WAKISSHA JOINT MOCK EXAMINATIONS
MARKING GUIDE
Uganda Advanced Certificate of Education
CHEMISTRY P525/2
July/August 2023

1. (a) Transition element is one which has partially filled 3 d- sub energy level in one of its stable oxidation states. (01 mark)
Reject 3d orbital and 3d energy level

(b) (i) They use both 3d and 4s electrons for ~~bounding~~ bonding. due to the small energy difference between the 4s and 3d sub energy levels (02 marks)

(ii) For chromium : +2, +3, and 6.
For manganese: +2, +3, +4, +6 and +7 (½ each) (04 marks)

(iii) CrO, Cr_2O_3 and CrO_3 (1½ marks)

(c) (i) $CrO_3(s) + H_2O(l) \rightarrow H_2CrO_4(aq)$ chromic acid
$Mn_2O_7(s) + H_2O(l) \rightarrow 2HMnO_4(aq)$ Manganic (VII) acid

(ii) $CrO_3(s) + 2\bar{O}H(aq) \rightarrow CrO_4^{2-}(aq) + H_2O(l)$
$Mn_2O_7(s) + 2\bar{O}H(aq) \rightarrow 2MnO^-_4(aq) + H_2O(l)$ (04 marks)
Wrong state $-\frac{1}{2}$
Not balanced 0
Accept molecular equations.

(d) (i) Green solution turned to purple and black precipitate formed. (2½ marks)
$3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$
Accept brown Precipitate

(ii) Orange solution turned green
$Cr_2O_7^{2-}(aq) + 3SO_2(g) + 2H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + H_2O(l)$ (2½ marks)

(iii) Green solid turned yellow solid.
$Cr_2O_3(s) + 3Na_2O_2(s) \rightarrow 2Na_2CrO_4(s) + Na_2O(s)$ (2½ marks)

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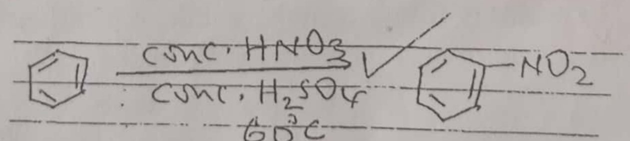
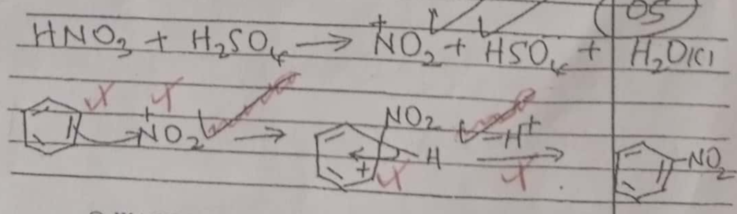
2. (a) (i) (Pale) yellow solution formed. Reject yellow solid (01 mark)

(ii) 
Without the temp, don't mark the equation but mark the mechanism

Mechanism
Accept $HNO_3 + 2H_2SO_4 \longrightarrow \overset{+}{N}O_2 + 2HSO_4^- + H_3O^+$ → Deny the marks if not balanced but mark the mechanism
(05 marks)

$HNO_3 + H_2SO_4 \rightarrow \overset{+}{N}O_2 + HSO_4^- + H_2O(l)$



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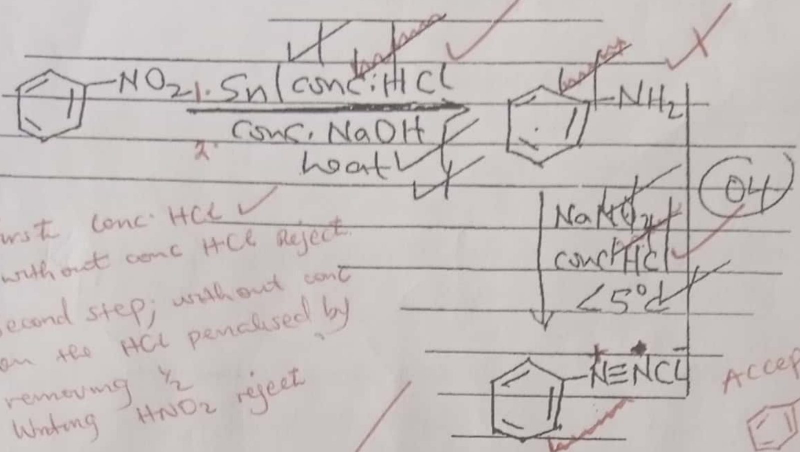
OR: $H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$
$HO{-}NO_2 + H^+ \longrightarrow H_2\overset{+}{O}{-}NO_2 \longrightarrow \overset{+}{N}O_2 + H_2O$

(b)



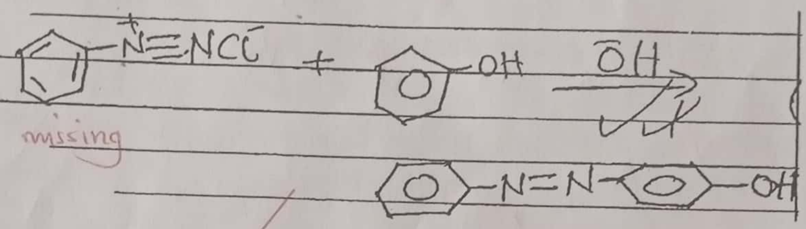
(05 marks)

- First conc. HCl ✓ without conc HCl Reject
- Second step; without conc on the HCl penalised by removing ½
- Writing HNO_2 reject

Accept N_2Cl

05

(d) (i) Yellow precipitate is formed. Accept yellow solid 01



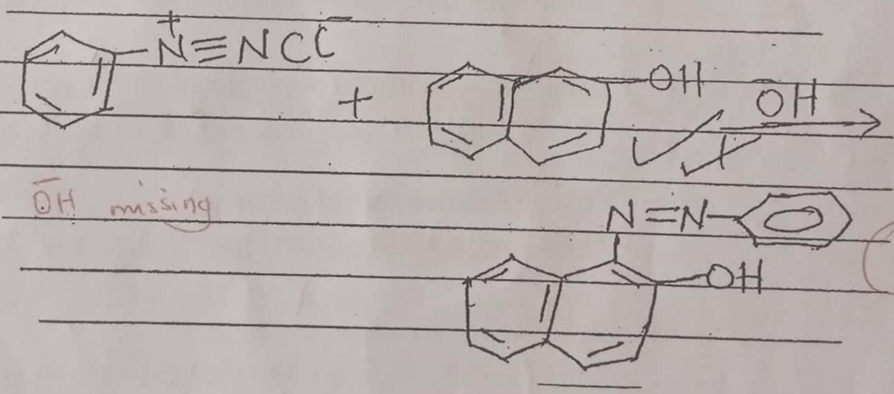
−½ for $\bar{O}H$ missing

02

03

(03 marks)

(ii) Red precipitate Accept red solid



−½ for $\bar{O}H$ missing

03

(02 marks)

(d) Benzene diazonium chloride is reacted with potassium cyanide in the presence of Copper(1) cyanide to form benzene cyanide, it is refluxed with dilute mineral acid (hydrochloric acid or nitric acid) to form benzoic acid. 02

(03 marks)

[20 marks]

Accept acidified water and heating instead of reflux.

3. (a) Raoult's law states that the partial vapour pressure of a volatile component in solution at a given temperature is equal to the product of the mole fraction of the component and the vapour pressure of the pure component at that temperature.

(01 mark)

(b) (i) RMM of $CH_3COCH_3 = 12 \times 3 + 1 \times 6 + 16 = 58$

RMM of $CHCl_3 = 12 + 1 + 35.5 \times 3 = 119.5$

No. of moles of $CH_3COCH_3 = \frac{203}{58} = 3.5$

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No. of moles of $CHCl_3 = \frac{179.5}{119.5} = 1.5021.$ (05 marks)

Total number of moles = 3.5+1.5021

= 5.0021

$PCH_3COCH_3 = \frac{3.5}{5.0021} \times 38.5$

$= 26.937 KNm^{-2}$

05

$PCHCl_3 = \frac{1.5021}{5.0021} \times 26.7$

$= 8.0178 KNm^{-2}$

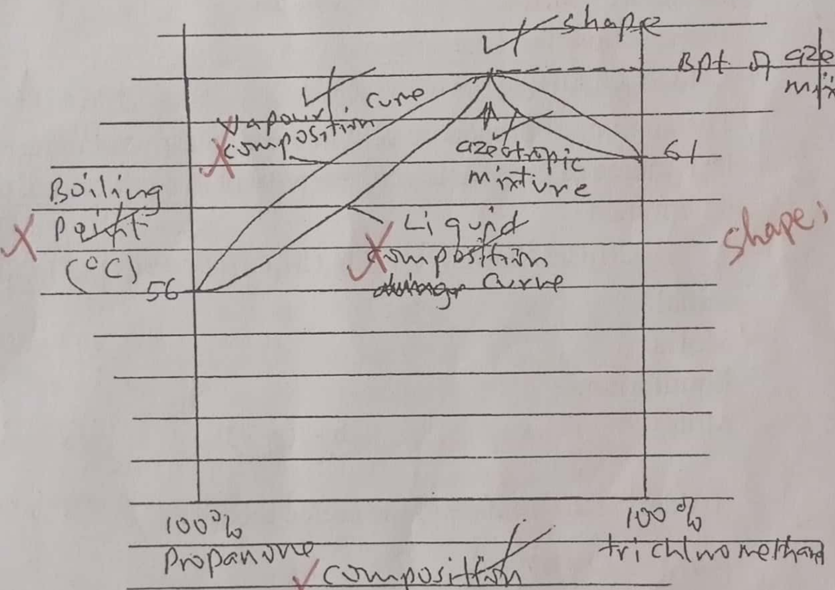
Total vapour pressure = 26.937+8.0178

$= 34.9548 KNm^{-2}$

Accept to a min of 3dps.

(ii) Solution deviates negatively from Raoult's law. (01 mark)

(iii)



(03 marks)

03

(iv) When a mixture of propanone and trichlorome thane is distilled, either pure propanone or pure trichlorome is obtained as a distillate and the residue in the flask is richer in the azeotropic mixture because the azeotropic mixture has a higher boiling point than either of the components. 04

(04 marks)

(c) (i) RMM of $C_{10}H_{16}$ = 12 x 10 + 1 x 16 = 136

RMM of H_2O = 1 x 2 +16

= 18

$$\frac{\text{\% of turpentine in the distillate}}{\text{\% of water in the distillate}} = \frac{V.P \times RMM(C_{10}H_{16})}{V.P \times RMM \ of \ H_2O}$$

$$\frac{55}{45} = \frac{P \times 136}{(101325 - P) \times 18}$$

45 x P x 136 = 55 x 18 x (101325 - P)

6120P = 990(101325 − P)

6120P + 990p = 100311750

(04 marks)

6,120P = 100, 311, 750-990P

7110P = 100, 311, 750

P = 1,450.3165Pa.

(ii) - By use of separating funnel
- By use of solvent extraction.

(02 marks)

[20 MARKS]

4. (a) $$K_C = \frac{[CH_3CH_2O_2CCH_2CH_3][H_2O]}{[CH_3CH_2COOH][CH_3CH_2OH]}$$ Reject KC (01 mark)

(b) Known amounts a moles of propanoic acid and b moles of ethanol are sealed in tube and the tube is placed in a thermostate for a week. Accept, water bath and same time

The tube is then broken into cold water and known volumes of the diluted mixture are titrated against standard sodium hydroxide solution using phenolphthalein indicator. Accept suitable indicator

The reaction that takes place is

$$CH_3CH_2COOH(aq) + NaOH(aq) \rightarrow CH_3CH_2COONa(aq) + H_2O(l)$$

The amount of propanoic acid in the equilibrium mixture is determined.

If x moles of propanoic acid are present at equilibrium, then the KC can be determined.

	$CH_3CH_2COOH(l)$ +	$CH_3CH_2OH(l)$	$\leftrightharpoons CH_3CH_2O_2H_5(l)$	+ H_2O
Initial Moles	a	b	o	o
Equilibrium Moles	x	b - ((a- x))	(a - x)	(a - x)

If Vdm^3 is the volume of the sealed tube.

$$[CH_3CH_2COOH] = \frac{x}{V}$$

$$[CH_3CH_2OH] = \frac{b-(a-x)}{V}$$

$$[CH_3CH_2O_2CCH_2CH_3] = [H_2O] = a - x$$ (06 marks)

$$\therefore K_C = \frac{[C_2H_5O_2CCH_2CH_3][H_2O]}{[C_2H_5OH][CH_3CH_2COOH]}$$

$$= \frac{\frac{(a-x)(a-x)}{V^2}}{\frac{x}{V} - \frac{b-(a-x)}{V}}$$

$$= \frac{(a-x)(a-x)}{x(b-a+x)}$$

(c) (i) Increase in temperature favours the backward reaction shifting the equilibrium position to the left since the reaction is exothermic. The concentration of the products reduces while that of the reactants increases and thus the equilibrium constant decreases.

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(03 marks)

(ii) The equilibrium position shifts to the left because calcium carbonate reacts with propanoic acid at equilibrium and the backward reaction is favoured to restore the concentration of propanoic acid. The equilibrium constant does not change. (02 marks) 02

(iii) The equilibrium position shifts to the right because anhydrous copper(II) sulphate absorbs water and this favours the forward reaction. The equilibrium constant does not change. (02 marks) 02

(d) RMM of CH_3CH_2OH = 12 x 2 + 1 x 6 + 16 = 46

RMM of CH_3CH_2COOH = 12 x 3 + 1 x 6 + 16 x 2 = 74

No. of moles of ethanol = $\frac{62.1}{46} = 1.35$

No. of moles of propanoic acid = $\frac{185}{74} = 2.5$

Let x moles be the number of moles of ethylpropanoate.

$$Kc = \frac{\frac{x}{V}\cdot\frac{x}{V}}{\left(\frac{1.35-x}{V}\right)\left(\frac{2.5-x}{V}\right)} = \frac{x^2}{(1.35-x)(2.5-x)}$$

$$4 = \frac{x^2}{(1.5-x)(2.5-x)}$$

$$4(3.75-4x+x^2) = x^2$$

$$15-16x+4x^2 = x^2$$

$$3x^2-16x+15 = O$$

$$x = 1.2137.$$

(06 marks)

$CH_3CH_2O_2CCH_2CH_3$ = 12x5 + 1x10 + 16x2 = 102

RFM of ~~CH_3CH_2COONa~~ = ~~12 x 3 + 1 x 6 + 10x2+23~~ = ~~97~~

Mass of ethylpropanoate = ~~97 x 1.2137~~ = 117.72899g

$102 \times \cancel{1.2137}$ 1.12 = ~~123.79~~ 74g = 114.....g

06

[20 MARKS]

5. (a) First electron affinity is the heat evolved when an electron is added to a gaseous atom to form a uninegatively charged gaseous ion. (02 marks)

OR

First electron affinity is the enthalpy change that occurs when one mole of electrons is added to one mole of gaseous atoms to form one mole of uninegatively charged gaseous ions.

$X_{(g)} + e \longrightarrow X^-_{(g)}$, $\Delta H = -Q\,kJmol^{-1}$

Accept +ΔH for Group(II) elements. Deny ½ if ΔH is not given

Deny ½ with generally

(b) Generally electron affinities increase across period 2 of the periodic Table. This is because from one element to the next, electrons ~~are~~ can is being added to the same energy level and a protons ~~are~~ is added to the nucleus. Nuclear charge increases while screening effect almost remains constant and thus effective nuclear charge increases across the period and the incoming electron is strongly attracted and this leads to increase in electron affinity.

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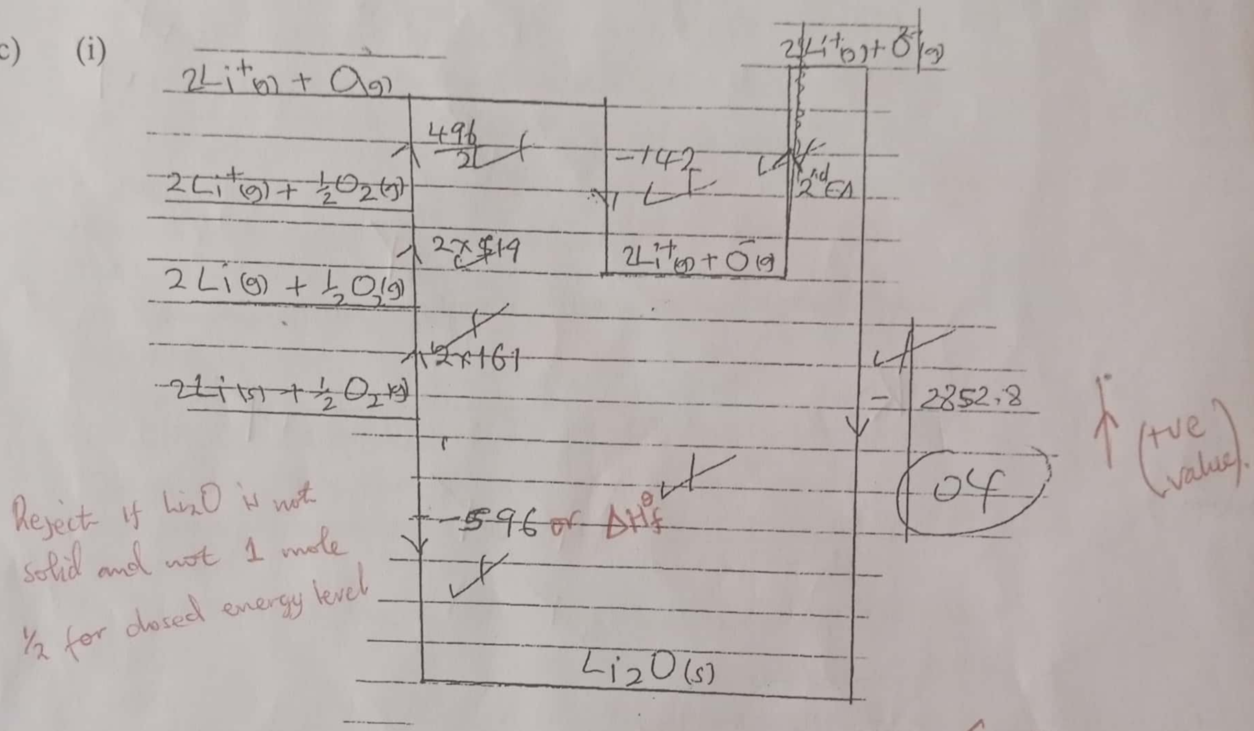
However, beryllium has a positive electron affinity because beryllium has th electronic configuration, $1S^2 2S^2$. The $2S$ orbital is full and thermodynamically stable. The incoming electron experience repulsion and thus energy must be supplied for the electron to be added to the atom.
Nitrogen has abnormally low electron affinity because $_7N$ $1S^2 2S^2 2p^3$.
The 3p sub-energy level is half filled and thus has some special stability and thus less energy is released on addition of the electron. (07 marks)

(c) (i)



(c) (ii) $2^{nd}EA = -596 - \left(161\times2+519\times2+\frac{496}{2}+-2852.8+-142\right)$

$= +790.8 KJmol^{-1}$

Reject missing (+)
Units missing deny ½
Wrong units reject

(03 marks)

(d) $K(s)+\frac{1}{2}Cl_2(g) \rightarrow KCl(s)\ \Delta H^0 f = ?$

$\Delta H^0 f(KCl) = (i) + (iii) + (iv) + -(ii) + -(v)$

$= -57.3 + -164.2 + -487.0$

$+285.9 + -18.4$

$= -441 KJmol^{-1}$

(04 marks)

6. (a) $CH_3CH_2CH_2NH_2$

CH_3CHCH_3
$\quad |$
$\quad NH_2$

$CH_3CH_2NHCH_3$

$(CH_3)_3N$

(02 marks)

(b) P is $CH_3CH_2NHCH_3$

Q is $CH_3CH\ CH_3$ (NH_2 on the middle carbon)
$\quad |$
$\quad NH_2$

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R is $CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{N}}-N=O$ (2½ marks)

S is $CH_3\underset{\displaystyle OH}{\underset{|}{C}H}\ CH_3$

T is N_2 (Nitrogen gas)

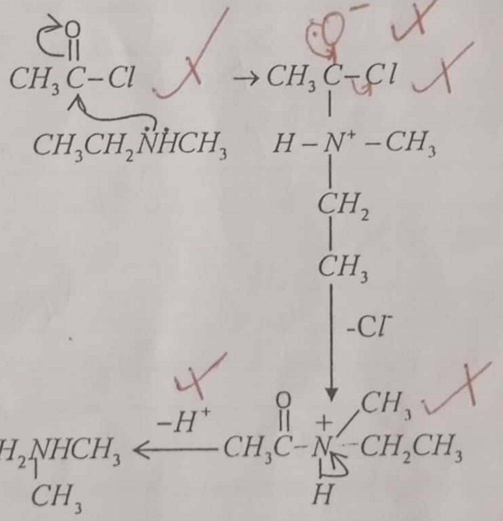
(ii) $CH_3CH_2NHCH_3 \xrightarrow[\angle 5^0C]{NaNO_2\,/\,conc.HCl}$ (01 mark)

$CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{N}}-N=O$ (01 mark)

$CH_3\underset{\displaystyle NH_2}{\underset{|}{C}H}\ CH_3 \xrightarrow[\angle 5^0C]{NaNO_2\,/\,conc.HCl} CH_3\underset{\displaystyle OH}{\underset{|}{C}}HCH_3 + N_2$

(c) (i) $CH_3CH_2NHCH_3 + CH_3\overset{O}{\overset{\|}{C}}-Cl \rightarrow CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{N}}-\overset{O}{\overset{\|}{C}}-CH_3$

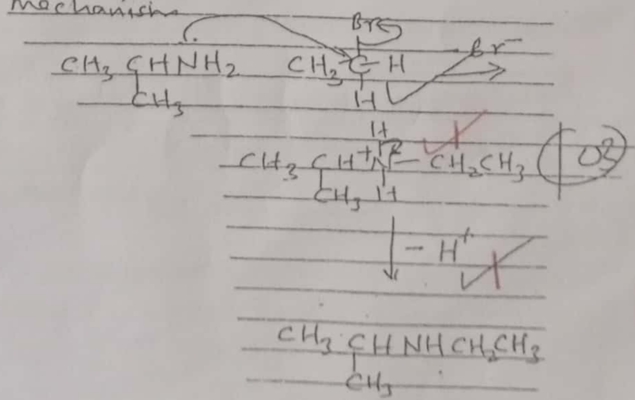
Mechanism



(3½ marks)

(ii) $CH_3\underset{\displaystyle NH_2}{\underset{|}{C}H}CH_3 + CH_3CH_2Br \longrightarrow CH_3\underset{\displaystyle NHCH_2CH_3}{\underset{|}{C}H}CH_3 + HBr$

mechanism



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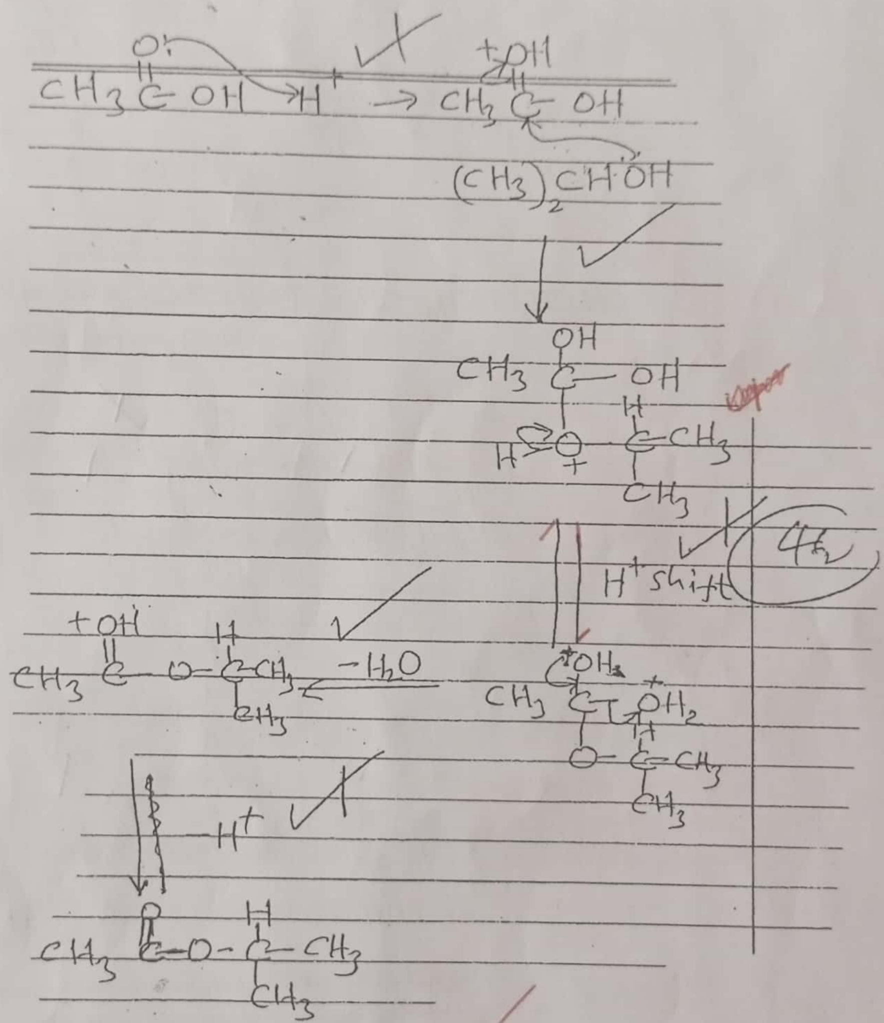
(iii) $CH_3\underset{OH}{C}HCH_3 + CH_3COOH \underset{}{\overset{conc.\,H_2SO_4}{\rightleftharpoons}} CH_3\underset{CH_3}{C}HO\overset{O}{\overset{\|}{C}}CH_3$

mechanism

$H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$



(d) (i) Orange solution turns green

$CH_3\underset{OH}{C}HCH_3 \xrightarrow[heat]{CrO_3/H^+} CH_3\overset{O}{\overset{\|}{C}}CH_3$

propanone

1½

7. (a) Concentrated sulphuric acid oxidises hydrogen iodide to iodine and itself reduced to sulphur and hydrogen sulphide and water. (05 marks)

$14HI(g)+2H_2SO_4(l)\rightarrow 7I_2(s)+H_2S(g)+8H_2O(l)$ + S(s)

2HI(g) + H2SO4(l) ⟶ I2(s) + SO2(g) + 2H2O(l)

(b) Copper(I) oxide disproportionates in sulphuric acid to form copper which is the brown solid and copper (II) sulphate solution which is blue. (04 marks)

$Cu_2O(s)+H_2SO_4(aq)\rightarrow Cu(s)+CuSO_4(aq)+H_2O(l)$

Cu2O(s) + 2H+(aq) ⟶ Cu(s) + Cu2+(aq) + H2O(l).

(c) Iron (III) ethanoate is formed which undergoes hydrolysis to form iron (III) oxide and ethanoic acid. (04 marks)

$FeCl_3(aq)+CH_3COONa(aq)\rightarrow (CH_3COO)_3Fe(aq)+3NaCl$

$2(CH_3COO)_3Fe(aq)+3H_2O(l)\leftrightharpoons Fe_2O_3(s)+6CH_3COOH$

(d) Trimethylamine lack a hydrogen atom on the amino functional group and therefore does not associate through hydrogen bonding instead molecules associate through weak vander waals forces which require less energy to break while Propylamine possesses hydrogen atoms on the amino functional group and therefore molecules associate through hydrogen bonds which are stronger than vander waals forces.

(e) Sulphurous acid processes fewer oxygen atoms and thus exert less negative inductive effect and the O – H bond is less polar and cannot easily break it.

possesses

8. (a) $NaH, MgH_2, AlH_3, SiH_4, PH_3, H_2S, HCl$

(b) (i) $2Na(s)+H_2(g)\rightarrow 2NaH(s)$

(ii) $Mg_2Si(s)+4H_2O(l)\rightarrow 2Mg(OH)_2(S)+SiH_4(g)$

(iii) $FeS(s)+2HCl(q)\rightarrow FeCl(aq)+H_2S(g)$

Accept SiCl4(l) + LiAlH4 → SiH4 + AlCl3 + LiCl

(4½ marks)

(c) (i) Sodium hydride doesnot react with Sodium hydroxide because it is basic.

Silicon (IV) hydride reacts to form Sodium silicate and hydrogen gas.

$SiH_4(g)+2NaOH_{(aq)}+H_2O(l)\rightarrow Na_2SiO_3(aq)+4H_2(g)$

Hydrogen sulphide reacts with aqueous Sodium hydroxide solution to form Sodium Sulphide and water. 2½

$H_2S(g)+2NaOH(aq)\rightarrow Na_2S(aq)+2H_2O(l)$

(ii) Sodium hydride reacts with cold concentrated to form Sodium Sulphate and hydrogen sulphide gas.

$Na_2S(s)+2H_2SO_4(l)\rightarrow 2NaHSO_4(s)+H_2S(g)$

Silicon (IV) hydride being acidic does not react with concentrated Sulphuric acid. 2½

(05 marks)

Hydrogen sulphide reduces concentrated sulphuric acid to sulphurdioxide and hydrogen sulphide itself is oxidized to sulphur.

$H_2S(g)+H_2SO_4(l)\rightarrow S(s)+SO_2(g)+2H_2O(l)$

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(d) (i) Yellow solid is formed

$$2H_2S(g) + O_2(g) \rightarrow 2S(s) + 2H_2O(l)$$

(ii) White fumes of a gas. (04 marks)

$$2H_2S(g) + 3O_2(g) \rightarrow 2SO_2(g) + 2H_2O(l)$$

(e) Sodium hydride is melted and electrolyzed between platinum electrodes. Hydrogen gas is evolved at the anode showing that the hydride ion is negatively charged.

$$NaH(l) \rightarrow Na^+(l) + H^-(l)$$

03

$$2H^-(l) \rightarrow H_2(g) + 2e$$

(03 marks)

[20 MARKS]

END

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