UACE 2018 MARKING GUIDE

P525/2 CHEMISTRY PAPER 2

1 (a) % oxygen $= 100 - (64.9 + 13.5) = 21.6\%$ ✓

Element	C	H	O
composition %	64.9	13.5	21.6
Moles	$\frac{64.9}{12} = 5.408$	$\frac{13.5}{1} = 13.5$	$\frac{21.6}{16} = 1.35$ ✓
mole ratio	$\frac{5.408}{1.35}$	$\frac{13.5}{1.35}$	$\frac{1.35}{1.35}$ ✓
	4	10	1 ✓

3

Empirical formula $C_4H_{10}O$ ✓

(b) $PV = nRT$ ✓

$101325 \times 969.8 \times 10^{-6} = \frac{1.85}{RMM} \times 8.31 \times 473$

$RMM = \frac{1.85 \times 8.31 \times 473}{101325 \times 969.8 \times 10^{-6}}$ ✓

$= 74$ ✓

$(C_4H_{10}O)_n = 74$

$4 \times 12n + 10 \times n + 16n = 74$

$74n = 74$

$n = 1$ ✓

3

Molecular formula $C_4H_{10}O$ ✓

Alt. using $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ ✓ or $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$V_2 = \frac{969.8 \times 273}{473} = 559.74\ cm^3$ ✓ weighing 1.85g

22400 cm³ of Q weigh $\frac{1.85 \times 22400}{559.74} = 74g = M_r$

(b) $CH_3CH_2CH_2CH_2OH$ butan-1-ol or 1-butanol

$CH_3CH(OH)CH_2CH_3$ butan-2-ol or 2-butanol

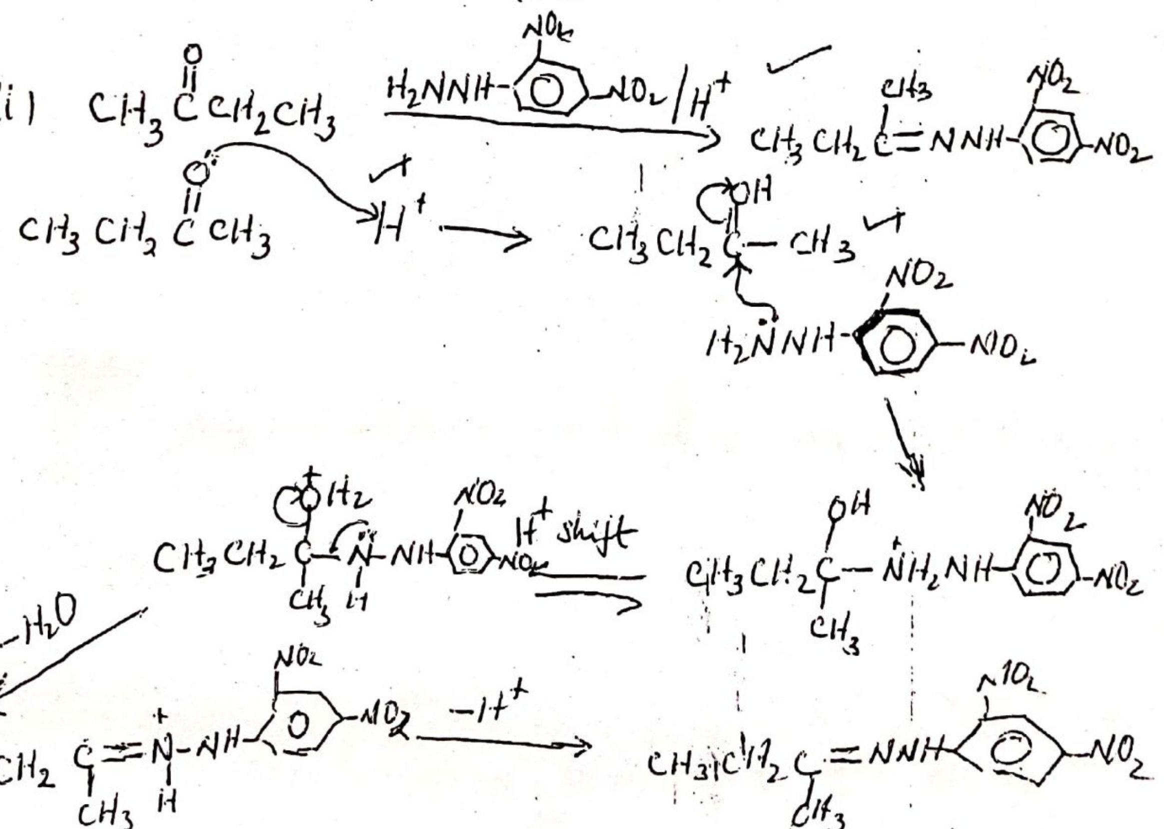
$CH_3CH(CH_3)CH_2OH$ 2-Methylpropan-1-ol (4)

$CH_3C(CH_3)_2OH$ 2-methylpropan-2-ol

(c) Butan-2-ol or $CH_3CH(OH)CH_2CH_3$

(d) (i) $CH_3CH(OH)CH_2CH_3 \xrightarrow[\text{heat}]{CrO_3/H^+} CH_3COCH_2CH_3$

(ii)



1(e) $CH_3CH=CHCH_3 \xrightarrow[\text{(ii) water, heat}]{\text{(i) conc } H_2SO_4} CH_3\underset{OH}{C}HCH_2CH_3$

<u>Mech</u>

$CH_3\overset{H}{C}=CHCH_3 \xrightarrow{H^+} CH_3\overset{+}{C}HCH_2CH_3$ 3½

OH_2

$\longrightarrow CH_3\underset{+OH_2}{C}HCH_2CH_3$

$\xrightarrow{-H^+} CH_3\underset{OH}{C}HCH_2CH_3$

<u>Alt (i)</u> $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$

$CH_3CH=CHCH_3 \xrightarrow{H^+} CH_3CH_2\overset{+}{C}HCH_3$ 2½

$^-OSO_3H$

$\longrightarrow CH_3CH_2\underset{OSO_3H}{C}HCH_3$

$:OH_2$

$\xrightarrow{-^-OSO_3H} CH_3CH_2\underset{+OH_2}{C}HCH_3$

$\xrightarrow{-H^+} CH_3CH_2\underset{OH}{C}HCH_3$

<u>Alt (ii)</u>

$(X = Cl, Br, I)$

$CH_3CH=CHCH_3 \xrightarrow{HX} CH_3CH_2\underset{X}{C}HCH_3 \xrightarrow[\text{heat}]{^-OH(aq)} CH_3CH_2\underset{OH}{C}HCH_3$

<u>Mech.</u>

$CH_3CH=CHCH_3 \xrightarrow{H-X} CH_3CH_2\overset{+}{C}HCH_3$

X^-

$\longrightarrow CH_3CH_2\underset{X}{C}HCH_3$

^-OH

$\xrightarrow{-X^-} CH_3CH_2\underset{OH}{C}HCH_3$

2. (a) When a mixture of two immiscible liquids (or mixture of a liquid immiscible with water) is agitated (heated) each component exerts its own vapour pressure independently.
The vapour pressure of the mixture is the sum of the vapour pressures of the two components.
As heating continues the vapour pressure of the mixture
The mixture boils when the total vapour pressure equals the atmospheric pressure at a temperature lower than the boiling points of the two components in the mixture.

(b) – Substance to be steam distilled is immiscible with water

– Substance exerts a high vapour pressure near the boiling point of water or compound/substance is volatile

(Any 3)

– Substance/compound has a high relative molecular mass.

– Avoids the decomposition of compounds that decompose/break down at their boiling points

– Distillation takes place at a lower temperature than during fractional distillation.

(c) (i)

Temperature (°C)	90	92	94	96	98	100
Vapour pressure of mixture (mm Hg)	622	673	725	781	839	901

See graph.

2(c) (iii) From graph

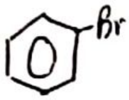
Boiling point of mixture $= 95^{\circ}C \pm 0.5^{\circ}C$

Vapour pressure of

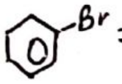
water $= 640\ mmHg$

Bromo benzene $= 120\ mmHg$

RMM of $H_2O = (2\times1) + 16 = 18$

RMM of  $= (6\times12) + 5 + 80 = 157$

$$\frac{\%\ \text{Bromobenzene}}{\%\ \text{water}} = \frac{VP\ \text{bromobenzene} \times RMM\ \text{of bromo benzene}}{V.P\ \text{water} \times RMM\ \text{of water}}$$

Let %  $= x\%$ % $H_2O = (100 - x)\%$ 3½

$$\frac{x}{100 - x} = \frac{157 \times 120}{640 \times 18}$$

$$x = 62.02 \approx 62\%$$

(e) – To separate organic compounds from mixtures

– To purify organic compounds

– To determine the relative molecular mass of compounds

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(To be fastened together with other answers to paper)

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Signature ....

Subject Name .... Paper code ..../........

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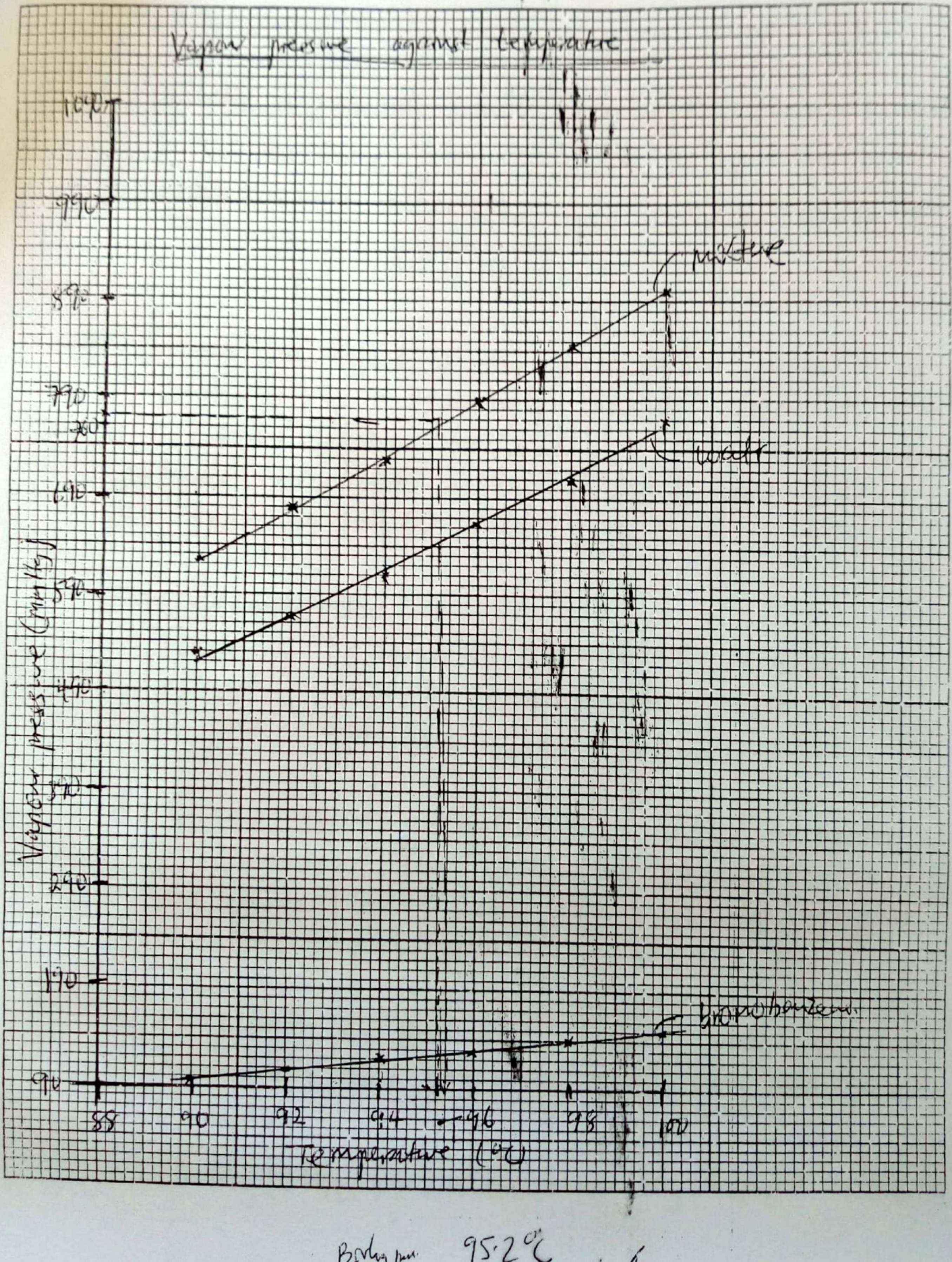

Boiling point 95.2°C

6

3 (a) (i) Solubility product is the product of the molar concentration of the ions of a sparingly soluble electrolyte raised to appropriate powers in a saturated solution at a given temperature

OR: Consider a sparingly soluble electrolyte, barium sulphate

$$BaSO_{4(s)} + aq \rightleftharpoons Ba^{2+}_{(aq)} + SO_4^{2-}_{(aq)}$$

(3mks) at constant temperature in a saturated solution

$$K_{sp} = [Ba^{2+}][SO_4^{2-}]$$

(ii) Common ion effect is the precipitation (reduction in solubility) of a sparingly soluble electrolyte from its saturated solution by adding a solution of a more soluble electrolyte containing one of the ions of the sparingly soluble salt.

or an example used

When a solution of silver nitrate is added to a saturated solution of silver chloride, silver chloride is precipitated. (any appropriate example)

(b) Excess magnesium hydroxide is added to water in a container. The mixture is shaken (stirred) and left to stand (settle) at a constant temperature to attain equilibrium.

The mixture is filtered and a known volume of the filtrate pipetted and titrated with standard hydrochloric acid (any suitable acid) using phenolphthalein indicator

$$Mg(OH)_{2(aq)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + 2H_2O_{(l)}$$

The molar concentration of magnesium hydroxide solution is calculated. ✓

Taking the concentration of magnesium hydroxide as x moles per litre

$$\underset{x}{Mg(OH)_2}(s) \rightleftharpoons \underset{x}{Mg^{2+}}(aq) + \underset{2x}{2OH^-}(aq) ✓$$

$$K_{sp} = [Mg^{2+}][\bar{O}H]^2 ✓$$

$$= x(2x)^2 ✓$$

$$= 4x^3 mol^3 dm^{-9} ✓$$

Alternative:

Excess✓ magnesium hydroxide is added to water in a container.

The mixture is shaken✓ (stirred) and left to stand✓ (settle) at a constant✓ temperature to attain equilibrium.

The molar conductivity, K, $ohm^{-1} cm$, is measured using a conductivity meter ✓

The molar conductivity of magnesium hydroxide at infinite dilution is determined by adding the molar conductivities of magnesium ions and hydroxide ions (from tables)

$$\Lambda_{Mg(OH)_2} = \Lambda_{Mg^{2+}} + 2\Lambda_{\bar{O}H}$$

The solubility of magnesium hydroxide is calculated using the expression

$$\Lambda_c = \frac{K}{C} ✓ \quad \left(\Lambda_c = 1000\frac{K}{C}\right)$$

C = solubility

$$K_{sp} = [Mg^{2+}][2OH^-]^2 \text{ from } Mg(OH)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq) ✓$$

$$= C \cdot (2C)^2 ✓$$

$$= 4C^3 mol^3 dm^{-9} ✓$$

(ii) - If the ionic product is less than the solubility product more of the sparingly electrolyte dissolves as the solution is unsaturated

- If the ionic product is equal to the solubility product no more of the sparingly soluble electrolyte dissolves as the solution is saturated

- If the ionic product is greater than the solubility product precipitation of a sparingly soluble electrolyte occurs

(c) (i) $CaSO_4(s) + aq \rightleftharpoons Ca^{2+}(aq) + SO_4^{2-}(aq)$

$K_{sp} = [Ca^{2+}][SO_4^{2-}]$

$[Ca^{2+}] = [SO_4^{2-}] = x \text{ mol dm}^{-3}$

$K_{sp} = 2.4 \times 10^{-5} = x.x = 2x$

$= x^2$

$x^2 = 2.4 \times 10^{-5}$

$x = \sqrt{2.4 \times 10^{-5}} = 4.899 \times 10^{-3} \text{ mol dm}^{-3}$

(ii) If the solubility of $CaSO_4 = x \text{ mol dm}^{-3}$

$[Ca^{2+}] = x$ and $[SO_4^{2-}] = x + 0.5 = 0.5M$

$K_{sp} = [Ca^{2+}][SO_4^{2-}]$

$2.4 \times 10^{-5} = x(0.5)$

$x = 4.8 \times 10^{-5} \text{ mol dm}^{-3}$

(d) - Temperature is kept constant

- Solution is saturated

- Electrolyte / salt is sparingly soluble

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4 (a) Carbon dioxide has a simple molecular structure with molecules held by weak Van der Waals forces. Silicon dioxide and germanium dioxide have giant covalent structures with atoms held by strong covalent bonds. Germanium has a bigger atomic radius than silicon making the covalent bonds in germanium(IV) oxide longer ~~but~~ and weaker than those in silicon(IV) oxide.

Tin(IV) oxide and lead(IV) oxide have giant ionic structures with strong ionic bonds.

The ionic radius of $tin^{(IV)}$ is smaller than that of lead (IV) ions therefore, the ionic bonds in lead(IV) oxide are weaker than those in tin(IV) oxide.

(b) Carbon dioxide is acidic and reacts with dilute alkalis to form a carbonate and water

$$CO_{2(g)} + 2\bar{O}H_{(aq)} \longrightarrow CO_3^{2-}{}_{(aq)} + H_2O_{(l)}$$

Accept The formation of a hydrogen carbonate

$$CO_{2(g)} + \bar{O}H_{(aq)} \longrightarrow HCO_3^-{}_{(aq)}$$

The other dioxides do not react with dilute alkalis

Silicon (IV) oxide reacts with dilute hydrofluoric acid to form Silicon tetrafluoride and water (or hexafluorosilicic acid and water)

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$SiO_{2(s)} + 4HF_{(aq)} \longrightarrow SiF_{4(g)} + 2H_2O_{(l)}$

OR $SiO_{2(s)} + 6HF_{(aq)} \longrightarrow H_2SiF_{6(aq)} + 2H_2O_{(l)}$

Other dioxides are acidic and do not react with dilute acids.

(c) Brown solid dissolves with effervescence /bubbles of a greenish-yellow gas

$PbO_{2(s)} + 4HCl_{(aq)} \longrightarrow PbCl_{2(aq)} + 2H_2O_{(l)} + Cl_{2(g)}$

(d) Sulphur dioxide reduces lead(IV) oxide to lead (II) sulphate

$PbO_{2(s)} + SO_{2(g)} \longrightarrow PbO_{(s)} + SO_{3(g)}$

$PbO_{(s)} + SO_{3(g)} \longrightarrow PbSO_{4(s)}$

OR $\{PbO_{2(s)} + SO_{2(g)} \longrightarrow PbSO_{4(s)}\}$

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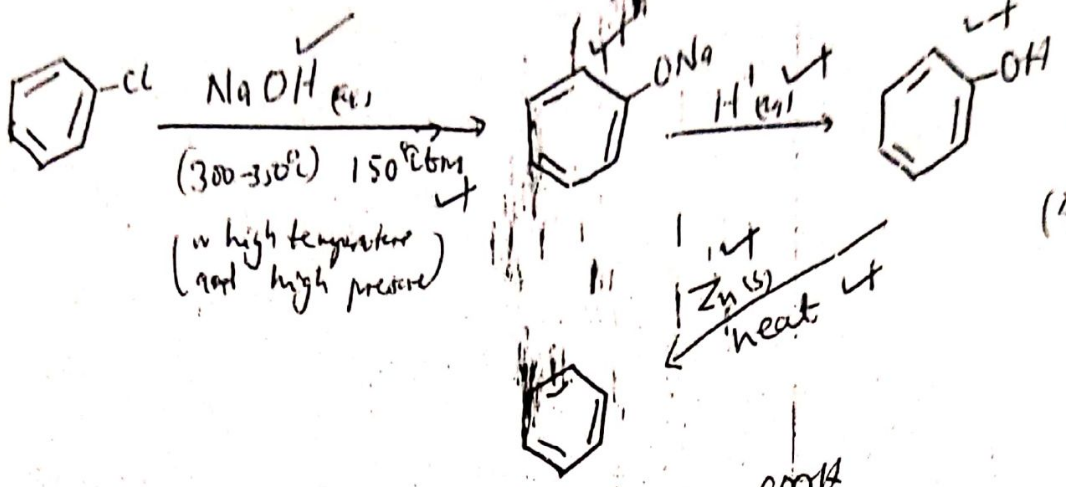
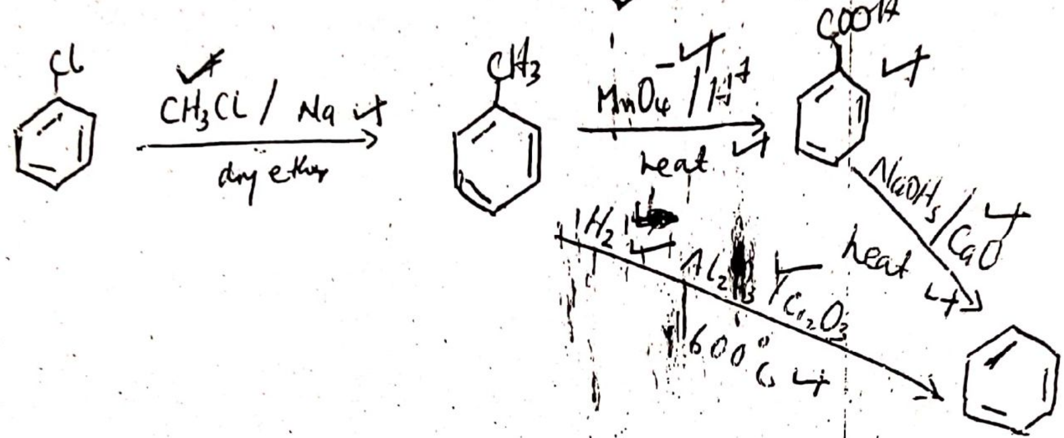
5 (a)



(4)

Alt.



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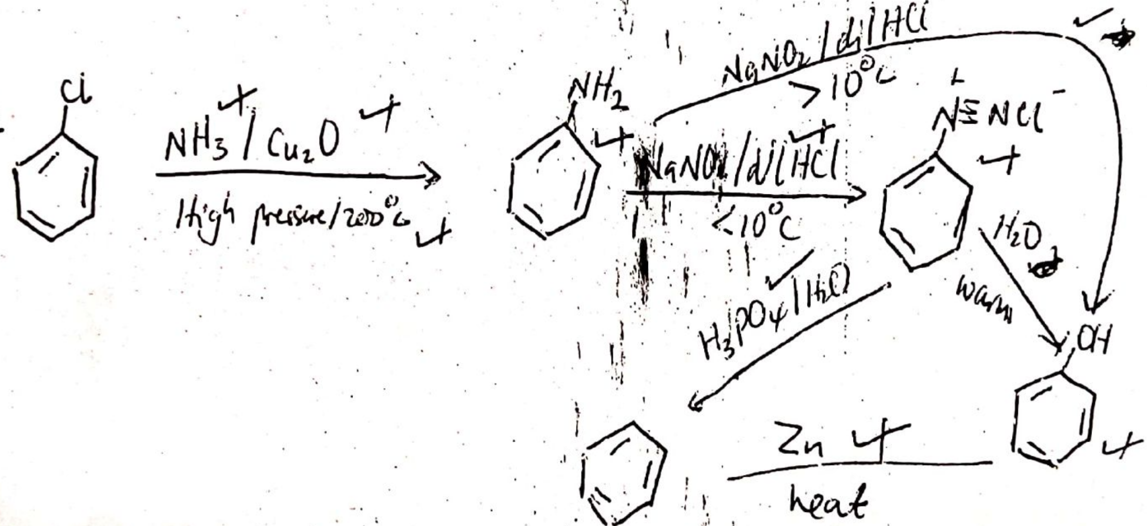

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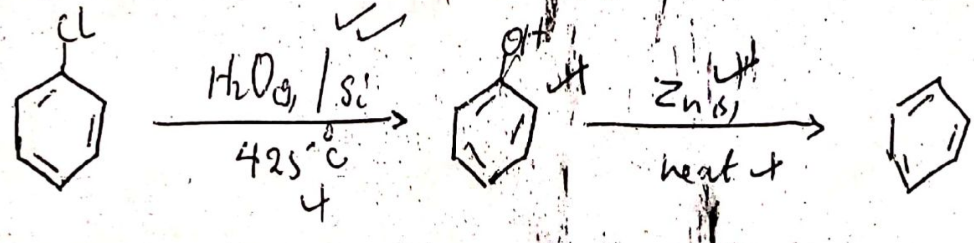
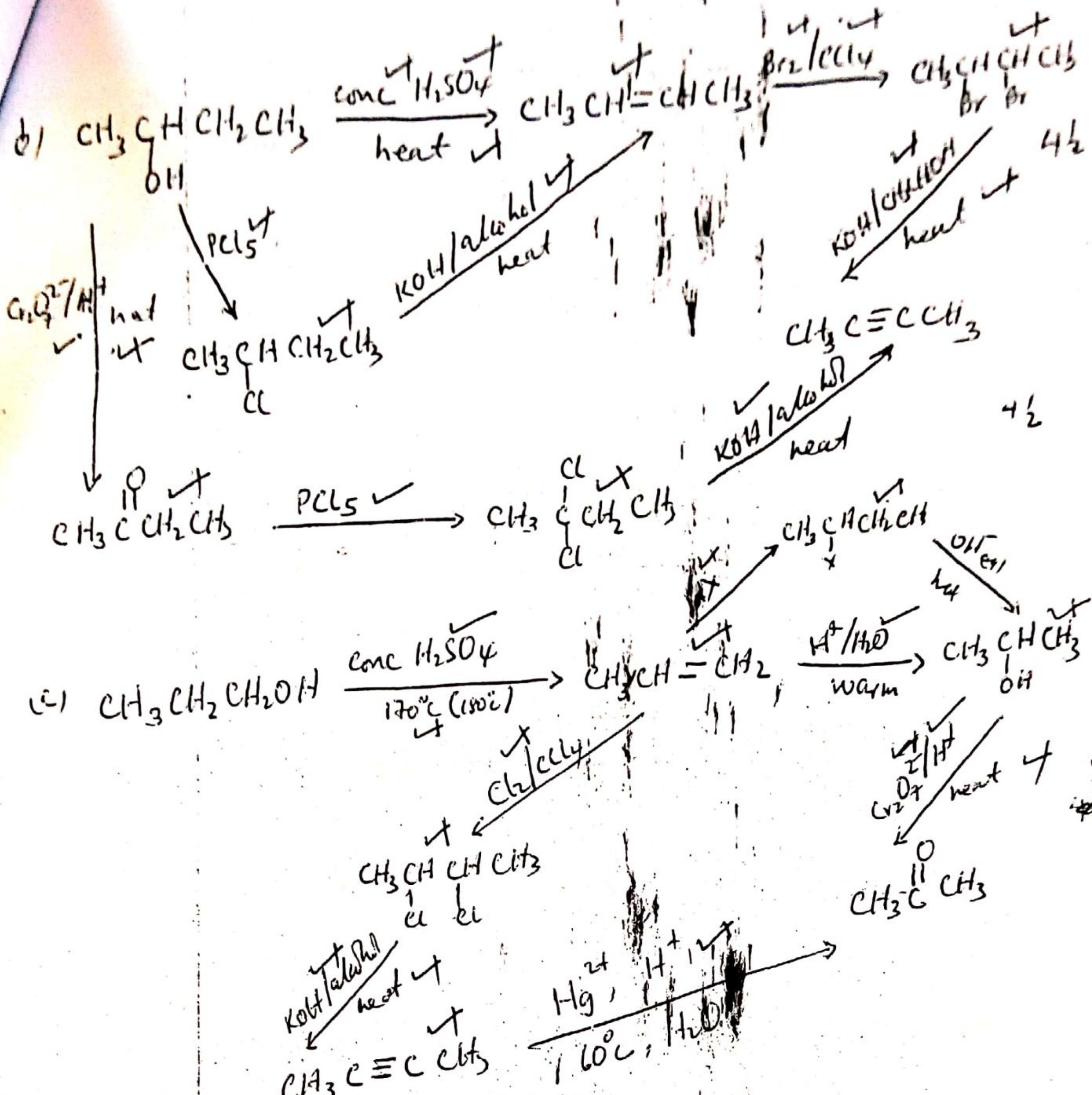
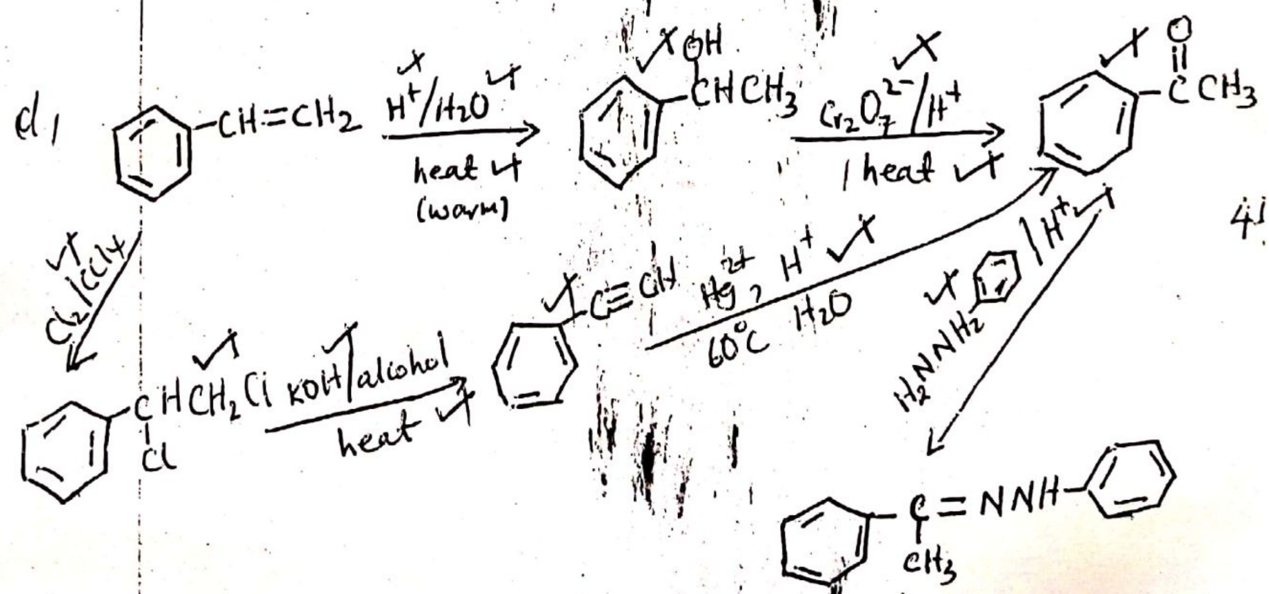



b)
CH3CHCH2CH3
OH
conc H2SO4
heat
CH3CH=CHCH3
Br2/CCl4
CH3CHCHCH3
Br Br
4½
PCl5
KOH/alcohol
heat
Cr2O7 2-/H+
heat
CH3CHCH2CH3
Cl
KOH/alcohol
heat
CH3C≡CCH3
KOH/alcohol
heat
4½
CH3CCH2CH3
O
PCl5
CH3CCH2CH3
Cl Cl
c)
CH3CH2CH2OH
conc H2SO4
170°C (180°C)
CH3CH=CH2
CH3CHCH2CH
X
OH-(aq)
H+/H2O
warm
CH3CHCH3
OH
Cl2/CCl4
Cr2O7 2-/H+
heat
5
CH3CHCHCH3
Cl Cl
CH3CCH3
O
KOH/alcohol
heat
Hg2+, H+
60°C, H2O
CH3C≡CCH3


d)
CH=CH2
H+/H2O
heat
(warm)
OH
CHCH3
Cr2O7 2-/H+
heat
O
CCH3
4
Cl2/CCl4
CHCH2Cl
Cl
KOH/alcohol
heat
C≡CH
Hg2+, H+
60°C H2O
H+
H2NNH
C=NNH
CH3

5(e) $2CH_3CH_2OH \xrightarrow{PCl_5} 2CH_3CH_2Cl \xrightarrow[\text{dry ether}]{Na} CH_3CH_2CH_2CH_3$

$CH_3CH_2OH \xrightarrow[180^\circ C]{\text{conc } H_2SO_4} H_2C=CH_2 \xrightarrow{HCl} CH_3CH_2Cl$

(1st for this route)

Alt accept

$CH_3CH_2OH \xrightarrow[170^\circ C]{\text{Conc } H_2SO_4} CH_2=CH_2 \xrightarrow{Cl_2/CCl_4} CH_2ClCH_2Cl$

$CH_2ClCH_2Cl \xrightarrow{KOH/\text{alcohol, heat}} HC\equiv CH$

$HC\equiv CH \xrightarrow{Na/\text{liq }NH_3} HC\equiv CNa \xrightarrow{CH_3CH_2Br} CH_3CH_2C\equiv CH$

$CH_3CH_2C\equiv CH \xrightarrow[150^\circ C]{H_2/Ni} CH_3CH_2CH_2CH_3$

(any 3 correct steps 1mk)

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6. (a) (i) The concentration of sulphur dioxide increases ✓
The position of the equilibrium shifts from left to right ✓ as excess sulphur dioxide reacts with oxygen to produce sulphur trioxide

(ii) The concentration of sulphur trioxide decreases ✓
The pressure of the system decreases ✓ since the forward reaction proceeds with a decrease in volume (or number of moles) ✓

(iii) The concentration of sulphur trioxide increases ✓
because the forward reaction is exothermic ✓ or lowering temperature favours a forward reaction

(b) Partial pressure of SO_3, $P_{SO_3} = 1 - (0.27 + 0.41) = 0.32$ atm ✓

$$K_p = \frac{P^2_{SO_3}}{P^2_{SO_2} \times P_{O_2}}$$ ✓

$$= \frac{(0.32)^2}{(0.27)^2 (0.41)}$$ ✓

$$= \underline{3.43\ atm^{-1}}$$ ✓

3

6(c) (i) $SO_{3(g)} + H_2SO_{4(l)} \longrightarrow H_2S_2O_{7(l)}$

$H_2S_2O_{7(l)} + H_2O \longrightarrow 2H_2SO_{4(l)}$

(ii) $1 cm^3$ of acid contain $1.84 \times \frac{98}{100}$ g H_2SO_4

$1000 cm^3$ of acid contain $1.84 \times \frac{98}{100} \times 1000g = 1803.2g$ 3

RMM $H_2SO_4 = (2\times1) + 32 + (4\times16) = 98$

Molarity of sulphuric acid $= \frac{1803.2}{98} = 18.4M$

(No volume of solution was given and any volume can produce 0.2M acid)

(d) (i) The colourless solution turn reddish-brown (fumes)
concentrated sulphuric acid oxidises hydrobromic acid to bromine as the acid is reduced to sulphur dioxide

$H_2SO_{4(l)} + 2HBr_{(aq)} \longrightarrow Br_{2(aq)} + SO_{2(g)} + 2H_2O_{(l)}$

(ii) The solution changes to brown (or black solid forms)
Hydroiodic acid reduces concentrated sulphuric acid to sulphur dioxide as it is oxidised to iodine

$H_2SO_{4(l)} + 2HI_{(aq)} \longrightarrow I_{2(s)} + SO_{2(g)} + 2H_2O_{(l)}$

Accept $H_2SO_{4(l)} + 8HI_{(aq)} \longrightarrow 4I_{2(s)} + H_2S_{(g)} + 4H_2O_{(l)}$

or $H_2SO_{4(l)} + 6HI_{(aq)} \longrightarrow 3I_{2(s)} + S_{(s)} + 4H_2O_{(l)}$

or $10HI_{(aq)} + 2H_2SO_{4(aq)} \longrightarrow SO_{2(g)} + H_2S_{(g)} + 5I_{2(s)} + 6H_2O_{(l)}$

(products depend on equation used)

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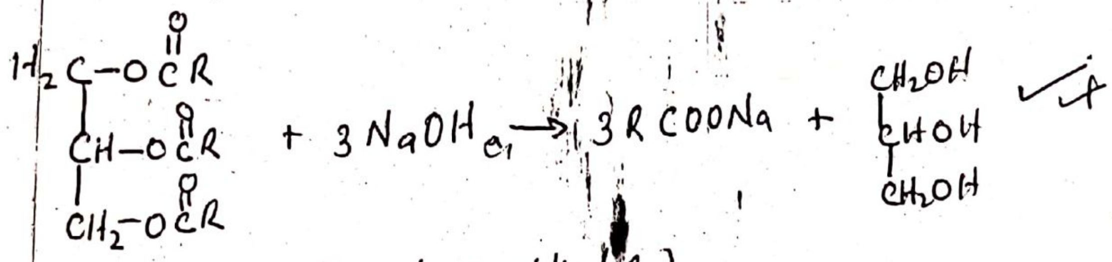
7 (a) (i) Saponification



(Accept specified R)

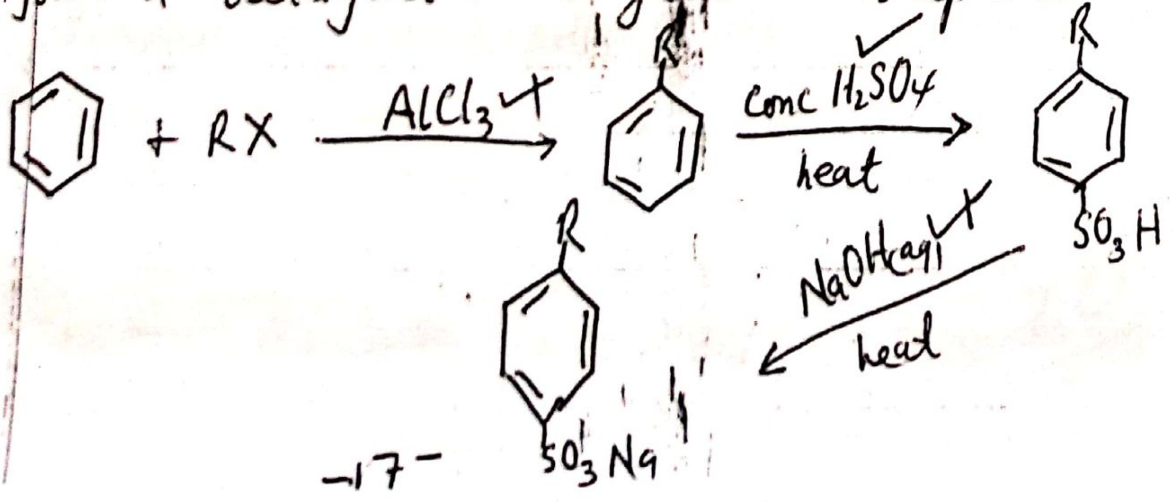
(ii) Cotton seed oil / Simsim oil / Groundnut oil / palm oil or animal fats

(b) (i) The vegetable oil / animal fat is boiled with concentrated sodium hydroxide solution / an alkali while stirring until the fat completely dissolves.

(5) The solution is cooled and concentrated sodium chloride (brine) is added to precipitate soap which floats and skimmed off / removed

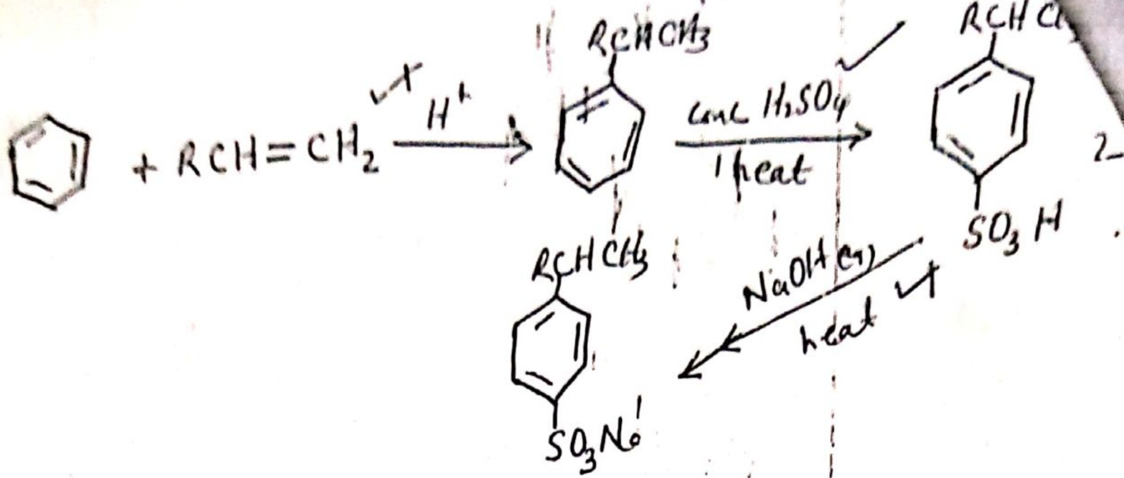
(ii) Benzene is reacted with a long chain alkene or alkyl halide in the presence of an acid (alkene) or aluminium chloride (alkyl halide) to form alkyl benzene

The alkyl benzene, produced, is heated with concentrated sulphuric acid to form a sulphonic acid which is reacted with sodium hydroxide to form a detergent or alkyl benzene sulphonate



2

alt OR



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alt OR - A long chain alcohol/vegetable oil is reacted with cold concentrated Sulphuric acid to form an alkyl hydrogen sulphate.
The alkylhydrogen sulphate is reacted with sodium hydroxide solution to form a detergent. 2½

$$RCH_2OH \xrightarrow{\text{Conc } H_2SO_4} RCH_2OSO_3H \xrightarrow{NaOH(aq)} RCH_2OSO_3Na$$

(b) (ii) The soap molecule has an alkyl group which is hydrophobic and the carboxylate group which is hydrophilic
The alkyl group is attracted to the oily dirt that reduces the surface tension between water and oil dirt.
(4½) The dirt particles are removed and suspended in water (or emulsified)

(c) (i) Soap reacts with hard water to form scum leading to Soap wastage 2

(ii) Soapless detergents pollute the environment because they are non-biodegradable and contain phosphates for algae growth 2

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8: (a) $CuFeS_2$

(b) (i) The ore is crushed (pulverised or grounded) to powder and mixed with water and a frothing agent in the concentration tank.
Air is blown/passed through the mixture and ore particles float on the surface where it is skimmed off.
(2)
Dilute acid is added to break the froth and the ore is filtered off and dried.

(ii) $2CuFeS_{2(s)} + 4O_{2(g)} \longrightarrow Cu_2S_{(s)} + 2FeO_{(s)} + 2SO_{2(g)}$

$Cu_2S_{(s)} + O_{2(g)} \longrightarrow 2Cu_{(s)} + SO_{2(g)}$

or
$$\left.\begin{array}{l} 2Cu_2S_{(s)} + 3O_{2(g)} \longrightarrow 2Cu_2O_{(s)} + 2SO_{2(g)} \\ Cu_2S_{(s)} + 2Cu_2O_{(s)} \longrightarrow 6Cu_{(s)} + SO_{2(g)} \end{array}\right\}$$

(iii) Smelting removes iron (II) oxide / impurities of iron as slag.

(iv) A solution of copper (II) sulphate is electrolysed using impure copper as the anode and pure copper as the cathode.

Impure copper dissolves at the anode and deposited as pure copper at the cathode.

Anode $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e^-$

cathode $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$

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(c) (i) Copper (II) ions oxidise iodide ions to iodine as copper (II) ions are reduced to copper (I) iodide

$$2Cu^{2+}_{(aq)} + 4I^-_{(aq)} \longrightarrow 2CuI_{(s)} + I_{2(aq)}$$

or $$2Cu^{2+}_{(aq)} + 4I^-_{(aq)} \rightarrow Cu_2I_{2(s)} + I_{2(aq)}$$

(ii) Insoluble copper (II) hydroxide is formed which reacts with excess ammonia solution to form a soluble complex of tetraammine copper (II) ions

$$Cu^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Cu(OH)_{2(s)}$$

$$Cu(OH)_{2(s)} + 4NH_{3(aq)} \longrightarrow Cu(NH_3)_4^{2+}{}_{(aq)} + 2OH^-$$

or $$Cu^{2+}_{(aq)} + 4NH_{3(aq)} \rightarrow Cu(NH_3)_4^{2+}{}_{(aq)}$$

(iii) Insoluble basic copper (II) carbonate is formed.

$$2Cu^{2+}_{(aq)} + 2OH^-_{(aq)} + CO_3^{2-}{}_{(aq)} \rightarrow CuCO_3 \cdot Cu(OH)_{2(s)}$$

or $$Cu^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)} \longrightarrow CuCO_{3(s)}$$

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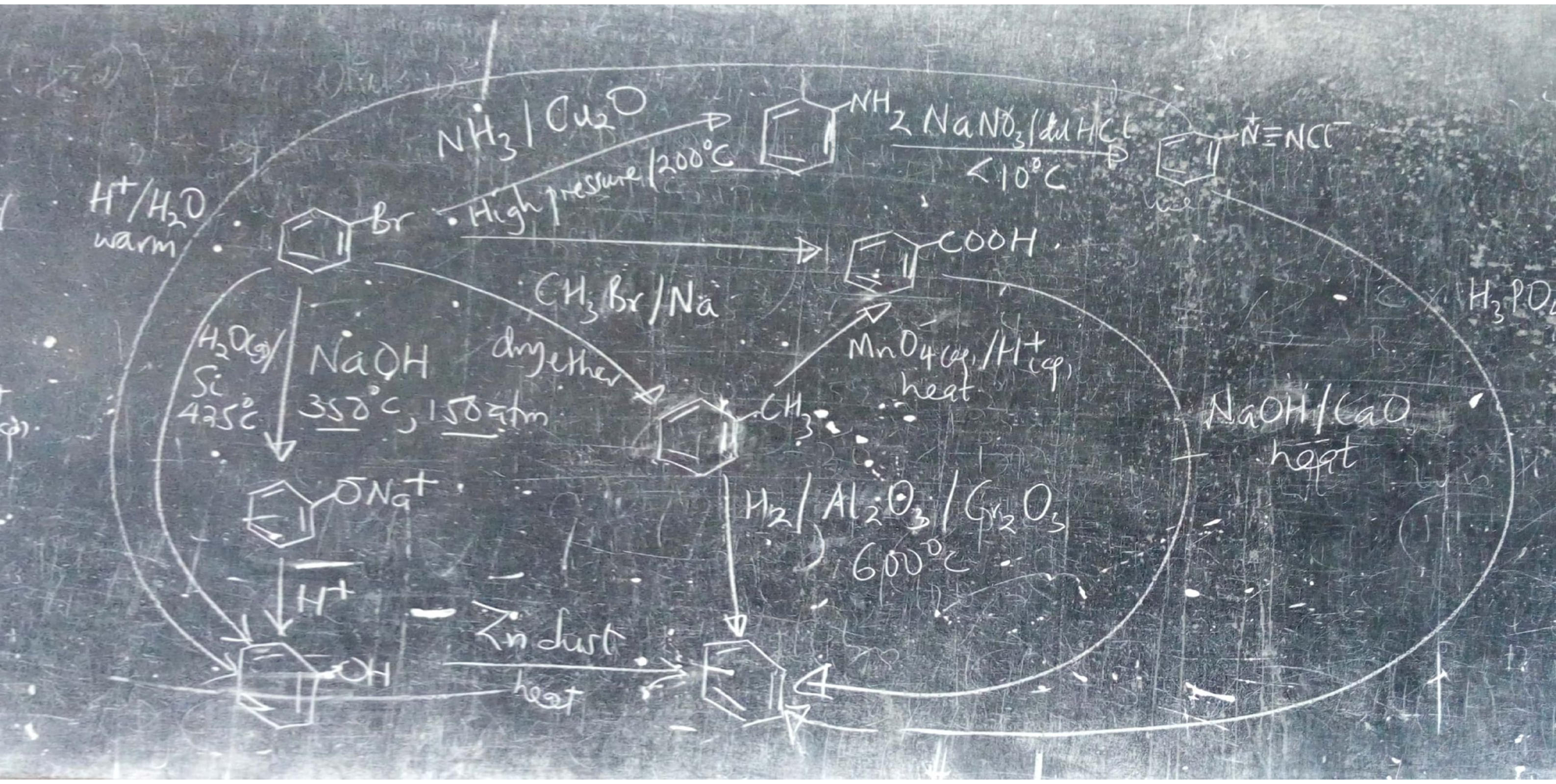
—END—



NH3 / Cu2O
High pressure / 200°C
NH2
NaNO2 / dil HCl
< 10°C
N≡NCl
H+/H2O
warm
Br
COOH
CH3Br / Na
dry ether
MnO4(aq) / H+(aq)
heat
H2O(g) /
Si
425°C
NaOH
350°C, 150 atm
CH3
NaOH / CaO
heat
H3PO
O-Na+
H2 / Al2O3 / Cr2O3
600°C
H+
Zn dust
heat
OH