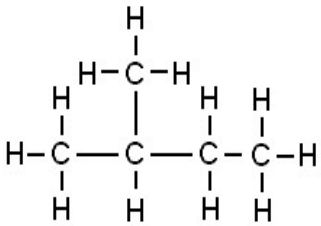
(ii) This is a gas. It is used as a primary blowing agent in the production of polystyrene foam and other foams. It is an ingredient for petrol fuel and is used as solvents.

(iii) This is when molecules have the same molecular formulae but different orientation of atoms in the structure (or different structural formulae.)

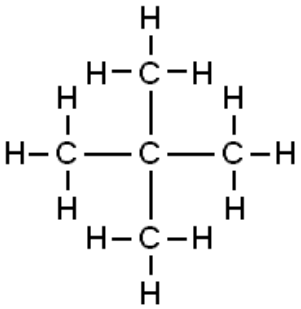
(iv)



Pentane



2- methylbutane



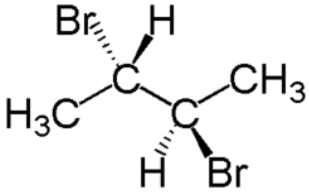
2,2-dimethylpropane

(b) (i) Compound Q is soluble in water because it has a hydrophilic group – OH. It is a polar compound with a water loving end. The polar OH group forms hydrogen bonds with H_2O.

(ii) This compound Q is acidic because it belongs to carboxylic acids. The functional group is acidic COOH and H^+ from the functional group will dissociate into solution which will make it acidic.

(c) (i) This will change from red-brown to colourless.

(ii)



2,3-dibromobutane

4. (a) A salt is an ionic compound which is formed from a neutralization reaction between an acid and a base. Calcium carbonate is used to manufacture dry walls, chalk for writing, agricultural lime to reduce acidity in soil and tablet in medicine. Sodium nitrate is used for the manufacture of fertilizers, pyrotechnics, smoke bombs, pottery enamels and food preservation.

(b) Calcium chloride + sodium carbonate $\longrightarrow$ calcium carbonate + sodium chloride

$CaCl_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaCl_{(aq)}$

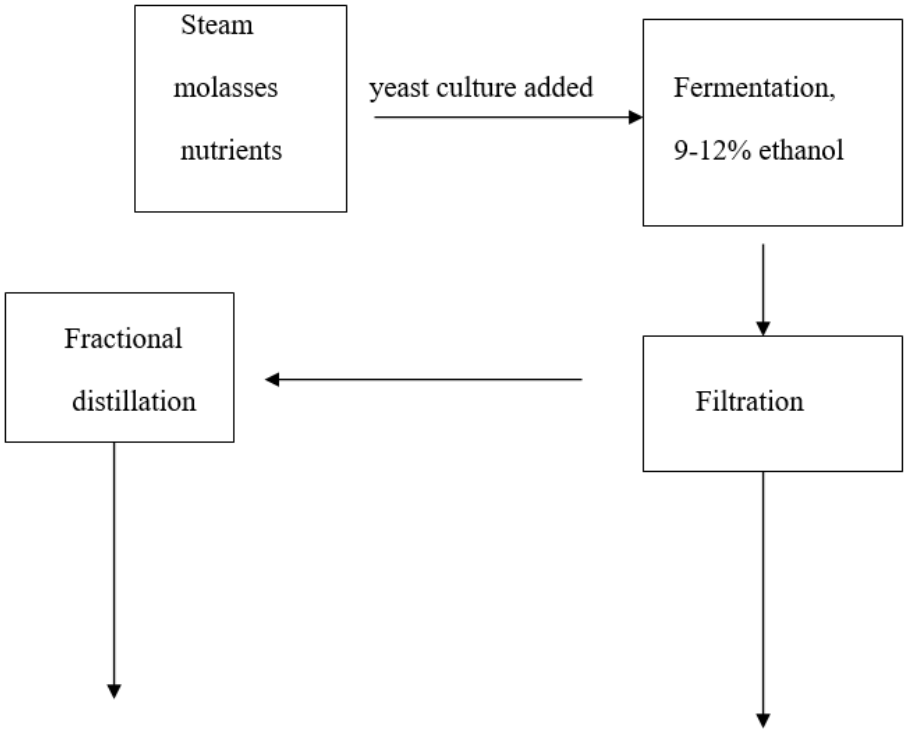
Put on safety goggles. Get two 250 mL beakers. To each one add 50 mL of water. To one beaker add 10 g of sodium carbonate. To the other add 10 g of $CaCl_2$. Stir to dissolve each component. Add the contents of one beaker into the other and mix for 5 minutes. Allow this mixture to settle for 5 minutes then filter using simple filtration method. The calcium carbonate salt will remain in the filter paper as it is an insoluble salt. Rinse with distilled water and allow to air dry.

(c) $Na_2CO_{3(s)} + 2HNO_{3(aq)} \longrightarrow 2NaNO_{3(aq)} + H_2O_{(l)} + CO_{2(g)}$

Sodium carbonate + nitric acid (V) $\longrightarrow$ sodium nitrate + water + carbon Dioxide

Add Na_2CO_3 in excess to neutralize all acid, then filter out excess and collect filtrate as $NaNO_{3(aq)}$.

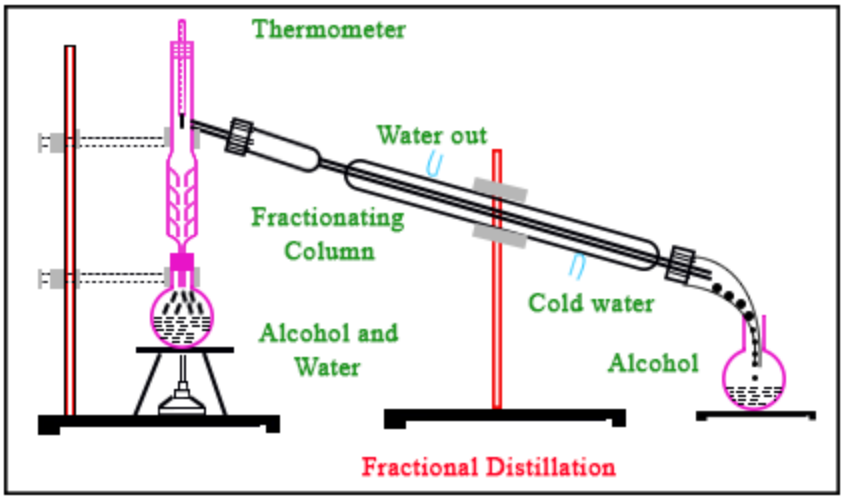
5. (a) Fermentation is a process of making ethanol from food groups full of sugars and carbohydrates by yeast. The starting material can be any food full of natural glucose and carbohydrates. Yeast and water is added to make a mixture. Yeasts are unicellular fungi and are the source of the enzyme which convert the carbohydrates to ethanol. Yeast grows exponentially and multiply rapidly when water, nitrogen, vitamins and mineral salts are present.



$$C_6H_{12}O_6 \xrightarrow[\text{Right pH in aqueous solutions}]{\text{Enzymes (zymase), 37°C}} 2C_2H_5OH + 2CO_2$$

Sugar, starchy material $\xrightarrow[\text{Enzymes supplied by yeast}]{}$ ethanol + carbon dioxide

(b) Distillation is necessary because the ethanol and remaining water are miscible. In order to separate the two from the filtered mixture distillation is used.



(c) The reagent used is acidified orange potassium dichromate (vi) crystals. A colour change with reaction of ethanol goes from orange to green. This is the oxidation of ethanol.

$$CH_3CH_2OH + (O) \xrightarrow[K_2Cr_2O_7/H^+]{} CH_3COOH$$

Ethanol Ethanoic acid

6. (a) (i) Least reactive to most: B, Fe, A.

$$A_{(s)} + FeSO_{4(aq)} \longrightarrow A_2SO_{4(aq)} + Fe_{(s)}$$
$$A_{(s)} + Fe^{2+}{}_{(aq)} \longrightarrow 2A^{+}{}_{(aq)} + Fe_{(s)}$$

(ii) $A + CuSO_{4(aq)} \longrightarrow A_2SO_{4(Aq)} + Cu_{(s)}$

$Cu_{(s)}$ is lower in the reactivity series than $Fe_{(s)}$. Since A is more reactive than $Fe_{(s)}$ it will displace $Cu_{(s)}$ from solution. The blue solution of copper II sulphate will slowly fade away as the copper is displaced and deposited as shiny brown solid.

(iii) A is very reactive and since vast amounts of energy is required, electrolysis is used to extract it from its ore while B is less reactive and reduction with coke (C) is used instead.

(b) An alloy of iron is steel (Fe 50%, chromium 10-30%, small amounts of carbon, nickel, manganese). This is used in the construction industry because of its strength and cost. Used in buildings and bridges.

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1. (a) (i) TABLE 1: TITRATION OF SOLUTION M (HCl) WITH SOLUTION N (NaOH)

Burette Readings (cm^3)	**Titration 1 (Rough)**	**Titration 2**	**Titration 3**
Final Volume	25.70	38.30	40.50
Initial Volume	0.25	13.30	15.50
Volume of solution M used	25.45	25.00	25.00

(ii) $\frac{25+25}{2} = 25 \text{ cm}^3$

(iii) Mass concentration $= 3.6 \text{ gdm}^{-3}$

$$\text{Molar concentration} = \frac{\text{gdm}^{-3}}{\text{RMM}}$$

$$= \frac{3.6 \text{ gdm}^{-3}}{36.5 \text{ gmol}^{-1}}$$

$$= 0.1 \text{ moldm}^{-3}$$

(iv) $1000 \text{ cm}^3 = 0.1 \text{ moles}$

$$1 \text{ cm}^3 = \frac{0.1}{1000}$$

$$\therefore 25 \text{ cm}^3 = \frac{0.1}{1000} \times 25$$

$$= 0.0025 \text{ moles}$$

(v) $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

(vi) From the balanced equation , 1 mol of HCl will react with 1 mol of NaOH
$\therefore 1:1$ mole ratio
0.0025 moles of HCl will react with 0.0025 moles of NaOH.

(vii) In $25cm^3$ of NaOH $= 0.0025$moles

$$1cm^3 \text{ of NaOH} = \frac{0.0025}{25}$$

$$\therefore 1000cm^3 \text{ of NaOH} = \frac{0.0025}{25} \times 1000$$

$$= 0.1 \text{ moldm}^{-3}$$

$$\text{Molar concentration} = \frac{gdm^{-3}}{RMM}$$

$$\text{Mass concentration } (gdm^{-3}) = \text{Molar concentration} \times RMM$$

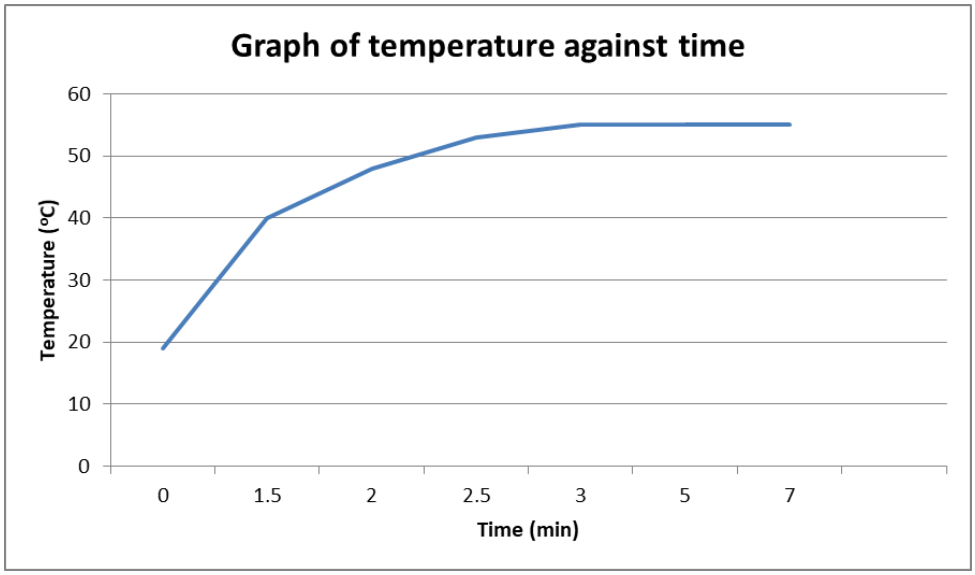
$$= 0.1 \text{ moldm}^{-3} \times 40 \text{ g}$$

$$= 4 \text{ gdm}^{-3}$$

(b) **(i)** Van der Waals forces

(ii) NaCl's melting point is higher because it forms an ionic crystal lattice structure when it forms bonds. The bonds between the Na^+ and Cl^- are ionic which makes it a very strong structure and requires a lot of energy to break it. NaCl has very strong intermolecular forces of attraction that bind the structure together.

(iii)



2. **(a)** **(i)** Acid - A substance that dissolves in aqueous solution to liberate H^+ ions.
Alkali - A substance that liberates OH^- ions when dissolved in aqueous solution.

(ii) Acid salts - A salt which is able to liberate H^+ ions when dissolved in solution because the salt is formed by incomplete replacement of the hydrogen of an acid.
Normal salts - A salt which all of the acid hydrogen atoms have been replaced by a metal or the hydroxide radical of a base are replaced by the acid radical.

(iii) $Na_3PO_{4(aq)}$

(iv) $3NaOH_{(aq)} + H_3PO_{4\,(aq)} \longrightarrow Na_3PO_{4(aq)} + H_2O_{(l)}$

(v) $Na_2HPO_{4(aq)}$ or $NaH_2PO_{4(aq)}$

(vi) $2NaOH_{(aq)} + H_3PO_{4(aq)} \longrightarrow Na_2HPO_{4(aq)} + 2H_2O_{(l)}$ or $NaOH_{(aq)} + H_3PO_{4(aq)} \longrightarrow NaH_2PO_{4(aq)} + H_{2(g)}$

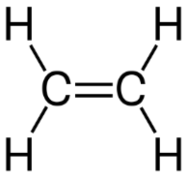
(b) 0.05M $H_2SO_{4(aq)}$. Note: lower the pH, stronger the acid.

(c) **(i)** Ascorbic acid, citric acid. Note: all citrus has citric acid, all Vitamin C is ascorbic acid.

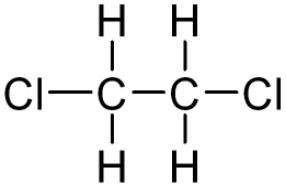
(ii) Neutralization

(iii) $NaHCO_3$, sodium hydrogen carbonate. This is the main ingredient in baking soda.

3. (a) **(i)**



(ii)



(iii) Addition reaction

(b) **(i)** $CH_{4(g)} + Cl_{2(g)} \xrightarrow{\text{UV light}} CH_3Cl_{(g)} + HCl_{(g)}$
$CH_3Cl_{(g)} + Cl_{2(g)} \xrightarrow{\text{UV light}} CH_2Cl_{2(g)} + HCl_{(g)}$

(ii) Substitution reaction

(c) **(i)** A polymer is made up of many smaller units joined together to form a macromolecule. These smaller units are called monomers.

(ii) This is when a long chain molecule is formed by combining unsaturated monomers. This is done by rearrangement of bonds without the loss of any atom or molecule under specific conditions of heat, pressure and catalysts.

4. **(a)** **(i)** Endothermic is when heat is absorbed from surroundings for a reaction or process to occur while exothermic is when heat is released to the environment when a reaction occurs.

(ii) Bond making – Exothermic
Bond breaking – Endothermic

(b) **(i)** RMM of $KNO_3 = 101\,g$
1 mol of $KNO_3 = 101$ g

OR

$$101\text{g of } KNO_3 = 1 \text{ mol}$$
$$1\text{g of } KNO_3 = \frac{1}{101} \text{ moles}$$
$$\therefore 12 \text{ g of } KNO_3 = \frac{1}{101} \times 12$$
$$= 0.12 \text{ mols}$$

N.B.: put what is given off on the L.H.S. and what you want to find on the R.H.S.

(ii) Using temperature change as Initial – final, you do not have to change the sign at the end,

$\therefore \Delta T = 4.20\,°C$

100 $cm^3 = 100$ g, assuming the density of water = 1gcm^{-3}.

$$\Delta H = mc\Delta T$$
$$= 100\text{ g} \times 4.2\text{ J} \times 4.2\,°C$$
$$= 1764\text{ J}$$

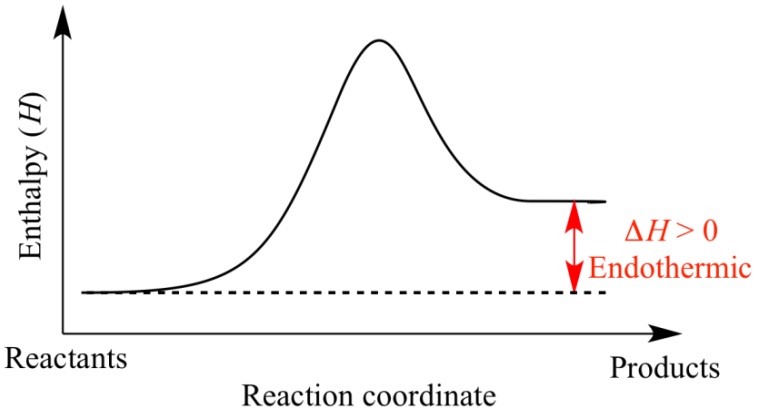
Sign is positive, therefore reaction is endothermic.

(iii) $0.12 \text{ mols} = 1.764$ J

$$\therefore 1 \text{ mol} = \frac{1.764}{0.12}$$
$$= 14.700 \text{ J}$$

(iv) Styrofoam cup - used as an insulating container for the reactants.
Thermometer - used to measure the temperature change.

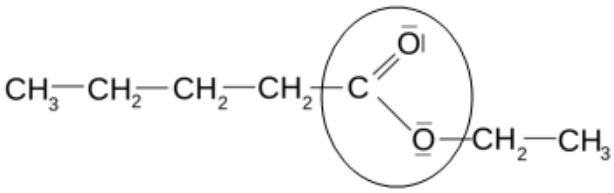
(v)



ΔH = +ve
=1764 J

5. (a) **(i)** Esters

(ii)



(iii) C_4H_9COOH – acid
C_2H_5OH – alcohol

(iv) Concentrated $H_2SO_{4(aq)}$

(v) An alcohol is very soluble in water due to the presence of polar OH (hydroxyl) functional group in the alcohol which is able to form hydrogen bonds with water while the ester has little or no solubility since it has a non-polar structure which is unable to form H bonds with water.

(b) Condition and reagent: $NaOH_{(aq)}$ and heat under reflux.
Balanced chemical equation:
$CH_3COOC_2H_{5(l)} + NaOH_{(aq)} \longrightarrow CH_3COONa_{(aq)} + C_2H_5OH_{(aq)}$

(c) Process: Saponification
Source: Animal fat or vegetable oil

6. (a) - It has a high specific heat capacity
-It has a high latent heat of vaporization
-It can dissolve many substances (universal solvent)
-It acts as a shock absorber

(b) Place blue $CoCl_2$ (Cobalt chloride) paper in the vapor. If water vapor is present the paper will change from blue to pink OR anhydrous copper II sulphate crystals from white to blue.

(c) $Ca(HCO_3)_{2(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + 2NaHCO_{3(aq)}$

(d) Ions to anode: $OH^-_{(aq)}$ and $SO_4^{2-}{}_{(aq)}$ but OH^{-1} will be preferentially discharged.
Ions to cathode: $H^+_{(aq)}$
Balanced equation at the cathode: $2H^+_{(aq)} + 2e^- \longrightarrow H_{2(g)}$
Balanced equation at the anode: $4OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^-$
Overall: $4H^+_{(aq)} + 4OH^-_{(aq)} \longrightarrow 2H_{2(g)} + O_{2(g)} + 2H_2O_{(l)}$

Note: Hydrogen gas is given off at a 2:1 ratio to oxygen i.e. for every 2 moles of hydrogen gas given off. 1 mole of oxygen gas is given off.