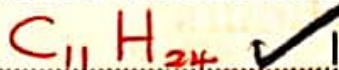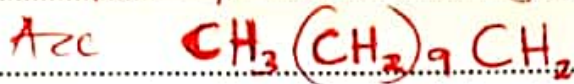1. Crude oil is a mixture of hydrocarbons which are separated by fractional distillation. One of the components obtained contains an alkane A, with eleven carbon atoms.

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

    $C_{11}H_{24}$ ✓ 1

    Accept open structural formula.

    Acc $CH_3(CH_2)_9CH_2$

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

    A → Pentane + B

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

    Cracking ✓ 1

    Acc Catalytic | Thermal Cracking

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

    High temperatures ✓½ / *Acc* 400-700°C // Heat

    High Pressure ✓½ *Acc* 70 atmospheres. // ~~high~~ pressure. *also*

    Catalyst ✓ *Acc* zeolite ✓ catalyst // Silica catalyst // Alumina catalyst

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

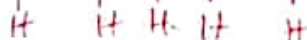   Hexene ✓ 1 *Acc* C_6H_{12}

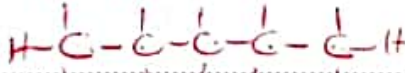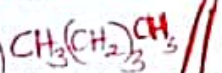   *Acc Hex-1-ene // Hex-2-ene // Hex-3-ene.*

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

Isomer 1	Structure	Name
$CH_3CH_2CH_2CH_2CH_3$ // $CH_3(CH_2)_3CH_3$	✓	Pentane ✓

    rej C_5H_{12} *molecular formula*

    * Name correct, wrong structure = 0·

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Isomer 2 Structure		Name

ACC condensed || open structure

Any 2

Structure:

$$H-C-C-C-C-H$$
with $H-C-H$ branch

2-methylbutane. ✓1

Structure:
with $H-C-H$ and $H-C-H$ branches

2,2-dimethylpropane ✓1

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

Either Isomer's Either

$$C_5H_{12(g)} + 3O_{2(g)} \longrightarrow 5C_{(s)} + 6H_2O_{(l)} \; ✓1$$

OR.

$$2C_5H_{12(g)} + 11O_{2(g)} \longrightarrow 10CO_{(g)} + 12H_2O_{(l)}$$

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 ✓1
in the Absence of Oxygen ✓1

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

Heat ✓½ a mixture of Sodium ethanoate & sodalime ✓1
Collect the gas over water ✓½ | use syringe || upward
delivery || downward displacement of air.

Condition of heat Must

Accept Correct diagram.

Mixture of Sodalime & Ethanoate ✓1
Arrow for heat ·½
method of collection ·½

Accept eqn.

Sodium ethanoate + Sodalime $\xrightarrow[\text{Heat}]{CaO}$ methane + Na_2CO_3 ✓ (2mks)
then mention method of collection. *Conditions*

2. **(a)** **(i)** State what is meant by the term 'dynamic equilibrium'. (1 mark)

State rxn. 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.
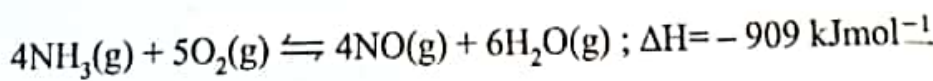
$$Cr_2O_7^{2-}(aq) + 2OH^-(aq) \rightleftharpoons 2CrO_4^{2-}(aq) + H_2O(l)$$

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

Intensity of Orange colour increases. Addition of H+ removes OH- hence backward rxn is favoured. // equilibrium Shifts to the left.

Accpt Cincamb of OH / *reverse.*

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

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g) \ ; \ \Delta H = -909 \ kJmol^{-1}$$

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 / HNO_2

Nitric (III) Acid

(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 right, 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 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 decreases, decrease in temperature leads reduction 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)

[Handwritten working:]

Molar mass NH_3 (17) ✓½

Molar mass NO (30) ✓½

Moles of $NH_3 = \frac{100,000}{17} = 5882.35$ ✓½

Moles of $NO =$ mole ratio $1:1$

Mass of $NO = 5882.35 \times 30 = 176470.58$ ✓½

% yield of $NO = \frac{160,000}{176470} \times 100 =$ ✓½

$\frac{160 \times 17}{30 \times 100} \times 100$

$= 90.667\%$ ✓½ $= 90.67\%$ All methods

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 ✓½	$FeCO_3$ ✓½
(ii)	Magnetite ✓½	Fe_3O_4 ✓½
	Iron pyrite ✓½	FeS_2 ✓½

(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.
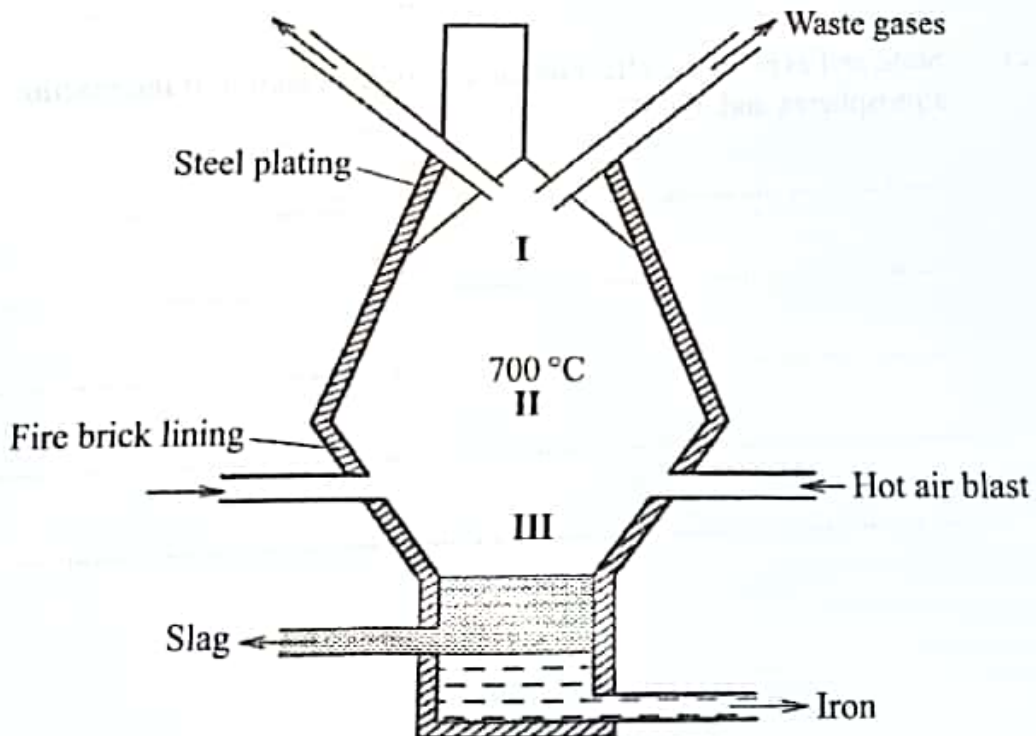

Figure 1

(i) State how the temperature in region I compares with that in region II. Give a reason. (1 mark)
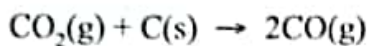
Temp. in region I is lower than that in II ✓½

Raw mtrl's are not pre-heated. ✓½ //

Region II is nearer to hot air blast that pre-heats //
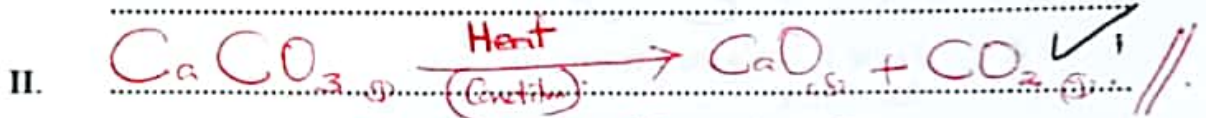
Hot air rises in the furnace it becomes cooler //

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

$$CO_2(g) + C(s) \rightarrow 2CO(g)$$

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

I. $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$ ✓1

II. $CaCO_{3(s)} \xrightarrow[\text{(Constikm)}]{Heat} CaO_{(s)} + CO_{2(g)}$ ✓1 //

$Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(l)} + 3CO_{2(g)}$

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

Any Value $1535°C \text{ --- } 3000°C$ ✓1

Helps mantain Iron in Molten state ✓1

(iv) Name the main component in the slag. ✓1 (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.

(1 mark)

   ....Carbon.....................✓..............................

   II. State one use of this iron.

(1 mark)

   ✓ 1 Making manhole covers | Electric poles | Main of pipes
      Making scissors | Fire grills | Many building blocks
      Bunsen burner bases | Manufacture of iron beams | electric
      Making sluice gate | | femse arch
      Making iron pipes | Manufacture of steel

(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.............

   $CO_2(g)$ ✓ ① CO_2 is converted CO / Oxides and slag used

   $CO(g)$ ✓ ① used to preheat the air blasts

   ① 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 .....Na_2O..... Oxide II .....Na_2O_2..... (1 mark)

   (ii) chlorine Oxide I .....Cl_2O..... Oxide II .....Cl_2O_7..... (1 mark)

   $Cl O, ClO_2, Cl_2O_2, Cl_2O_5, Cl_2O_6, Cl_2O_3 ClO_3,$

(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)

   $2P(s) + 3Cl_2(g) \rightarrow 2PCl_3(l) \text{ or } (l)$ ✓

   $P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g) \text{ or } (l)$ ✓

   $P_{10}(s) + 15Cl_2(g) \rightarrow 10PCl_3(g) \text{ or } (l)$ ✓

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

Al (Aₛ Al³⁺). Highest number of delocalised electrons./ highest number of valence electrons/
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₍g₎ is diatomic while Ar₍g₎ is monoatomic hence Cl₂₍g₎ has stronger vander waals forces of attraction/molecules of Cl₂₍g₎ are larger/bigger than Ar₍g₎ molecules, hence intermolecular forces in Cl₂ are stronger than Ar
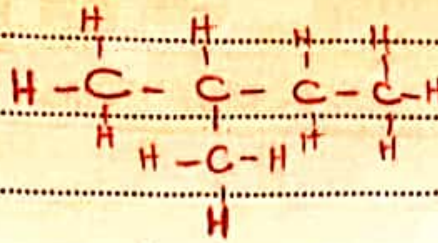
(ii) magnesium oxide and silicon(IV) oxide. (2 marks)

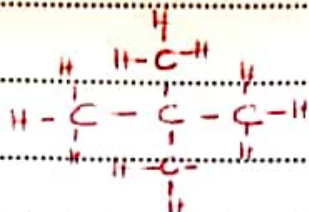Magnesium has a higher melting than oxide silicon(IV) oxide

Isomer 2	Structure	Name

Acc condensed || open structure

$$H-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H-C-H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-\overset{\overset{\displaystyle H}{|}}{\underset{\underset{\displaystyle H}{|}}{C}}-H$$
2-methylbutane. ✓

Any 2.

$$H-\overset{H}{\underset{H}{C}}-\overset{\overset{H-C-H}{|}}{\underset{\underset{H-C-}{|}}{C}}-\overset{H}{\underset{H}{C}}-H$$ ✓
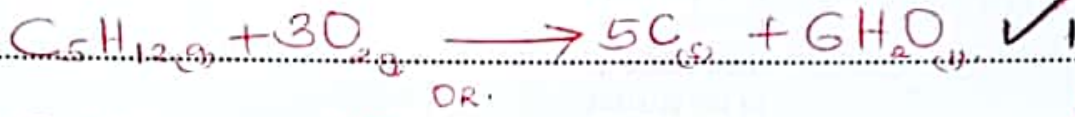2,2-dimethylpropane ✓

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

Either | Immer chlar

$$C_5H_{12(g)} + 3O_{2(g)} \longrightarrow 5C_{(s)} + 6H_2O_{(l)} ✓$$

OR.   **OR**

$$2C_5H_{12(g)} + 11O_{2(g)} \longrightarrow 10CO_{(g)} + 12H_2O_{(l)}.$$

(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 ✓

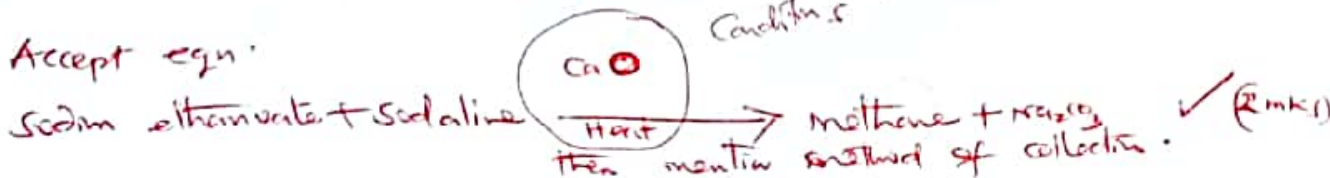(f) In the laboratory, methane can be prepared from salts of alkanoic acids. Describe how methane is prepared from sodium ethanoate. — Isa.   *Is in stim.* **(2 marks)**

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 ·½
method of collection ·½

Condition s

Accept eqn:
Sodium ethanoate + Sodalime $\xrightarrow[\text{Heat then mention method of collection}]{CaO}$ methane + ... ✓ (2mks)

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

    Table 2

Half cell	Half cell equation	E^θ / V
I	$Fe^{3+}(aq) + e \rightarrow Fe^{2+}(aq)$	+ 0.77
II	$K^+(aq) + e \rightarrow K(s)$	– 2.92
III	$Ag^+(aq) + e \rightarrow Ag(s)$	+ 0.80
IV	$Pb^{2+}(aq) + 2e \rightarrow Pb(s)$	– 0.13
V	$I_2(aq) + 2e \rightarrow 2I^-(aq)$	+ 0.54

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

IM solution
1 atmospheric pressure.
Temperature of 25°C or 298K

3 Correct 2mks
2 Correct 1mk
1 Correct ½mk

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

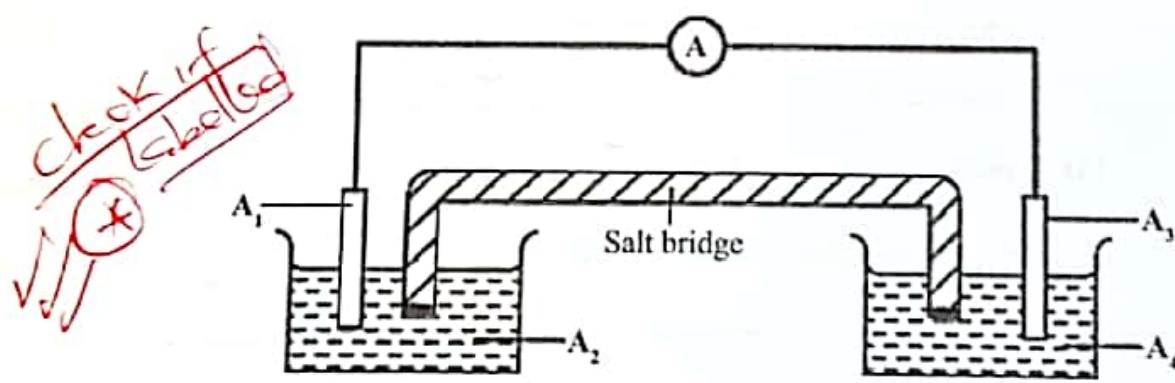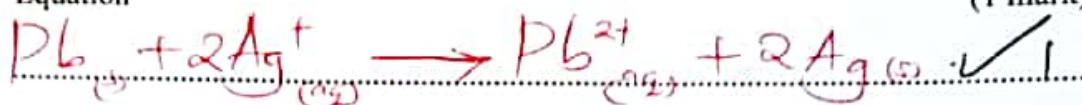(i) Complete **Figure 2** by labelling the parts of the cells indicated as $A_1 - A_4$ (2 marks)

check if labelled

Figure 2

A₁ ....Pb // Lead electrode. ✓½

soluble salt A₂ ....Pb²⁺ // Lead (II) Nitrate soln. // 1·M Pb²⁺ ✓½
of Pb.

A₃ ....Ag // Silver electrode. ✓½

Soluble salt A₄ ....Ag⁺ // Silver Nitrate // 1M Ag⁺. ✓½
of Ag.

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

Equation   (1 mark)

$$Pb_{(s)} + 2Ag^+_{(aq)} \longrightarrow Pb^{2+}_{(aq)} + 2Ag_{(s)}$$ ✓1

e.m.f.   (1 mark)

+0.8 - ⁻0.13 · ✓½

+0.93V ✓½

(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.

(1 mark)

Formation of insoluble PbCl₂ ✓
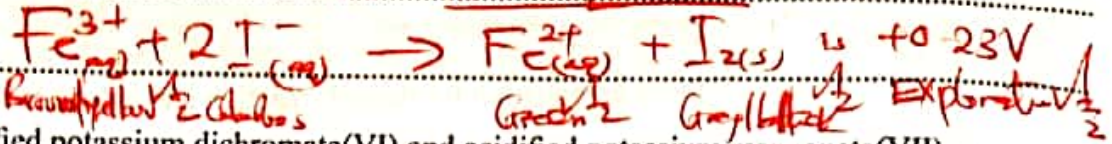That reduces concentration of ions in electrolyte.
OR Formation of AgCl that reduces the effectiveness of cell.

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

(1 mark)

K reacts explosively with water. ✓1
acc E.m.f of cell is very high which can explode the cell.

(d) State and explain the observations made when aqueous potassium iodide is added to aqueous iron(III) sulphate. (2 marks)

(yellow)

Brown 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

$$Fe^{3+}_{(aq)} + 2I^-_{(aq)} \rightarrow Fe^{2+}_{(aq)} + I_{2(s)} \quad 4 \quad +0.23V$$

Must mention colour *Brown/yellow* *2 colours* *Green 2* *Grey/black 2* *Explanation $\frac{1}{2}$*
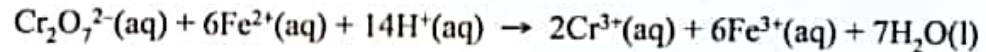
(e) Acidified potassium dichromate(VI) and acidified potassium manganate(VII) may be used in determining concentration of Fe^{2+} ions in a sample. If acidified potassium dichromate(VI) is used, an indicator is added to determine the end point but for acidified potassium manganate(VII), no indicator is added.

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

$H^+/KMnO_4$, acts as its own indicator changing from purple to colourless (decolonised)

(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:

$$Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

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

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

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

Moles of Fe in 250 cm³ = $0.0162 \times \left(\frac{250}{25}\right) = 0.162$ *(in 250 cm³)*

Mass of Iron = 0.162×56

= 9.072 g

Condensed working

$$\frac{18 \times 0.15 \times 6 \times 250 \times 56}{1000 \times 25}$$

$$= 9.072g$$

All marks awarded

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

910107

$$= 0.648M$$

0.648M

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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) ½

CO_2 dissolves in rain water to form Carbonic acid ✓

Carbonic acid react with carbonate rock/ Ca & Mg forming Hydrogen Carbonates of Ca & mg that gets into rivers ✓ ½

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

The $CaHCO_3$ & $MgCO_3$ 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 ✓ 1

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

Addition of Washing Soda/ Na_2CO_3 ✓ 1

Ca^{2+} and Mg^{2+} precipitates as Carbonates

which can be filtered off ✓ 1

$(0.0162 \times 250 \times 25)$

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

Water sample

Resin, $RNH_3{}^+OH^-$

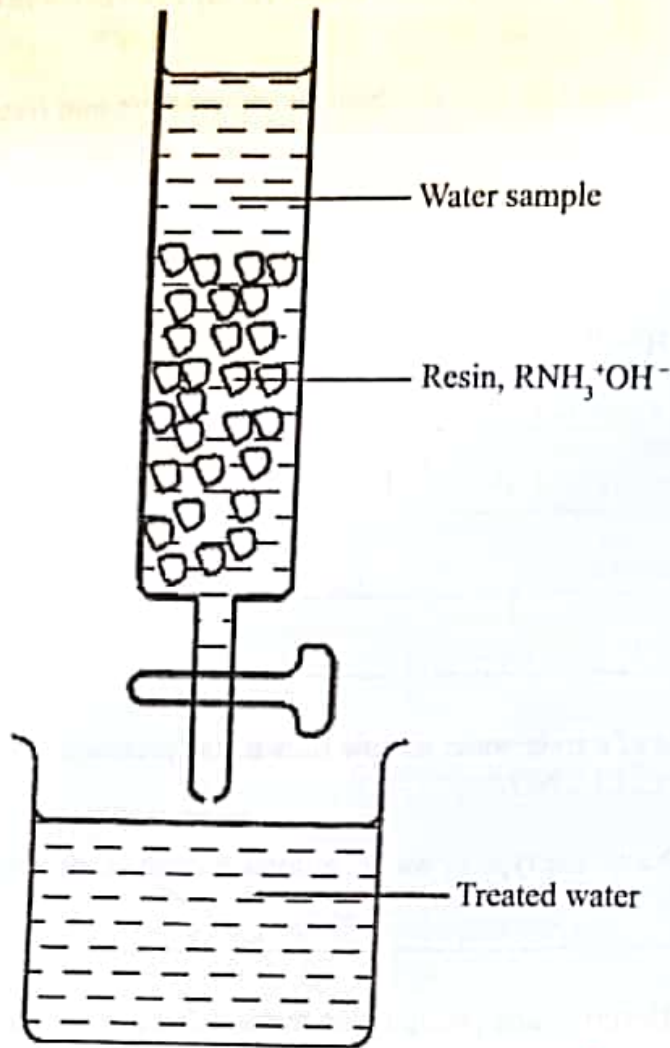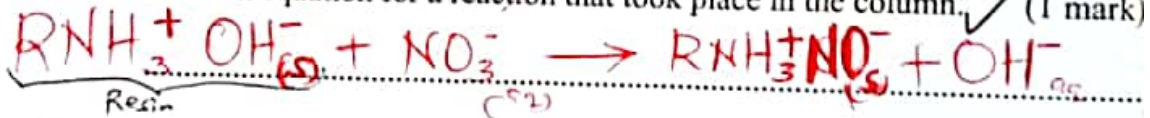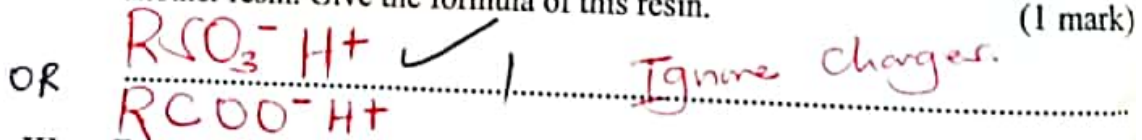Treated water

Figure 3

OR Cl^-

Cl^- if it was used

*how charges balance and state
*Ignore states

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

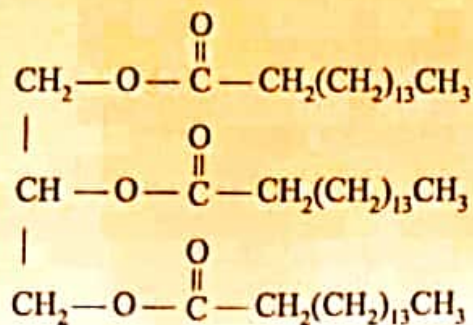$RNH_3^+ OH^-_{(s)} + NO_3^- \longrightarrow RNH_3^+NO_3^-_{(s)} + OH^-_{aq}$

Resin   (S2)

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

$RSO_3^- H^+$ Ignore Charges.

OR

$RCOO^- H^+$

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)

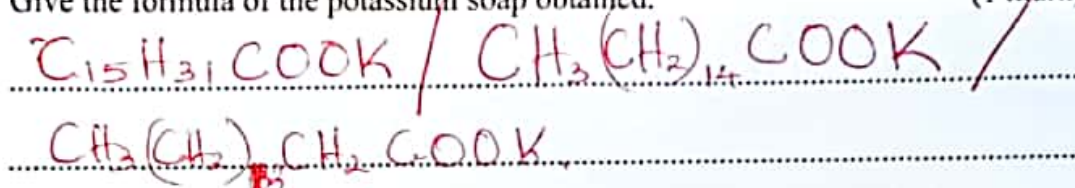Resin does not kill bacteria/pathogens/ger

Boiling kills

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

$$CH_2-O-\overset{\overset{\textstyle O}{\|}}{C}-CH_2(CH_2)_{13}CH_3$$

$$CH-O-\overset{\overset{\textstyle O}{\|}}{C}-CH_2(CH_2)_{13}CH_3$$

$$CH_2-O-\overset{\overset{\textstyle O}{\|}}{C}-CH_2(CH_2)_{13}CH_3$$

Compound **C**

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

C15H31 COOK / CH3(CH2)14 COOK /

CH3(CH2)13 CH2 COOK

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

Potassium soaps lather more readily in water than Na soap / Potassium soaps have lower/less melting points / potassium salt are more soluble in water; Potassium soaps are soft/mild whilst sodium soaps are hard
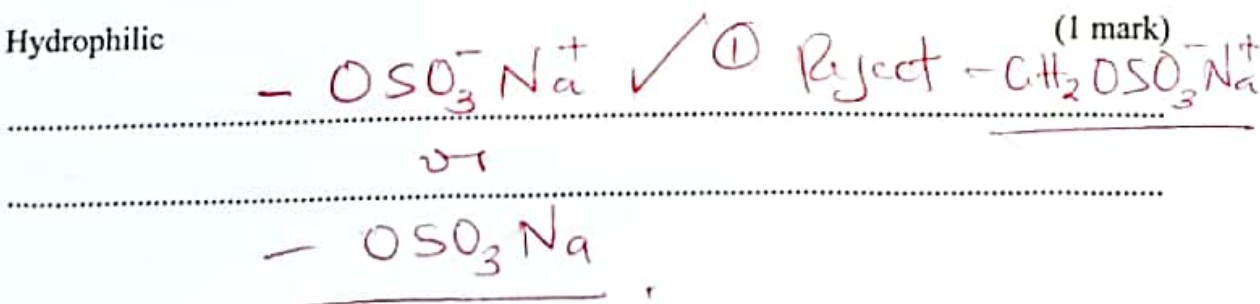
(d)   A soapless detergent has the formula
$CH_3(CH_2)_{10}CH_2OSO_3Na$

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

Hydrophobic   (1 mark)

$CH_3(CH_2)_{10}CH_2^-$ Reject $CH_3(CH_2)_{10}$

or

$(CH_3)_3(CH_2)_{11}^-$

Hydrophilic   (1 mark)

$-OSO_3^-Na^+$ ✓ Reject $-CH_2OSO_3^-Na^+$

or

$-OSO_3Na$

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