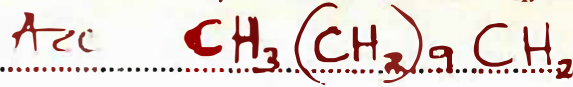


1. Crude oil is a mixture of hydrocarbons which are separated by fractional distillation. One of the components obtained contains an alkane A, with eleven carbon atoms.

(a) Write the molecular formula of A. (1 mark)



Accept open structural formula.



(b) Pentane can be obtained from compound A as shown.



(i) Give the name of this conversion process. (1 mark)

Cracking ✓

Acc Catalytic / Thermal Cracking.

(ii) State the conditions used in this process. (1 mark)

High temperatures ✓ Acc 400-700°C // Heat

High Pressure ✓ Acc 70 atmospheres. // ~~High~~ pressure. also
Catalyst ✓ Acc zeolite catalyst // silica catalyst // Alumina catalyst

(iii) Give the name of compound B. (1 mark)

Hexene ✓ Acc C_6H_{12}

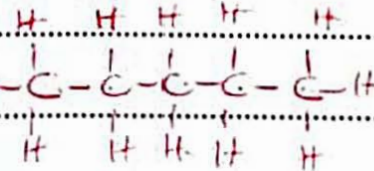
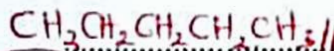
Acc Hex-1-ene // Hex-2-ene // Hex-3-ene.

(c) Draw and name two isomers of pentane. (4 marks)

Isomer 1

Structure

Name

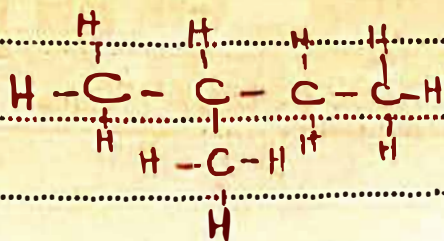


Pentane ✓

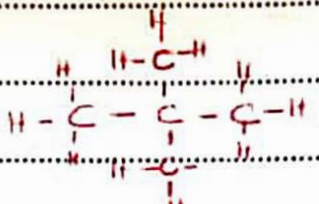
* Name correct, wrong structure = 0.

Isomer 2 Structure Name

ACC Condensed / open structure
Any 2



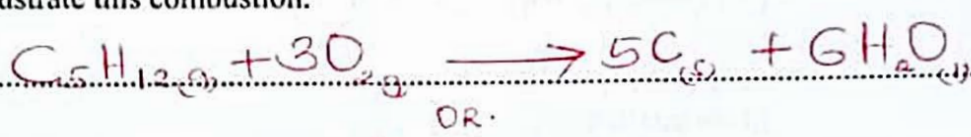
2-methylbutane



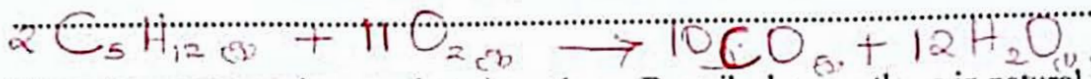
2,2-dimethylpropane

(d) Incomplete combustion of pentane may result in air pollution. Write an equation to illustrate this combustion. (1 mark)

Either 1
Equation



OR



(e) The main component in natural gas is methane. Describe how methane in natural gas is formed. (2 marks)

Decomposition / breakdown / decay of organic matter
in the absence of oxygen

(f) In the laboratory, methane can be prepared from salts of alkanoic acids. Describe how methane is prepared from sodium ethanoate. (2 marks)

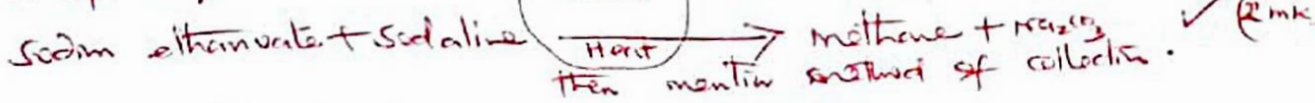
Condition of heat must

Heat a mixture of sodium ethanoate & sodalime
Collect the gas over water / use syringe / upward delivery / downward displacement of air.

Accept correct diagram.

Mixture of Sodalime & Ethanoate
Arrow for heat
method of collection

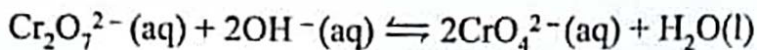
Accept eqn.



2. (a) (i) State what is meant by the term 'dynamic equilibrium'.

State where the rate of forward and backward reaction are the same, but in opposite direction.

(ii) Dichromate(VI) ions are orange in colour while chromate(VI) ions are yellow. Consider the following equilibrium.

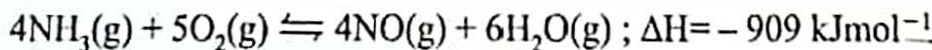


State and explain the observation that will be made if sulphuric(VI) acid is added to the mixture. (2 marks)

Accept
Conc of OH⁻ removed
reverse.

Intensity of orange colour increases.
Addition of H⁺ removes OH⁻ hence
backward rxn is favoured. // equilibrium
shifts to the left.

(b) One of the reactions in the manufacture of nitric(V) acid involves catalytic oxidation of ammonia as shown in the equation.



The reaction is carried out at a pressure of 10 atmospheres and a temperature of 900°C

(i) Other than nitric(V) acid, name another product that is formed. (1 mark)

Nitrous acid / HNO₂ ✓
Nitric (III) Acid

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(ii) State and explain the effect on the position of equilibrium if the reaction is carried out:

I. at 10 atmospheres pressure and 450°C; (2 marks)

Equilibrium shifts to the left, forward reaction is favoured since it is exothermic.

II. at 900 °C and 20 atmospheres pressure; (2 marks)

Equilibrium shifts to the left. Backward reaction is favoured / favours the direction with fewer molecules / due to decrease in number of moles / molecules.

III. in the absence of a catalyst. (1 mark)

No effect.

(c) State and explain the effect on the rate of the reaction if the reaction is carried out at 10 atmospheres and 450°C. (2 marks)

Rate of reaction ^{Reduces} ~~decreases~~ ^{slows} ~~decreases~~ ¹, decrease in temperature leads to decrease in kinetic energy of the molecules hence less effective collisions.

- (d) A factory uses 100 kg of ammonia each day to produce 160 kg of nitrogen(II) oxide. Calculate the percentage yield of nitrogen(II) oxide. (3 marks)

Molar mass NH_3 (17) $\checkmark \frac{1}{2}$
 Molar mass NO (30) $\checkmark \frac{1}{2}$

Moles of $\text{NH}_3 = \frac{100,000}{17} = 5882.35$ $\checkmark \frac{1}{2}$

Moles of $\text{NO} =$ mole ratio 1:1 $\checkmark \frac{1}{2}$

Mass of $\text{NO} = 5882.35 \times 30 = 176470.58$ $\checkmark \frac{1}{2}$

% yield of $\text{NO} = \frac{160,000}{176470} \times 100 = \frac{(160 \times 17)}{(30 \times 100)} \times 100$ $\checkmark \frac{1}{2}$
 $= 90.667\%$ $\checkmark \frac{1}{2}$
 $= 90.67\%$ $\checkmark \frac{1}{2}$

3. (a) One of the ores of iron is haematite, Fe_2O_3 . Give the name and formula of two other ores of iron. (2 marks)

Name	Formula
(i) siderite $\checkmark \frac{1}{2}$	FeCO_3 $\checkmark \frac{1}{2}$
(ii) Magnetite $\checkmark \frac{1}{2}$	Fe_3O_4 $\checkmark \frac{1}{2}$
Iron pyrite $\checkmark \frac{1}{2}$	FeS_2 $\checkmark \frac{1}{2}$

- (b) In a certain factory, iron is extracted from the haematite ore using the blast furnace as shown in Figure 1. The other raw materials are coke, limestone and air. The melting and boiling points of iron are 1535°C and 3000°C , respectively.

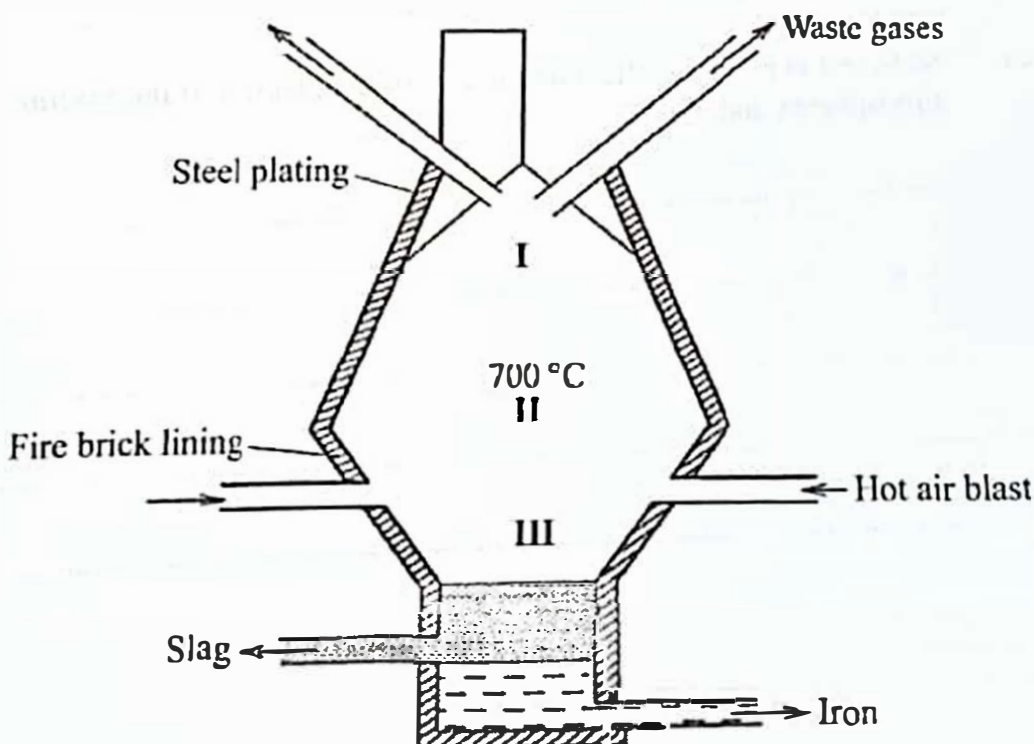
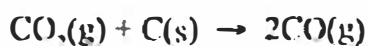


Figure 1

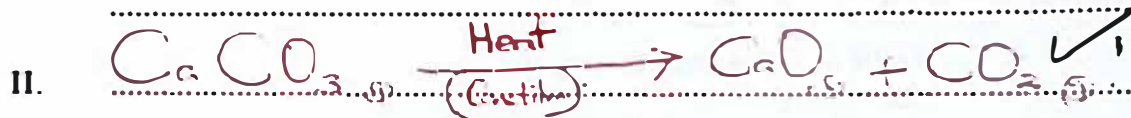
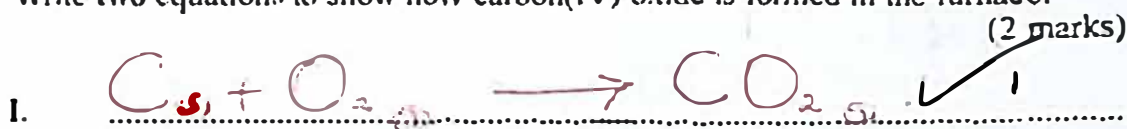
- (i) State how the temperature in region I compares with that in region II. Give a reason. (1 mark)

Temp. in region I is lower than that in II ✓^{1/2}
 Raw mtrls are not pre-heated ✓^{1/2} //
 Region II is nearer to hot air blast that pre-heats //
 Hot air rises in the furnace it becomes cooler //
~~Decreases~~ of gases

- (ii) The main reducing agent in the furnace is carbon(II) oxide formed by the reaction:



Write two equations to show how carbon(IV) oxide is formed in the furnace. (2 marks)



- (iii) Suggest a value for the temperature in region III. Give a reason. (2 marks)

Any Value

1535°C — 3000°C ✓¹

Helps maintain Iron in Molten state ✓¹

- (iv) Name the main component in the slag. (1 mark)

Calcium silicate // CaSiO_3

- (v) State one role that slag plays in the blast furnace. (1 mark)

Prevents oxidation of Iron by hot air ✓¹

(vi) The iron produced in the blast furnace is brittle due to presence of impurities.

I. Name the main impurity in this iron.

Carbon. ✓ (1 mark)

II. State one use of this iron.

✓ Making machine covers | Electric poles | Man of pipes
 Making scissors | Fire grills | Man of building
 Bunsen burner bases | Manufacture of iron beams | electric
 making silica gate | Manufacture of steel | furnace arch
 making iron pipes

(vii) Recycling is one method used to reduce production costs. State and explain the by products that can be recycled in this factory. (2 marks)

✓
 WASTE gases - used to preheat the air blasts.
 CO₂(g) ✓
 CO₂ is coming CO ✓
 - used to preheat the air blasts
 CO(g) ✓
 used as a reducing agent
 - used to preheat air blasts.

4. Table 1 shows the elements in period 3 of the periodic table. Study it and answer the questions that follow.

Table 1

Element	Na	Mg	Al	Si	P	S	Cl	Ar
---------	----	----	----	----	---	---	----	----

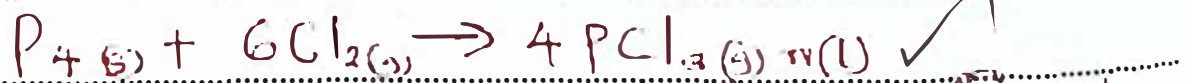
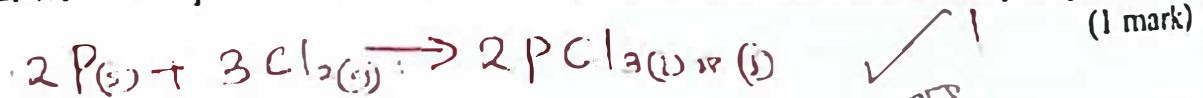
(a) Write the formulae of two oxides, for each of the following:

(i) sodium: Oxide I Na₂O Oxide II Na₂O₂ (1 mark)

(ii) chlorine Oxide I Cl₂O Oxide II Cl₂O₇ (1 mark)

ClO, ClO₂, Cl₂O₃, Cl₂O₅, Cl₂O₆, Cl₂O₇

(b) The products of the reaction between phosphorus and chlorine depend on the conditions used. Write the equation for the reaction when chlorine reacts with excess phosphorus. (1 mark)



- (c) Identify the element with the highest electrical conductivity. Give a reason. (2 marks)

Al (aged Al³⁺). Highest number of delocalised electrons / highest number of valence electrons per atom.
It has 3 delocalised electrons per atom.

- (d) Describe an experiment that can be used to illustrate the variations in reaction of sodium, magnesium and aluminium with water. (3 marks)

Sodium reacts vigorously with water / hissing sound produced
Magnesium reacts slowly with water / produces few bubbles on the surface.
Aluminium does not react with water / produces no bubbles.

- (e) State and explain the differences in the melting points of:

- (i) chlorine and argon. (2 marks)

Melting point chlorine greater / higher than that of argon.
Cl₂ is diatomic while Ar is monoatomic.
hence Cl₂(g) has stronger van der Waals forces of attraction molecules of Cl₂(g) are larger / bigger than Ar(g) molecules. Hence intermolecular forces in Cl₂ are stronger than Ar.

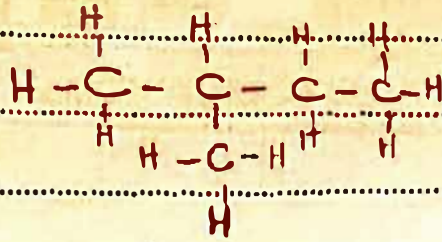
- (ii) magnesium oxide and silicon(IV) oxide. (2 marks)

Magnesium has a higher melting than oxide silicon(IV) oxide.

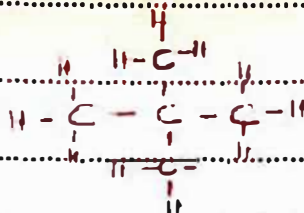
Description is not marking point

Isomer 2 Structure Name

Acc Condensed / open structure
Any 2



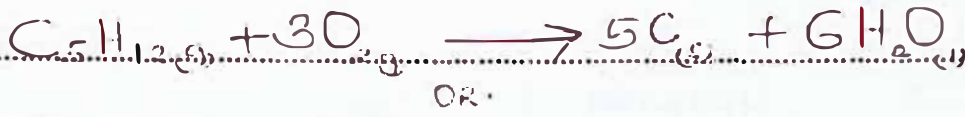
2-methylbutane



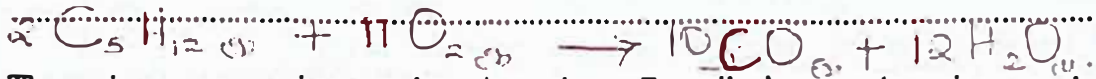
2,2-dimethylpropane

(d) Incomplete combustion of pentane may result in air pollution. Write an equation to illustrate this combustion. (1 mark)

Either 1
burn sites



OR



(e) The main component in natural gas is methane. Describe how methane in natural gas is formed. (2 marks)

Decomposition / breakdown / decay of organic matter
in the absence of oxygen

(f) In the laboratory, methane can be prepared from salts of alkanoic acids. Describe how methane is prepared from sodium ethanoate. (2 marks)

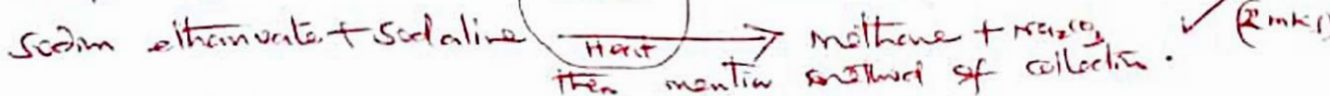
Caution of heat must

Heat a mixture of sodium ethanoate & sodalime
Collect the gas over water / use syringe / upward delivery / downward displacement of air.

Accept correct diagram.

Mixture of Sodalime & Ethanoate
Arrow for heat
method of collection

Accept eqn



5. Table 2 gives standard reduction potentials for some half cells.

Table 2

Half cell	Half cell equation	E^\ominus / V
I	$\text{Fe}^{3+}(\text{aq}) + \text{e} \rightarrow \text{Fe}^{2+}(\text{aq})$	+ 0.77
II	$\text{K}^+(\text{aq}) + \text{e} \rightarrow \text{K}(\text{s})$	- 2.92
III	$\text{Ag}^+(\text{aq}) + \text{e} \rightarrow \text{Ag}(\text{s})$	+ 0.80
IV	$\text{Pb}^{2+}(\text{aq}) + 2\text{e} \rightarrow \text{Pb}(\text{s})$	- 0.13
V	$\text{I}_2(\text{aq}) + 2\text{e} \rightarrow 2\text{I}^-(\text{aq})$	+ 0.54

- (a) State the standard conditions of an electrochemical cell. (2 marks)

1M solution
 Atmospheric pressure.
 Temperature of 25°C or 298K

} 3 correct 2 marks
 } 2 correct 1 mark
 } 1 correct 1/2 mark

- (b) An electrochemical cell was constructed using half-cells III and IV.

- (i) Complete Figure 2 by labelling the parts of the cells indicated as $A_1 - A_4$. (2 marks)

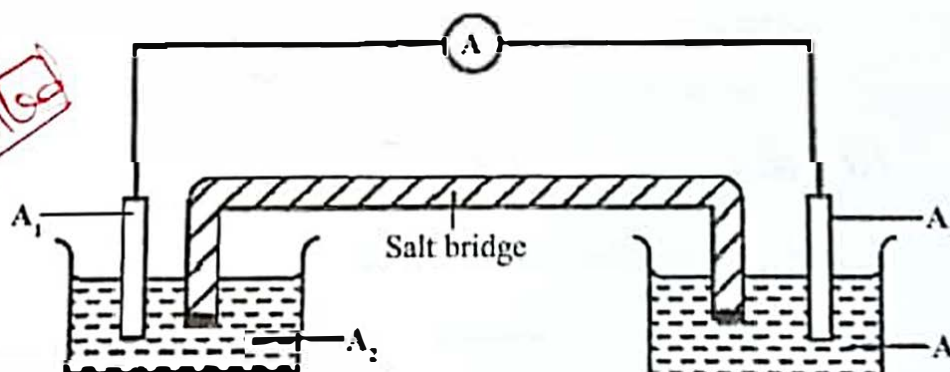


Figure 2

Soluble salt of Pb.

A₁ Pb // Lead electrode. ✓₂

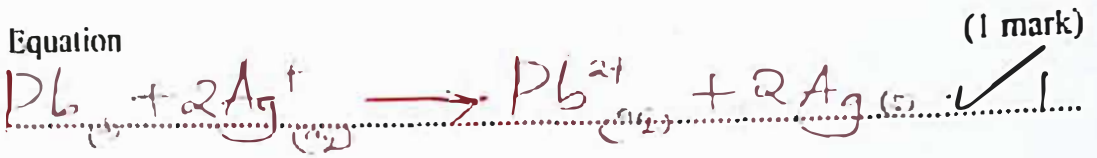
A₂ Pb²⁺ // lead (II) nitrate soln. // 1M Pb²⁺. ✓₂

A₃ Ag // silver electrode. ✓₂

A₄ Ag⁺ // silver nitrate // 1M Ag⁺. ✓₂

Soluble salt of Ag.

(ii) Write an equation for the cell reaction and calculate the e.m.f. of the cell.



e.m.f. (1 mark)

$$+0.8 - -0.13 \cdot \frac{1}{2}$$

$$+0.93V \quad \checkmark$$

(iii) The salt bridge helps in completing the circuit. Explain why a saturated solution of potassium chloride is not suitable for use in the salt bridge in this electrochemical cell.

Formation of insoluble PbCl₂ ✓ (1 mark)

That reduces concentration of ions in electrolyte OR formation of AgCl that reduces the effectiveness of cell.

(c) State why it is not possible to construct a similar electrochemical cell using half-cells II and III. (1 mark)

✗ reacts explosively with water. ✓
 because E.m.f. of cell is very high which can explode the cell.

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(d) State and explain the observations made when aqueous potassium iodide is added to aqueous iron(III) sulphate.

Yellow solution turns to green. Fe^{3+} ions are reduced to Fe^{2+} .
 Grey/black precipitate is formed. Iodide ions are oxidised to iodine. An equation



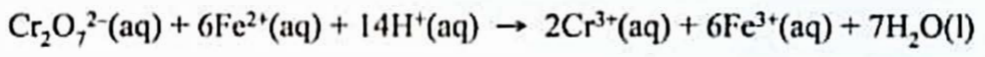
Must mention (c) Fe^{3+} is reduced to Fe^{2+} and I^- is oxidised to I_2 .

Acidified potassium dichromate(VI) and acidified potassium manganate(VII) may be used in determining concentration of Fe^{2+} ions in a sample. If acidified potassium dichromate(VI) is used, an indicator is added to determine the end point but for acidified potassium manganate(VII), no indicator is added.

(i) Explain why it is not necessary to use an indicator when acidified potassium manganate(VII) is used. (1 mark)

$KMnO_4$ acts as its own indicator changing from purple to colourless (decolourised).

(ii) An alloy containing iron was dissolved in an acid and the total volume made up to 250 cm³. 25.0 cm³ of this solution required 18.0 cm³ of 0.15 M acidified potassium dichromate(VI) to react completely. The equation for the reaction is:



Calculate the mass of iron in the alloy (Fe = 56.0). (3 marks)

Mols of $Cr_2O_7^{2-} = \frac{18 \times 0.15}{1000} \sqrt{\frac{1}{2}} = 0.0027$

Mols of Fe^{2+} in 25.0 cm³ = $6 \times 0.0027 = 0.0162$

Mols of Fe^{2+} in 250 cm³ = $0.0162 \times 10 \left(\frac{250}{25}\right) = 0.162$ (in 250 cm³)

Mass of iron = $0.162 \times 56 \sqrt{\frac{1}{2}} = 9.072$

M = $\frac{0.0162 \times 1000}{25} = 0.648 M$

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6. (a) Water containing hydrogen carbonate, HCO_3^- , and calcium Ca^{2+} ions, is said to be hard water.

(i) Describe one way in which HCO_3^- ions get into river water. (1 mark)

CO_2 dissolves in rain water to form Carbonic acid ✓
 Carbonic acid react with carbonate rock // CaCO_3 forming hydrogen carbonate of Ca & Mg that gets into rivers. ✓

(ii) Explain the disadvantage of using this type of water in boilers. (2 marks)

The CaHCO_3 & MgHCO_3 decomposes forming CaCO_3 / Scales / fur lining the boilers and causing poor thermal conductivity & reducing efficiency.

(b) Analysis of a river water sample showed the presence of the following ions: Ca^{2+} , Na^+ , Cl^- , NO_3^- .

(i) Name the type of water hardness present in the sample. (1 mark)

Permanent ✓

(ii) Describe one precipitation method that can be used to soften the water. (2 marks)

Addition of washing soda // Na_2CO_3 ✓
 Ca^{2+} and Mg^{2+} precipitates as carbonates which can be filtered off ✓

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(0.0162 x 250 x 25)

(iii) The water sample was passed through a resin as shown in Figure 3.

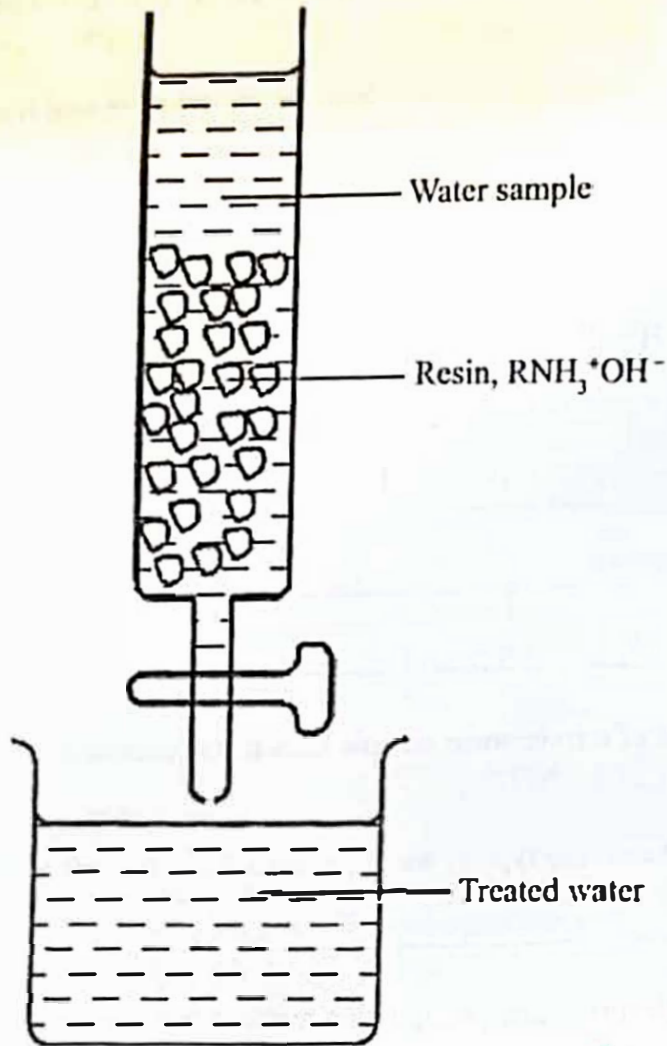
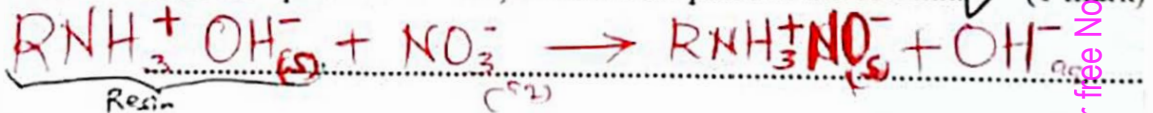
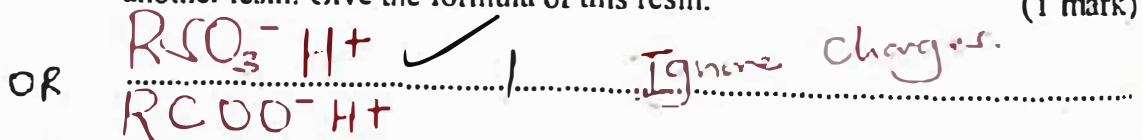


Figure 3

I. Write an equation for a reaction that took place in the column. (1 mark)



II. Complete treatment of the water sample required passing it through another resin. Give the formula of this resin. (1 mark)



III. Explain why a river water sample that has been treated using resins may still require boiling to make it safe for drinking. (2 marks)

Resin does not kill bacteria/pathogens

Boiling kills ✓

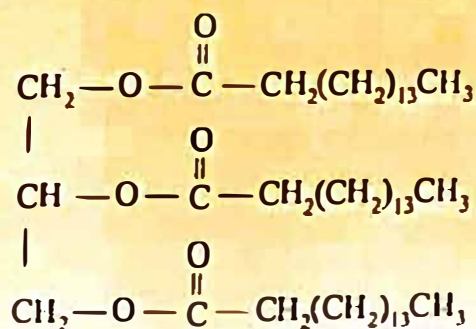
**Show charges and balance*

**Ignore states*

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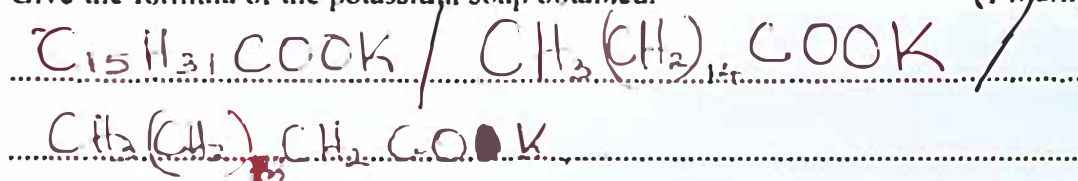
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(c) Compound C was used to prepare a potassium soap.



Compound C

(i) Give the formula of the potassium soap obtained. (1 mark)



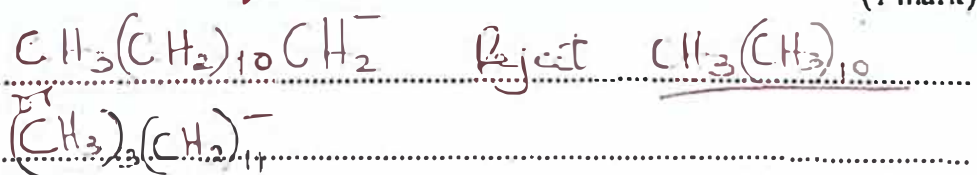
(ii) State one difference in the properties of potassium and sodium soaps. (1 mark)

Potassium soaps ^{than Na soaps} better more readily in water / Potassium soaps have lower / less melting points / potassium salt is more soluble in water.
 Potassium soaps are soft / mild while sodium soaps are hard

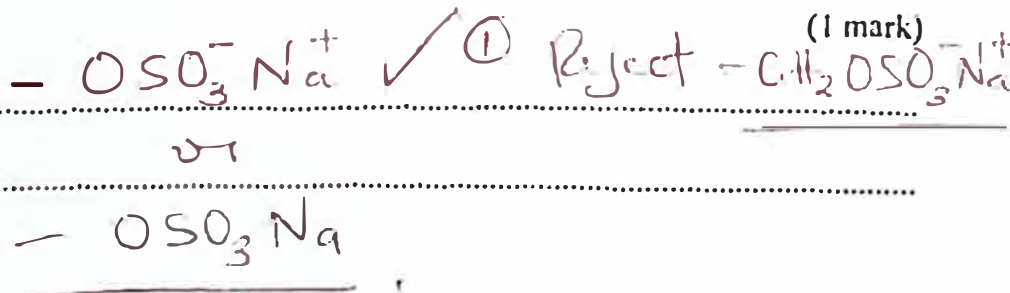
(d) A soapless detergent has the formula $\text{CH}_3(\text{CH}_2)_{10}\text{CH}_2\text{OSO}_3\text{Na}$

With reference to this formula, identify the hydrophobic and the hydrophilic parts of the detergent.

Hydrophobic



Hydrophilic



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