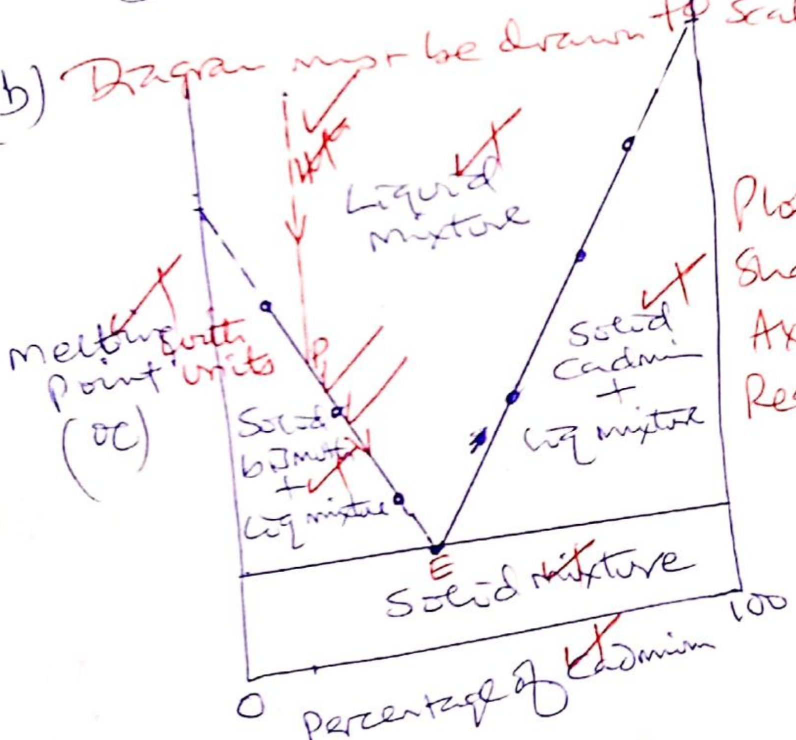
UMTA – 2021 MARKING GUIDE
UACE CHEMISTRY PAPER 2.

Q1 a (i) A heterogeneous solid mixture which when heated at constant pressure, melts to form a liquid mixture of the same composition as the solid mixture.

ii) The lowest possible temperature at which a liquid mixture solidifies to form a heterogeneous solid mixture of the same composition as the liquid.

(b) Diagram must be drawn to scale on a graph paper.



Plotting 01
Shape 01
Axes 01
Regions 02
05 mks

(i) m.pt of pure cadmium = 314 ± 0.5 °C
m.pt of pure bismuth = 264 ± 0.5 °C 02

(ii) m.pt of eutectic mixture = 150 ± 0.5 °C
Eutectic composition = 54 ± 0.5 % cadmium

(iii) Showing the cooling on the graph. 02
composition of the liquid mixture remains unchanged until point P when bismuth begins to solidify (or crystallise). On

further cooling, more the bismuth crystallises along PE as the remaining liquid mixture becomes richer in cadmium. At point E, all the remaining liquid solidifies to form a eutectic mixture.

02

(iv) % of Bismuth at 300°C = 75%.

mass of bismuth at 300°C = $\frac{75}{100} \times 200$

= 150g.

% of bismuth at 168°C = 56% ± 0.5 (using the graph)

Showing it on the graph

mass of bismuth at ~~300~~ 168°C = $\frac{56}{100} \times 200$

= 112g.

Mass of Bismuth crystallised = 150 − 112

= 38g.

04

c) Similarities:

- Both have definite melting points
- Both have definite composition at constant pressure.

03 max

Differences:

- Pure compound is homogeneous under microscope while eutectic mixture is heterogeneous.
- composition of eutectic varies with pressure but that of a pure cpd is fixed.

a(ii)

Q.2. Mass of $CO_2 = \frac{5.04}{22.4} \times 44$

$= 9.9g$

Mass of C $= \frac{12}{44} \times 9.9 = 2.7g$

Mass of H $= \frac{2}{18} \times 2.7 = 0.3g$

Mass of O $= 3.4 - (2.7 + 0.3) = 0.4g$

Elements	C	H	O
moles	$\frac{2.7}{12}$	$\frac{0.3}{1}$	$\frac{0.4}{16}$
=	0.225	0.3	0.025
Mole ratio	$\frac{0.225}{0.025}$	$\frac{0.3}{0.025}$	$\frac{0.025}{0.025}$
	9 :	12 :	1

5½

Empirical formula is $C_9H_{12}O$

V.P of Q $= 760 - 526 = 234$ mmHg.

$\frac{P_Q}{P_w} = \frac{n_Q}{n_w}$.

$\frac{234}{526} = \frac{77.1/Mr}{22.9/18}$ $Mr = 126$

$\Rightarrow (C_9H_{12}O)_n = 126$

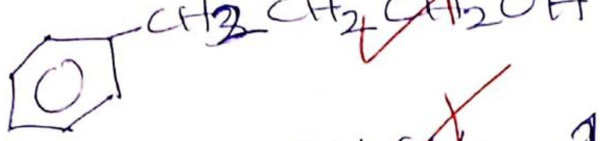
$n = 1$

molecular formula is $C_9H_{12}O$.

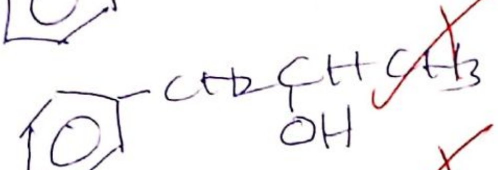
a(i) Steam distillation is separation of a substance immiscible with water from a mixture by passing a current of steam so that the mixture boils at a temperature below 100 °C.

01

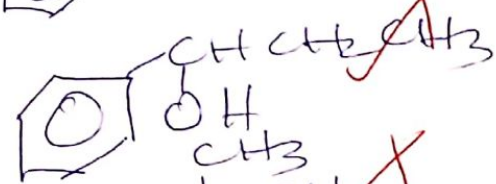
(b)



3-Phenyl propan-1-ol

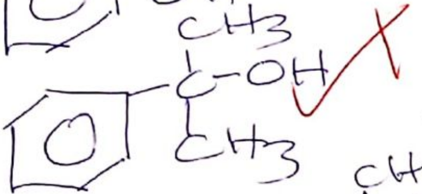


1-phenyl propan-2-ol



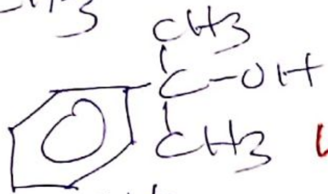
1-Phenyl propan-1-ol

04



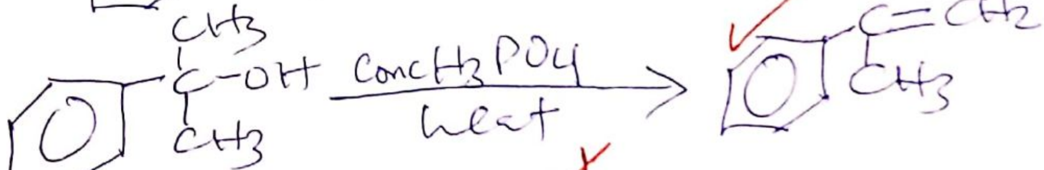
2-phenyl propan-2-ol

c) Q is

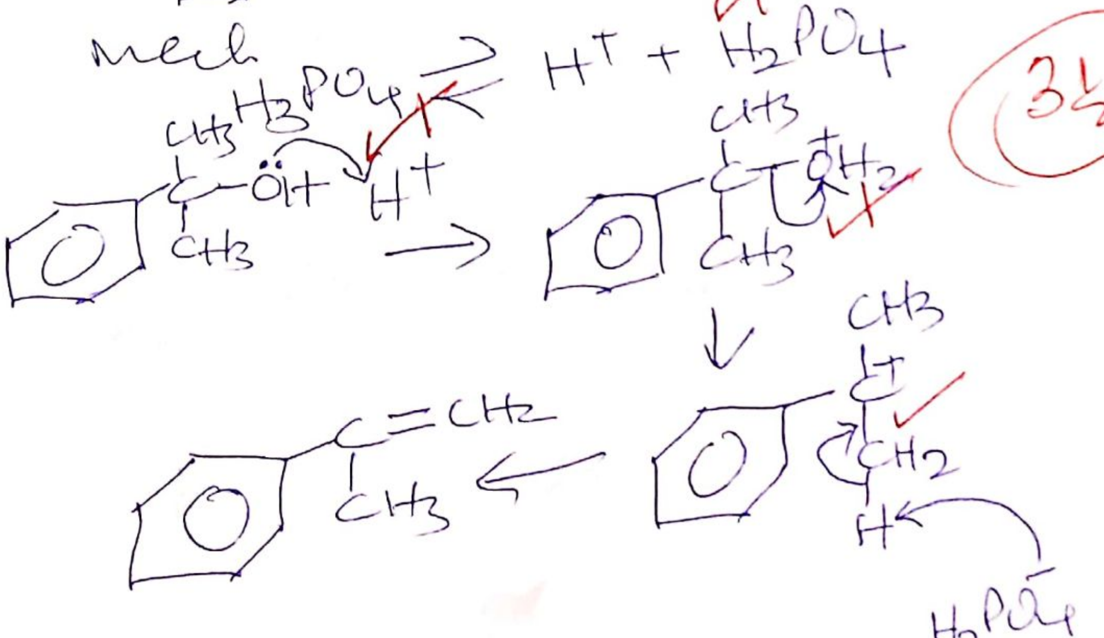


01

d (i)

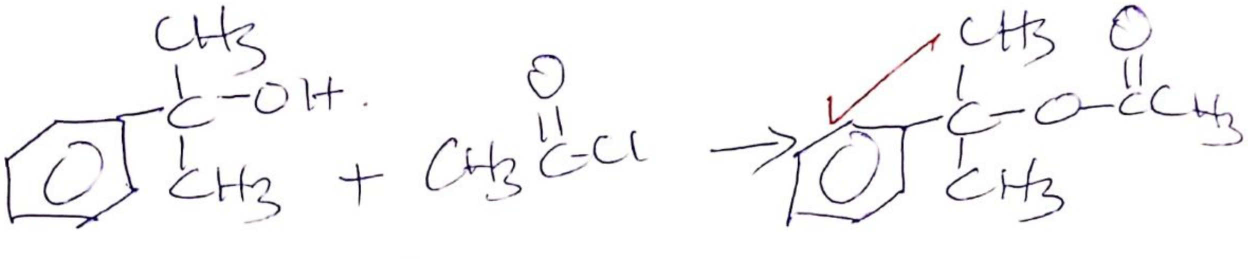


mech

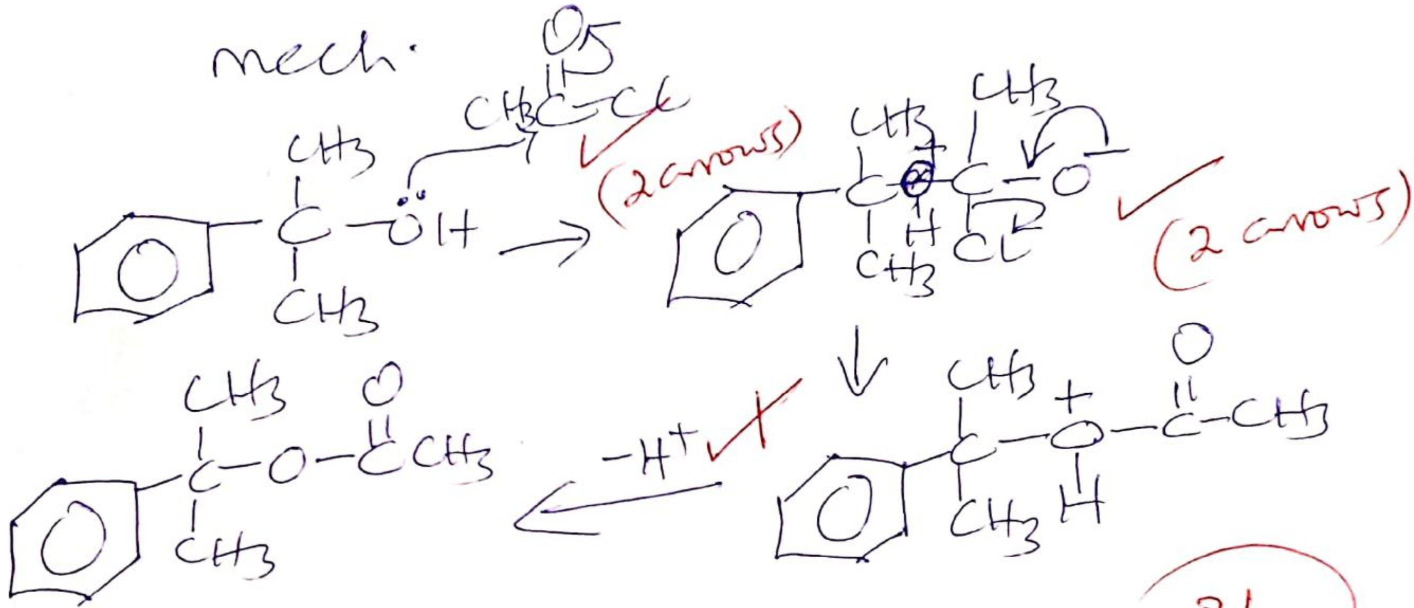


3½

ii)

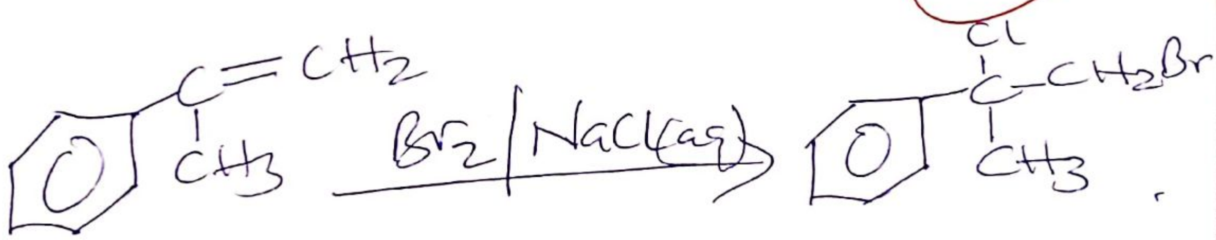


mech.



3½

(e)



Q3 (a) (i) metallic bond.

Factors → Atomic radius.
The larger the atoms, the weaker the metallic bond due to increased distance btn the nucleus and the delocalised electrons.

04

→ No of electrons contributed to the electron cloud per atom.
The more the electrons, the stronger the metallic bond due to increased electrostatic attrn btn the +ve ions & the delocalised es.

(ii) Ionic bond.
→ Ionic charge
The higher the charges, the stronger the electrostatic attractions, hence the stronger the ionic bond.

03

→ Ionic radius
The smaller the ionic radius of the cation, The more closely anions are attracted. Then the stronger the ionic bond.

(iii) Van der waals forces of attraction.
→ No of es in the molecules.
The more the electrons, the stronger the vwfs of attrn.

03

→ Molecular size/mass.
The bigger the molecule, the more the no of contact points for vwfs to

act upon, hence the stronger the forces.

b)(i) m.pts of the metals increase from sodium to aluminium due to increasing no of delocalised electrons per atom.
The m.pt of silicon is very high b'se it has a giant atomic structure ~~where~~ in which each atom is tetrahedrally bonded to 4 other silicon atoms with strong covalent bonds that require much heat energy to break.
The low m.pt of phosphorus is because its molecules are held to one another by weak VWfs of attrn that require low heat energy to break.

(ii) All the fluorides of the metals have giant ionic structures. Due to the rising ionic charge from sodium ion to aluminium ion, ionic bonds become stronger, hence the observed increase in m.pt.
The fluorides of silicon & phosphorus exist ~~as~~ molecules held together by weak VWfs of attraction. The m.pt of SiF_4 is higher b'se its molecules pack more closely that the molecules of ~~Pcl~~ PF_5.

Q.4.

(a) States that "A solute soluble in two immiscible solvents distributes itself btn the solvents in eqbm in a constant ratio of concentration at constant temperature.

03

Condns:

- Solute must not dissociate or associate in any of the solvents.
- Temp must be constant.
- Solute must not react with any solvent.
- Solute must not saturate any of the solvents

etc.

b (i) Solvent extraction is the removal of a substance ~~soluble~~ (or soluble) dissolved in water by addition of an immiscible solvent in which the substance is more soluble.

01

(ii) $[I_2]_{Aq} = \frac{50 - x}{1000}$

$[I_2]_{org} = \frac{x}{500}$

$K_D = \frac{[I_2]_{Aq}}{[I_2]_{org}}$

$0\frac{1}{2}$

(ii) using the graph, $[NH_3]$ in the complex $= 0.60 mol dm^{-3}$.

0.1 moles of Ni^{2+} require 0.6 moles of NH_3.

∴ 1 mole requires $\frac{0.6 \times 1}{0.1}$

$= 6$ moles

01

⇒ $n = 6$.

(iii) $[NH_3]_{Aq}$.

$NH_3(aq) + H^+(aq) \longrightarrow NH_4^+(aq)$.

Moles of HCl reacted $= \frac{1 \times 35}{1000} = 0.035$

Moles of NH_3 reacted $= 0.035$ (1:1)

Total concn of NH_3 in aq layer $= \frac{0.035 \times 1000}{25}$

$= 1.4M$.

$[NH_3]_{org}$.

4½

Moles of HCl reacted $= \frac{20 \times 0.04}{1000}$

$= 0.0008$

Moles of NH_3 reacted $= 0.0008$ (1:1)

Concn of free NH_3 in org layer $= \frac{0.0008 \times 1000}{25}$

$= 0.032M$.

Using the eqn;

$Ni^{2+}(aq) + 6NH_3(aq) \longrightarrow Ni(NH_3)_6^{2+}(aq)$

(0.1M)

$[NH_3]_{complexed} = 6 \times 0.1 = \cancel{1.2M}$ 0.6M.

∴ $[NH_3]_{free}$ in aq layer $= 1.4 - 0.6 = \cancel{0.2M}$ 0.8M.

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(i) $0.2 = \frac{50 - x}{1000} / \frac{x}{500}$ ✓

$x = 35.7g$ ✓

(1½)

(ii) 1st extraction:

$0.2 = \frac{50 - y}{1000} / \frac{y}{250}$ ✓

$y = 27.8g$ ✓

Iodine left $= 22.2g$ ✓

(04)

2nd extraction

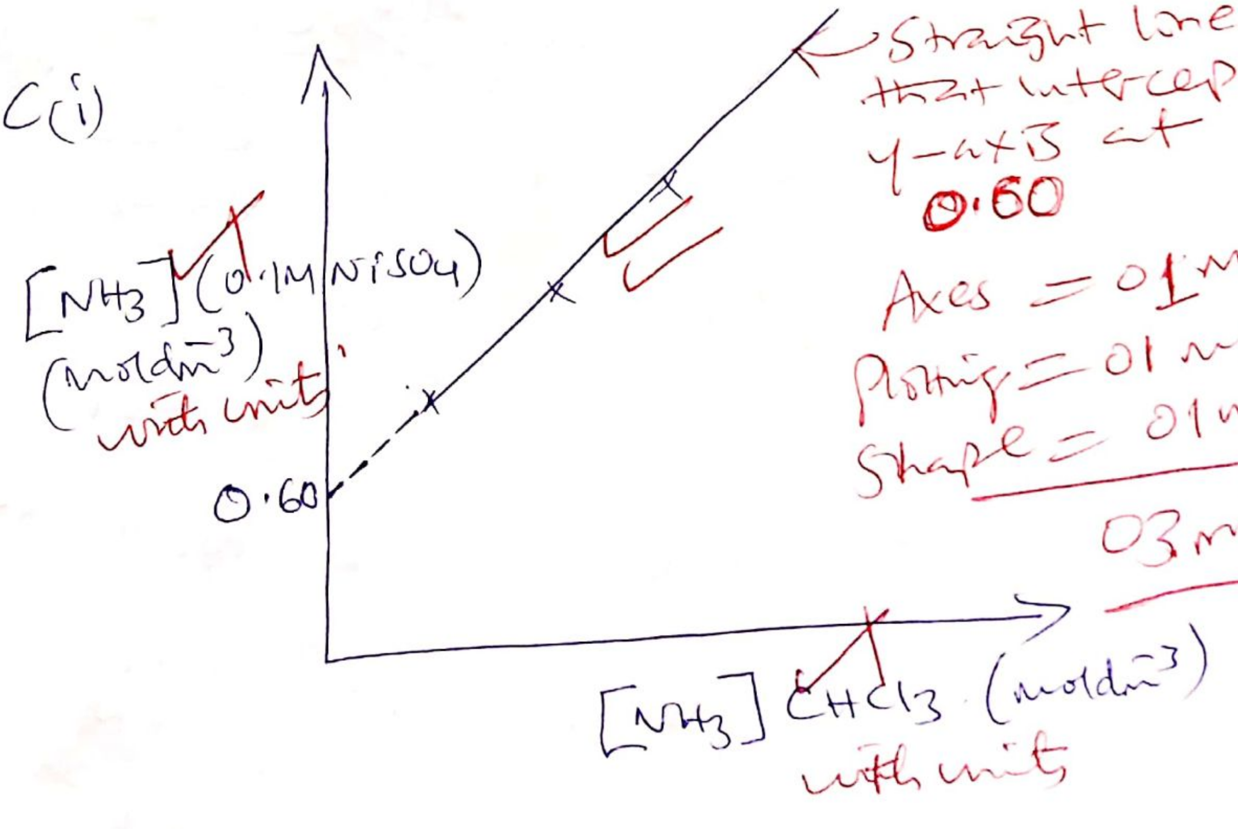
$0.2 = \frac{22.2 - y'}{1000} / \frac{y'}{250}$ ✓

$y' = 12.3g$ ✓

Total extraction $= 27.8 + 12.3$

$= 40.1g \simeq 40g$

C(i)



Axes = 01 mk.

Plotting = 01 mk

Shape = 01 mk.

03 mks

$$KD = \frac{[NH_3]_{free\ Aq\ layer}}{[NH_3]\ org.\ layer} = \frac{0.8}{0.032}$$

1½

$= \cancel{8}25$

Q.5 (a) Hydrogen chloride is more ~~less~~ volatile than sulphuric acid. Therefore, concentrated Sulphuric acid displaces it from Sodium Chloride.

$NaCl(s) + H_2SO_4(l) \rightarrow NaHSO_4(s) + HCl(g).$

Hydrogen bromide is a reducing agent, readily oxidised by conc sulphuric acid to free bromine liquid.

5 max

$2HBr(g) + H_2SO_4(l) \rightarrow SO_2(g) + 2H_2O(l) + Br_2(l)$

(b) Due to high charge density of Chromium (III) ions, the ions are heavily hydrated in solution as hexaaqua chromium (III) ions, which undergo hydrolysis to form hydroxonium ions responsible for acidity of the solution.

3½

$$Cr(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons [Cr(H_2O)_5OH]^{2+}_{(aq)} + H_3O^+_{(aq)}$$

(c) water and aminobenzene are immiscible. When heated, each liquid vapourises independently to form vapour above the mixture. The v.p above the mixture is the sum of their individual (or partial) vapour pressures. Therefore, the total vapour pressure builds up to the external atmospheric pressure at a temperature lower than the b.pt of each pure component, hence the mixture boils at 98°C.

$3\frac{1}{2}$

(d) Following Markonikoff's rule, bromine ~~atom~~ is added to carbon atom of the double bond having more hydrogen atoms as the second carbon becomes electron deficient. Since chloride ions are in higher concentration than bromide ions in the solution, chlorine is added to the electron deficient carbon to form 1-bromo-2-chloropropane as the major product. For formation of 1,2-dibromopropane, bromine molecule alone is added across the double bond. [illegible] forms as the minor product

04

(e) The ethyl group bonded to nitrogen atom exhibits positive inductive effect in which it pushes bonding electrons to nitrogen increasing the electron density around it hence making the lone pair of $\bar{e}s$ more available

02

[illegible] protons.

In phenyl amine, the lone pair of electrons on nitrogen atom is incorporated into the benzene ring, hence making it less available to a proton since electron density is reduced.

02

Q.6 (a)(i) An ion that contains a central ion linked to other atoms, ions or molecules called ligands through dative bonding. 02

(ii) - High ionic charge.
- Small ionic radius   any 2   01
- Presence of empty d-orbitals.

(b) (i) The green solution turned to a yellow solution and finally orange solution.

$2Cr^{3+}_{(aq)} + 4OH^-_{(aq)} + 3O_2^{2-}{}_{(aq)} \rightarrow CrO_4^{2-}{}_{(aq)} + 2H_2O_{(l)}$

$2CrO_4^{2-}{}_{(aq)} + 2H^+_{(aq)} \rightleftharpoons Cr_2O_7^{2-}{}_{(aq)} + H_2O_{(l)}$.

$4\frac{1}{2}$

(ii) The green solid dissolved to form a blue solution.

$Ni(OH)_{2(s)} + 6NH_{3(aq)} \rightarrow Ni(NH_3)_6^{2+}{}_{(aq)} + 2OH^-_{(aq)}$

$2\frac{1}{2}$

(iii) Green precipitate soluble in hydrochloric acid forming green solution.

$1\frac{1}{2}$

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$Ni(NH_3)_6^{2+}(aq) + 2OH^-(aq) + H^+(aq) \rightarrow Ni(OH)_2(S) + NH_4^+ + 5NH_3(aq)$

$Ni(OH)_2(S) + 2H^+(aq) \rightarrow Ni^{2+}(aq) + 2H_2O(l)$. 03

e (i) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(S)$ $1\frac{1}{2}$

(ii) White precipitate dissolved in excess ammonia to form colourless solution 04

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

$AgCl(s) + 2NH_3(aq) \rightarrow Ag(NH_3)_2^+(aq) + Cl^-(aq)$

Q7 (a) (i) A solution in which no more solute dissolves at a particular temperature in presence of excess undissolved solute.

(ii) Mass of a solute required to saturate 100g of a solvent at a given temperature.

(iii) Product of the molar concentrations of ions of a sparingly soluble salt in a saturated soln of the salt at a given temperature where each concentration is raised to an appropriate power.

b (i) Let $[Ag_3PO_4] = S$.

$$Ag_3PO_{4(s)} + aq \rightleftharpoons 3Ag^+_{(aq)} + PO_{4(aq)}^{3-}$$

$$S \qquad\qquad 3S \qquad S$$

$$K_{sp} = [Ag^+]^3[PO_4^{3-}]$$

$$1.4\times10^{-21} = (3S)^3 \cdot S$$

$$\cancel{27}\ 9S^4 = 1.4\times10^{-21}$$

$$S = \cancel{3.531}\times10^{-6}\ mol\,dm^{-3}$$

RFM of $Ag_3PO_4 = (3\times108) + 31 + 64$

$$= 419$$

$\therefore$ solubility in $g\,l^{-1} = \cancel{3.531}\times10^{-6}\times419$

$$= 1.48\times10^{-3}\ g\,dm^{-3}$$

04

(ii) $[Ag^+] = 3S$

$$= 3\times\cancel{3.531}\times10^{-6}$$

$$= 1.0593\times10^{-5}\ mol\,dm^{-3}$$

01

C(i) A known mass of Strontium hydroxide is added to a known volume of water in a flask. The mixture is shaken (or stirred) for several minutes & left to settle so as to attain equilibrium.
The top clear portion (or soln) is carefully pipetted into a conical flask and titrated with standard hydrochloric acid using methyl orange indicator.
The titre value obtained can be used to determine the molar concentration of hydroxyl ions in the solution.

06

Using the eqn;

$$Sr(OH)_2(s) + aq \rightleftharpoons Sr^{2+}(aq) + 2\bar{O}H(aq)$$

$$[Sr^{2+}] = \frac{1}{2}[\bar{O}H]$$

Since $Ksp = [Sr^{2+}][\bar{O}H]^2$

$\Rightarrow$ $Ksp = \frac{1}{2}[\bar{O}H][\bar{O}H]^2$

$\therefore$ $Ksp = \frac{1}{2}[\bar{O}H]^3$.

(ii) Moles of NaOH reacted $= \frac{12.55 \times 0.025}{1000}$

$= 0.00031375$ moles.

Moles of xss HCl reacted $= 0.00031375$

∴ $20\,cm^3$ of soln cont. 0.00031375 moles of xss HCl

∴ $250\,cm^3$ " " $\left(\frac{0.00031375 \times 250}{20}\right)$ " "

$= 0.003921875$ moles.

Initial moles of HCl $= \frac{50 \times 0.2}{1000}$

$= 0.01$

moles of HCl reacted with $Sr(OH)_2 = 0.01 - 0.003921875$

$= 0.006078125$

Moles of $Sr(OH)_2$ reacted $= \frac{1}{2} \times 0.006078125$ moles

$= 0.003039062$ moles.

∴ $25\,cm^3$ of saturated soln cont. 0.003039062 moles of $Sr(OH)_2$

∴ $1000\,cm^3$ " " $\frac{0.003035062 \times 1000}{25}$

$= 0.12\,M$

05

$$Sr(OH)_2(s) + aq \rightleftharpoons Sr^{2+}(aq) + 2OH^-(aq)$$

0.12   0.12 2×0.12

max

$K_{sp} = [Sr^{2+}][OH^-]^2$

$= 0.12 \times (0.12 \times 2)^2$

$= 6.912 \times 10^{-3}\, mol^3\, dm^{-9}$

(d) – Determination of solubility products

– Fractional crystallisation (or precipitation)

01

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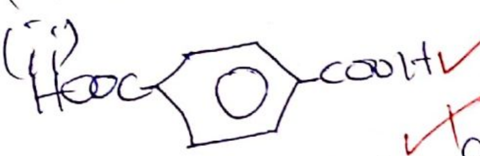
Q8 (a) Addn: Joining together of several small molecules repeatedly to form a polymer without loss of simpler molecules such as water.

03

condensation: Joining together of several small molecules repeatedly to form a polymer with loss of simpler molecules such as water.

07

b (i) Condensation polymerisation

(ii)  and 

Benzene-1,4-dioic acid. Benzene-1,4-diol.

03

(c)(i) $\Pi V = nRT$

$1400 \times 1000 \times 10^{-6} = \frac{0.09}{Mr} \times 8.314 \times 298$

04

$Mr = 59.3$

∴ molar mass is 59.3 g with units

(ii) Polymers have high relative molecular masses. A given mass of a polymer produces negligible changes in boiling and freezing points, difficult to measure but a small quantity exerts high osmotic pressure that can be measured easily.

03

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(d) (i) By placing a small amount on white paper. A greasy spot spreads outwardly. 01

ii) Sunflower seeds
Simsim seeds

(iii) - Heating
- use of concentrated sodium hydroxide. 01

(iv)

$$CH_3(CH_2)_{16}COOCH_2 \quad | \quad CH_3(CH_2)_{16}COOCH \quad | \quad CH_3(CH_2)_{16}COOCH_2 + 3NaOH(aq) \longrightarrow CH_2OH \quad | \quad CHOH \quad | \quad CH_2OH + 3CH_3(CH_2)_{16}COONa(s)$$

02

(v) Removing grease from fabrics. 01

END