Zahira College
Board of Examinations

E M

Third Term Test - 2021

Grade 13 | **Chemistry - I** | **2 Hrs.**

Admission No :.....Class :.....

- Answer all the question.

Universal gas constant	**$R = 8.314\ JK^{-1}mol^{-1}$**
Avogadro constant	**$N_A = 6.022 \times 10^{23}\ mol^{-1}$**
Planck's constant	**$h = 6.626 \times 10^{-34}\ Js$**
Velocity of light	**$C = 3 \times 10^{8}\ ms^{-1}$**
Faraday's constant	**$96500\ Cmol^{-1}$**

(01) The one who revealed that the charge to mass ratio of cathode ray particles obtained from different gases were same was,

(1) Earnest Rutherford (2) William Crookes (3) J.J. Thomson
(4) Stoney (5) Millikan

(02) The correct order of increasing 1st ionization energies,

(1) $K < Li < O < N < Ar < Ne$ (2) $Ne < Ar < N < O < Li < K$
(3) $K < Li < O < N < Ne < Ar$ (4) $K < O < Li < N < Ar < Ne$
(5) $Li < N < O < K < Ar < Ne$

(03) Correct IUPAC name of below compound is,

$$CH_2 = CH - \underset{\displaystyle OH}{\underset{|}{CH}} - \underset{\displaystyle CONH_2}{\underset{|}{CH}} - CH_2CH_3$$

(1) 2-ethyl-3-hydroxypent-4-enamine
(2) 4-aminohex-1-en-3-ol
(3) 2-ethyl-3-hydroxypentenamide
(4) 3-hydroxy-2-ethyl-4-pentenamide
(5) 2-ethyl-3-hydroxypent-4-enamide

(04) X is a non-transition element in 3rd period. It forms compound XCl_4^- with see-saw shape. The correct set of quantum numbers an electron in the last sub energy level of X can have is,

(1) $n = 3, \ell = 2, m_\ell = -1, m_s = +{}^1/_2$ (2) $n = 3, \ell = 1, m_\ell = 1, m_s = -{}^1/_2$
(3) $n = 3, \ell = 0, m_\ell = 0, m_s = -{}^1/_2$ (4) $n = 2, \ell = 1, m_\ell = -1, m_s = +{}^1/_2$
(5) $n = 2, \ell = 0, m_\ell = 0, m_s = +{}^1/_2$

(05) A, B, C, D & E are consecutive elements in the same period. Their 1st ionization energies take the order, $A < B < D < C < E$. Which of them can take a $(+ve)$ value for $\triangle H_{EG}$

(1) A (2) B (3) C (4) D (5) E

(06) The composition of an NH_4OH solution is 30%(w/w) & the density is $0.9 gcm^{-3}$. In order to prepare $850 cm^3$ of $2 moldm^{-3}$ NH_4OH solution, how much volume (cm^3) should be taken from initial NH_4OH solution.

$(\boldsymbol{N = 14}, \boldsymbol{H = 1}, \boldsymbol{O = 16})$

(1) 123 (2) 190 (3) 204 (4) 220 (5) 267

(07) $X \xrightarrow{CH_3MgCl} CH_4$, in this conversation X cannot be,

(1) CH_3CH_2OH (2) CH_3NH_2 (3) NH_3

(4) CH_3COOH (5) CH_3C00CH_3

(08) Select the false statement about Na,

(1) Gives a yellow colour flame in flame test.

(2) When heated with a stream of $H_{2(g)}$form ionic $NaH_{(s)}$

(3) On reaction with $O_{2(g)}$ sodium peroxide is mainly produced with some sodium oxide.

(4) In the group to which Na belongs, thermal decomposition of bicarbonates increases down the group.

(5) Density of Na is lower than that of H_2O

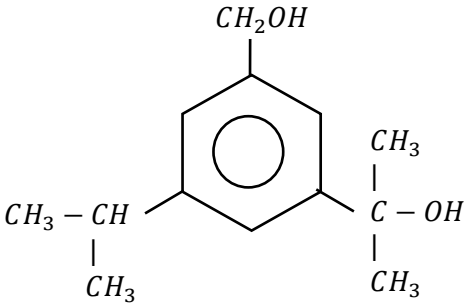
(09) Correct order of increasing acidity.

(1) $MgO < Al_2O_3 < P2O5 < Cl_2O_7 < SO_3$ (2) $MgO < Al_2O_3 < SO_3 < P_2O_5 < Cl_2O_7$

(3) $Al_2O_3 < MgO < P_2O_5 < SO_3 < Cl_2O_7$ (4) $Cl_2O_7 < MgO < P_2O_5 < SO_3 < Al_2O_3$

(5) $MgO < Al_2O_3 < P_2O_5 < SO_3 < Cl_2O_7$

(10) When compound A is reacted with $H^+/KMnO_4$,the product can be,



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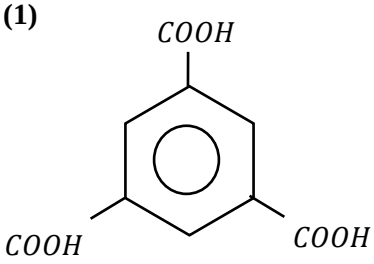

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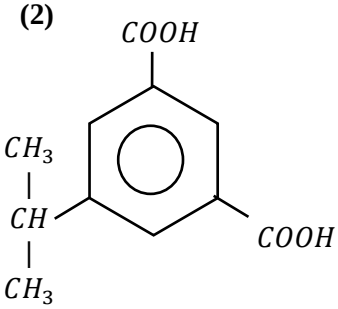

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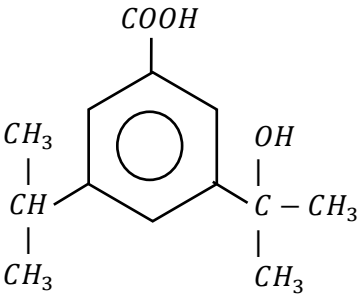

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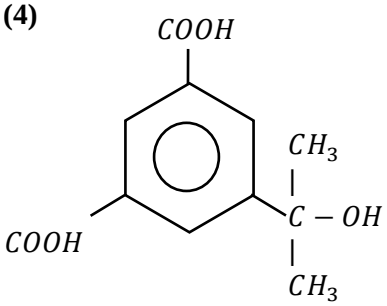

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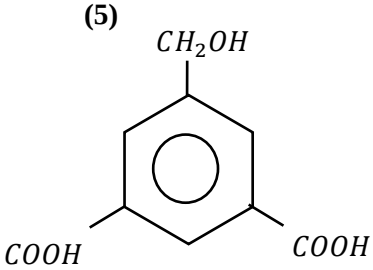


(11) $8.0g$ of a particular gas is in a rigid container with a volume $3.0dm^3$& under a pressure of $2.05 \times 10^5 Pa$ The mean square speed of the gas is,

(1) $2.0 \times 10^4 m^2 s^{-2}$ (2) $2.3 \times 10^5 m^2 s^{-2}$

(3) $2.4 \times 10^6 m^2 s^{-2}$ (4) $7.6 \times 10^4 m^2 s^{-2}$

(5) Data given is insufficient

(12) Select the correct statement about $[Co(NH_3)_5Cl]SO_3$

a) Oxidation no. of Co is +3
b) Forms a white precipitate with an aqueous solution of $Ba(NO_3)_2$
c) With aqueous NaOH and Nessler's reagents gives a brown color precipitate.
d) With $Pb(NO_3)_2$ gives a white color precipitate soluble in hot water.

(1) only (a) (2) Only (a) & (b) (3) Only (a)& (c)
(4) only (a), (b)& (c) (5) only (a),(b), & (d)

(13) Select incorrect statement,

(1) Among allotropic forms of Sulphur, rhombic and monoclinic forms are crystalline.
(2) N form oxides for it's all $+ve$ oxidation states.
(3) $NH_{3(g)}$with excess Cl_2 form NCl_3& HCl
(4) Thiosulphuric acid at room temperature dissociates giving S.
(5) NH_3 act as a week oxidant with CuO

(14) At $25°C$ $X\ moldm^{-3}$ of CH_3COOH is reacting with Ymoldm^{-3} NaOH. At equivalence point pH is equal

S = Concentration of salt
K_a= Dissociation constant of acid
K_w = Dissociation constant of water at$25°C$

(1) $\frac{1}{2}pKa + \frac{1}{2}pKw + \frac{1}{2}logS$ (2) $pKw + logY$

(3) pKa (4) $\frac{1}{2}pKa - \frac{1}{2}log\ X$

(5) $-\frac{1}{2}pKa - \frac{1}{2}pKw + \frac{1}{2}logS$

(15) 10.00cm^3 of a sample of natural vinegar (density = 1.07g/cm^3) was titrated with 0.428M NaOH using a suitable indicator. End point reading was 25.00cm^3. Calculate the mass percentage of weak acid present vinegar. (C=12, O=16, H=1)

(1) 0.0658% (2) 3.3% (3) 7.65%
(4) 6.58% (5) 0.7%

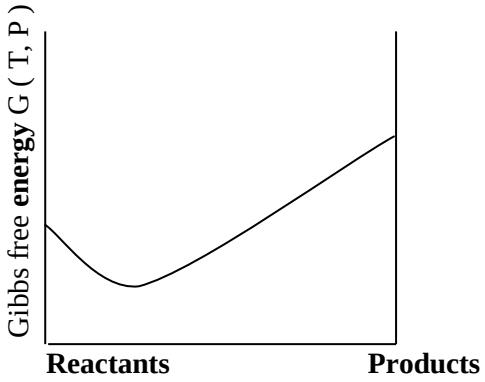
(16) Arrange the following compounds in increasing order of basicity,

A	**B**	**C**	**D**	**E**
CH_3NH_2	$C_6H_5NH_2$	$CH_3-\overset{\overset{O}{\|\|}}{C}-\underset{\underset{C_6H_5}{\|}}{NH}$	$CH_3NHC_2H_5$	$CH_3NHC_6H_5$

(1) C < D < B < A < E (2) A < E < B < D < C (3) C < B < E < A < D
(4) C < B < A < D < E (5) C < A < E < B < D

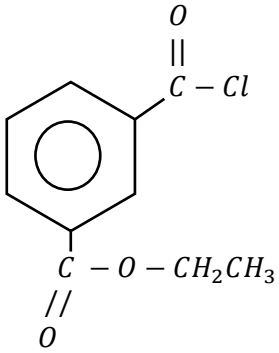
(17) Select the true statement on reaction related to given graph.

(1) Above reaction is spontaneous.
(2) The equilibrium constant of above reaction is less than 1.
(3) Above is an endothermic reaction.
(4) The reaction goes to completion at high temperature.
(5) Entropy of products is always greater than entropy of reactants.



(18) $SO_{2(g)} + NO_{2(g)} \leftrightharpoons SO_{3(g)} + NO_{(g)}$
At a certain temperature $Kc = 16$ for above reaction. 1 mol each from above all 4 gases were taken into a rigid container with volume ldm^3 and allowed to attain equilibrium. Equilibrium concentrations of $NO_{(g)}$ & $NO_{2(g)}$ respectively are,
(1) 0.16 & 0.4
(2) 0.4 & 0.4
(3) 0.4 & 1.6
(4) 0.6 & 1.4
(5) 1.6 & 0.4

(19) Consider given organic compound. Identify product/s when it is allowed to react with excess CH_3MgBr/dry ether and then treated with H^+/H_2O,



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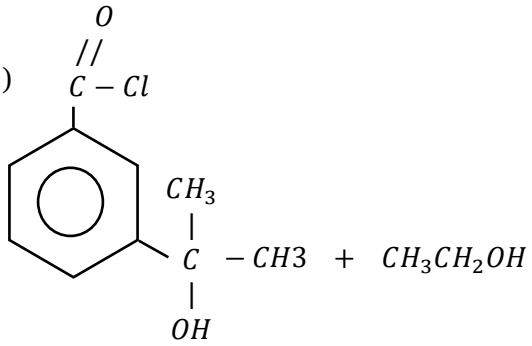

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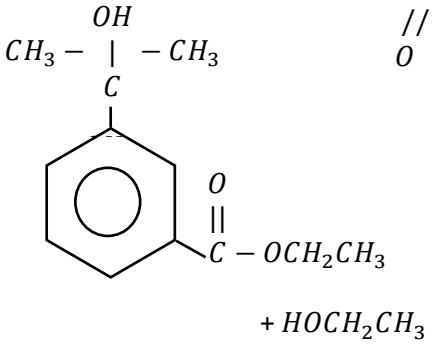

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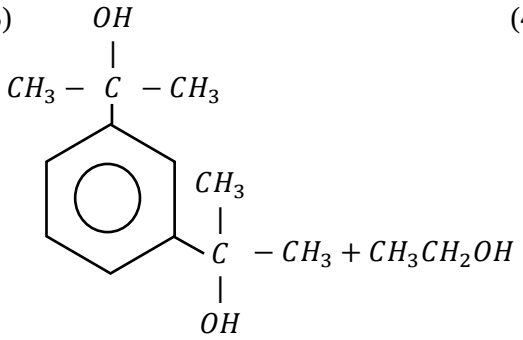

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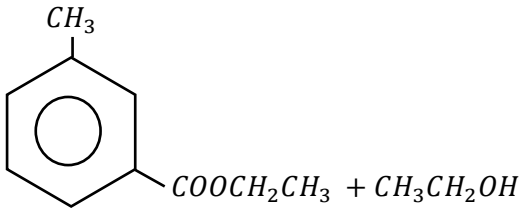

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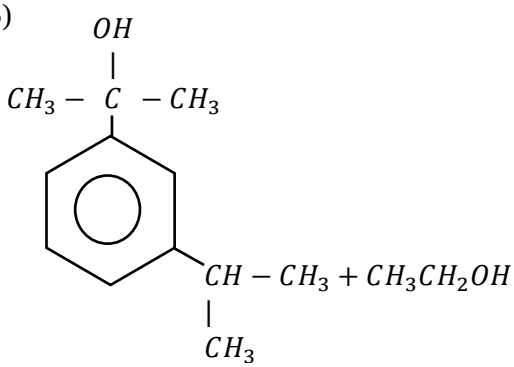


(20) Liquids A and B forms an ideal solution when mixed. When the molar composition of A is changed from 0.2 to 0.6, it was observed that the total vapor pressure (P_T) gets doubled. Temperature was maintained constant during this process and saturated vapor pressure of A and B are P^0_A and P^0_B respectively. The correct relationship is,

(1) $P_T = P^0_B + 6P^0_A$
(2) $P_T = P^0_B (5X_A+1)$
(3) $P_T = P^0B (5-6XB)$
(4) $P_T = P^0B (\frac{1-5XA}{6})$
(5) $P_T = 6P^0_B.X_A$

(21) When a small amount of $NH_4Cl_{(s)}$is added to water, it dissolves easily & it was observed that the system is cooled. Which of the following option is corrected regarding this process.?

	Δ G	$\Delta_s H$	ΔS
(1)	-	-	+
(2)	-	+	+
(3)	+	+	+
(4)	0	+	+
(5)	0	-	-

(22) Select incorrect statement regarding conductivity,
(1) When the temperature is increased conductivity of a solution also increases.
(2) Conductivity of H^+ ions is greater than Na^+ ions.
(3) To analyze ion concentration of a water sample conductivity is used.
(4) SI unit of a conductivity S & conductance is Sm^{-1}.
(5) To find out the point of a titration between NaOH & CH_3COOH conductivity can be used.

(23) M is a divalent metal. A solution of $CuSO_4$ is electrolyzed using M electrodes by passing a current of 5mA. Mass of cathode increased by 21.74g & mass of anode got decreased by 8.32g M can be,

$$(Mg = 24, \quad Ni = 58.6, \quad Fe = 56, \quad Cu = 63.5, \quad Zn = 65.38)$$

(1) Ni (2) Cu (3) Fe (4) Zn (5) Mg

(24) A sample of $CO_{2(g)}$was under pressure of $0.5 \times 10^5 Pa$ at $1000K$. When a small amount of graphite powder is added to system following equilibrium get established, $CO_{2(g)} + C_{(S)} \rightleftharpoons 2CO_{(g)}$.The overall pressure of the system at equilibrium was, $0.8 \times 10^5 Pa$. Calculate Kc of the system.
(1) $1.8 \times 10^5 (RT)$ (2) $1.8 \times 10^5 \left(\frac{1}{RT}\right)$ (3) $1.8 \times 10^5 Pa$
(4) 1.8×10^5 (5) $1.8 \times 10^5 moldm^{-3}$

(25) At 25℃, pH of a saturated solution of $Mg(OH)_2$ was 10.45. Solubility product of $Mg(OH)_2$ at 25℃ is, $(Kw = 1 \times 10^{-14} mol^2 dm^{-6})$
(1) $2.24 \times 10^{-11} mol^3 dm^{-9}$ (2) $3.36 \times 10^{-11} mol^3 dm^{-9}$
(3) $1.12 \times 10^{-11} mol^3 dm^{-9}$ (4) $5.60 \times 10^{-12} mol^3 dm^{-9}$
(5) $3.36 \times 10^{-9} mol^3 dm^{-9}$

(26) pH of a solution which contains a weak acid and its salt NaA is x. If the value of concentration of salt to acid ratio is increased by 10 times, the new pH of the solution is,

(1) x-1 (2) x+1 (3) 1/x (4) X-10 (5) X+1

(27) To an inorganic compound Y when dil. HCl is added gives a brown colour gas and a coloured solution. When conc.NH_3 is added to the coloured solution it turns yellow-brown, to the same when H_2O_2 is added turns brownish red. Y can be,
(1) $Cu(NO_3)_2$ (2) $Cr(NO_2)_3$ (3) $CuBr$
(4) $Co(NO_2)_2$ (5) $Fe(NO_2)_2$

(28) Select the incorrect statement regarding NaOH production through membrane cell method.
(1) Anode and cathode material used are Ti & Ni respectively.
(2) During electrolysis Na^+ ion migrate to cathodic chamber through selective membrane.
(3) In the cathodic chamber $Cl_{2(g)}$is formed on Ni cathode.
(4) Higher purity NaOH is produced through this method.
(5) NaOH is formed in cathodic chamber.

(29) At temperature T a gas mixture is under pressure $1 \times 10^5 Pa$. The volume fraction of gas A in it is 0.21 Then the gas mixture was compressed until the volume is $1/10^{th}$of initial. Calculate new partial pressure of A in Pa.
(1) 1×10^5 (2) 2.1×10^5 (3) 2.1×10^3 (4) 11×10^4 (5) 1.1×10^6

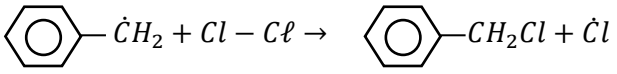
(30) For the reaction $NO_{2(g)} + CO_{(g)} \rightarrow NO_{(g)} + CO_{2(g)}$, the experimentally observed rate law is, $R = k[NO_{2(g)}]^2$
Select the correct statement.
(1) The mechanism of the reaction can be
Step 1: $NO_{2(g)} + NO_{2(g)} \rightarrow NO_{3(g)} + NO_{(g)}: slow$
Step 2: $NO_{3(g)} + CO_{(g)} \rightarrow NO_{2(g)} + CO_{2(g)}$
(2) Reaction can be elementary.
(3) When$[CO_{(g)}]$ is double rate doubles.
(4) Magnitude of$k$quadruples when $[NO_{2(g)}]$ doubles.
(5) Reaction proceeds through only one transition state.

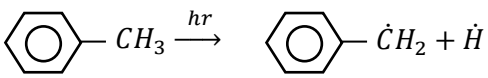
- For each of the questions from 31 to 40 one or more responses out of four responses (a), (b), (c) and (d) given is/are correct. Select the correct response in accordance with the instructions given below. Mark.
(1) If only (a) and (b) are correct.
(2) If only (b) and (c) are correct
(3) If only (c) and (d) are correct
(4) If only (a) and (d) are correct
(5) If any other number or combination of responses is/are correct.

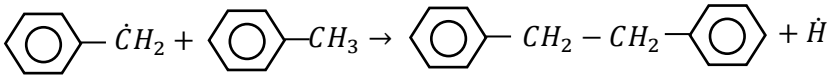
(31) Two acids HA(strong) and HB (weak) are neutralized by NaOH. The enthalpy of neutralization was found to be -57kJmol^{-1}& -54kJmol^{-1} respectively. Select the correct statement.
(a) $\Delta H = -57\text{kJmol}^{-1}$,for the reaction.
$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell)}$$
(b) $\Delta H = +3kJmol^{-1}$,for the reaction $HB_{(aq)} \rightarrow H^+_{(aq)} + B^-_{(aq)}$
(c) When 100 cm^3 of 0.1$moldm^{-3}$ HCl is neutralized heat released will be $5.7kJ$.
(d) $\Delta H = +3\text{kJmol}^{-1}$, for hydration of A^- ion.

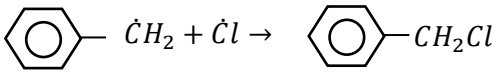
(32) Select the correct statement,
(a) In Dow process limestone is used as a raw material.
(b) In contact process to produce $SO_{3(g)}$ high pressure is used.
(c) In Solvay process $NH_3$is added in second tower through counter current principal.
(d) In Haber Process the enthalpy is $-ve$ for the reaction between N_2 & H_2 thus lower temperature condition (<300℃) are used.

(33) Step/s of chlorination of a toluene in the presence of Sunlight can be,

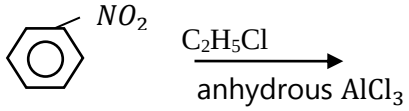
(a) 

(b) 

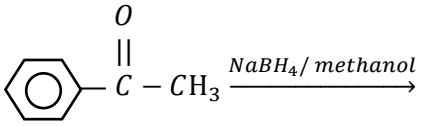
(c) 

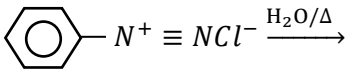
(d) 

(34) The product/s obtained by which of the following reaction/s can be oxidized by $H^+/KMnO_4$

(a) 

(b) $CH_3CH_2CHO \xrightarrow[2.\,H^+/H_2O]{1.\,LiAlH_4/ether}$

(c) 

(d) 

(35) A sample of water taken from a certain area consist of Na_2CO_3 and $NaHCO_3$. By which of the following method/s given, the concentration of Na_2CO_3 and $NaHCO_3$ in 25.00cm^3 of a sample can be determined by titrating with 1M HCl.

(a) Using phenolthalein as the indicator.
(b) First using methyl orange as the indicator and further titrating same solution using phenolthalein as indicator.
(c) First using phenolthalein as the indicator and further titrating same solution using methyl orange as indicator.
(d) Titrate two 25.00cm^3 samples separately using phenolthalein indicator for one and methyl orange indicator for the other.

(36) A sample of acetic acid is neutralized by equivalent amount of ammonia. Select correct statement regarding above titration.

(a) At equivalence point, pH = $7 + \frac{1}{2}(pK_a - pK_b)$.
(b) Indicators with pK_{In} value < 7 are ideal for above titration
(c) If $K_a > K_b$ the solution is acidic & if $K_a < K_b$ the solution is basic.
(d) At equivalence point pH is governed by hydrolysis of CH_3COOH and NH_3 .

(37) Select the incorrect statement on H_2SO_4

(a) Turns blue colour $CuSO_4$ solid to white.
(b) conc H_2SO_4 act as dehydrating agent with liquid ethanol.
(c) Cl_2 gas is liberated when added to solid KCl.
(d) It cannot oxidize HBr.

(38) Which of the following statement/s is/are correct regarding steam distillation?

(a) The Essential oil must have low vapour pressure around 100 ℃.
(b) This principle is very useful in purification of temperature sensitive compound like phenylamine.
(c) The Essential oil must be immiscible with water.
(d) The mixture will boil at a temperature lower than the boiling points of the pure components.

(39) The standard electrode potentials of metal/metal ion electrodes, P/P^+ and Q/Q^{2+} are 0.80 and -0.44 respectively. Which of the following reaction/s is/are consistent with the above potentials?

(a) $2P(s) + Q^{2+}(aq) \rightarrow 2P^+(aq) + Q(s)$
(b) $Q(s) + 2H^+(aq) \rightarrow H_2(g) + Q^{2+}(aq)$
(c) $H_2(g) + P_2O(s) \rightarrow 2P(s) + H_2O(l)$
(d) $H_2O(l) + P(s) \rightarrow H_2(g) + POH(aq)$

(40) Whichof the following can be used to differentiate between $NaCl$ & NaI,

(a) $Cl_2/CHCl_3$
(b) $conc\ H_2SO_4$
(c) $dil\ NH_3$
(d) $dil\ HNO_3$

- From question no 41 to 50 two statements are given. Select the correct response as instructions given below.

Statement 1	Statement 2	Response
True	True & explains 1st statement	1
True	True but do not explain 1st statement	2
True	False	3
False	True	4
False	False	5

Statement 1	Statement 2
(41) The inverse of resistance (R) is conductance (G)	the inverse of resistivity (ρ) is conductivity (κ)
(42) NO_2 is green house gas.	Heteroatomic gases stable in atmosphere and are capable of absorbing IR radiation are greenhouse gases.
(43) Normal Leclanche cell is a secondary cell.	The cells that can be recharged by reversing the cell reaction are called secondary cells.
(44) NCl_3 can be used as a water disinfectant.	NCl_3 on reaction with water from hypochlorous acid
(45) At temperature above 373K water vapour cannot be condensed.	Liquid water cannot exist above normal boiling temperatures.
(46) When at constant temperature the $[HCl_{(aq)}]$ in an aqueous sample is decreased by 100 times, pH would increase by 2 units.	When at constant temperature the$[CH3COOH_{(aq)}]$ in an aqueous sample is decreased by 100 times, pH would increase by 1 unit.
(47) Coagulation of natural rubber latex is promoted by dil. acids while retarded by bases like ammonia.	In natural rubber latex, the rubber particles are enclosed by a protein layer which is negatively charged.
(48) Butan-2-ol gives a turbidity with conc. $HCl/ZnCl_2$ within a short time compared to 2-methylpropan-2-ol	Tertiary carbonium ions are more stable than secondary carbonium ions
(49) Two samples of $Cu^{2+} and\ Al^{3+}$ can be distinguished using $NH_{3(aq)}$	Both Cu and Al forms clear solution with excess NaOH
(50) When a molecule of an ideal gas bounces off the wall of the container, the momentum of the molecule changes	When a molecule bounces off the wall, its speed as well as the direction changes.

Zahira College
Board of Examinations

E I

Third Term Test - 2021

Grade 13	Chemistry - II	3 Hrs.

Admission No :.....Class :.....

Part A - Structured Essay

Answer all the questions

Universal gas constant	**R = 8.314 $JK^{-1}mol^{-1}$**
Avogadro constant	**N_A = 6.022 $\times 10^{23}$ mol^{-1}**
Planck's constant	**h = 6.626 $\times$ 10^{-34} Js**
Velocity of light	**C = 3 $\times$ 10^{8} ms^{-1}**
Faraday's constant	**96500 $Cmol^{-1}$**

(01)

(a) Answer below questions based on elements given.

$$Cr, Co, Mn, C, N, Si, S$$

(i) The element/s that forms amphoteric oxide with +3 oxidation state.

_____

(ii) State the element/s which combines with O to form a compound with high melting point.

_____

(iii) A chloride of an element on hydrolysis gives a mixture of two acid and a turbid solution. The element is,

_____

(iv) A strong oxoacid formed by one of above element is unstable under sunlight. The element is.

_____

(v) The element/s which shows highest oxidation state.

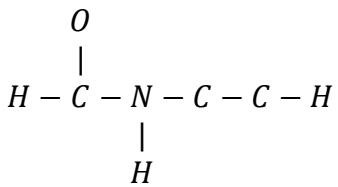
_____

(vi) The exceptional element/s that forms coloured compounds with empty d-orbitals.

_____

(b)

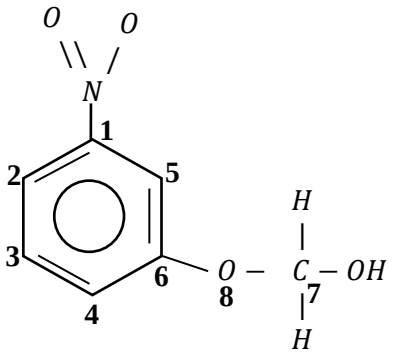
(i) Draw most suitable Lewis structure for C_3H_3NO,



(ii) Draw three possible resonance structures for below compound,

$$R - \underset{\displaystyle O}{\overset{|}{C}} - N - N - N$$

- Consider below molecule and answer questions (iii), (iv) and (v).



(iii) Complete the table.

	C_5	N	C_7	O_8
No. of VSEPR units				
Electronic geometry				
Molecular geometry				
Hybridization				

(iv) Identify the atomic/hybrid orbital involved in formation of following σ bonds.

1) $N - C_1$ N____ C_1_____

2) $C_5 - C_1$ C_5____ C_1_____

3) $C_6 - O$ C_6____ O_____

(v) Identify the atomic orbitals involved in formation of below π bonds,

1) $N - O$ N____ O____

2) $C_3 - C_4$ C_3____ C_4____

(c) Arrange the following in increasing order of the property given in parenthesis.

(i) CO_2, NH_3, He, Ne (Boiling point) _____

(ii) C_2H_4, CCl_4, CO, CF_4 (Electro-negativity of C) _____

(iii) $SO_2, SOCl_2, S_2O_3^{2-}, SO_4^{2-}$ (S-O bond length) _____

(iv) $Li_2CO_3, Na_2CO_3, K_2CO_3$ (Solubility in water) _____

(v) Microwaves, $Xrays$, γ-rays, IR Rays (wavelength) _____

(02)

(a) Z is an element in 3rd period. It reacts with $F_{2(g)}$ and form compounds Z_1 & Z_2. Z_1 takes see-saw shape and Z_2 is octahedral in shape. Z is used as a raw material in an important industrial process and occur as a natural ore.

(i) Identify Z_____

Z_1_____

Z_2_____

(ii) Give reason for identifying above element as Z,

_____

(iii) Write ground state electronic configuration of Z.

_____

(iv) Identify and draw the structure of most commonly occurring and most stable allotropic form of Z.

(v) Write balanced chemical equations for reactions of Z with

conc. HNO_3:-_____

conc H_2SO_4 :-_____

(vi) State two other allotropic form of Z.

_____

(vii) Z on reaction with O_2 forms two stable compounds E & F. Write balanced chemical equation for E & F reaction with water.

E:-_____

F:-_____

(viii) State 1 use of Z

_____

(b) Test performed separately to identify compounds ZnS, $SbCl_3$, Li_2CO_3, $CaSO_3$ & KNO_2 are given with relevant observations.

	Test 1 Test for the solubility in water	**Test 2** Addition of dil HCl
A	Insoluble, results a white precipitate	Dissolved forming a colourless solution & a colourless gas
B	Soluble	Evolved a brown colour gas
C	Insoluble	Dissolved forming a colourless gas that turns $Cr_2O_7^{2-}/H^+$ green
D	Cloudy solution	Clear solution
E	Insoluble	Dissolved forming a colorless gas that turns $H^+/KmnO_4$ turbid

i. Identify A-E.

A- B- C-

D- E-

ii. Write relevant balance chemical equation leading to above observation.

_____

_____

_____

_____

_____

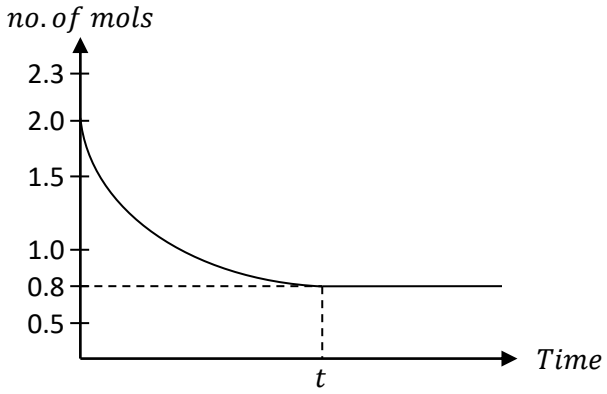
_____

_____

_____

(03)

(a) At 77℃, 2 mol each of gases $H_{2(g)}$& $I_{2(g)}$were inserted into a rigid vessel with the volume 1dm^3 and allowed to attain equilibrium. Below is a graphical representation of variation of $I_{2(g)}$ mols with time.



(i) Write balanced chemical equation for the reaction taking place in vessel.

(ii) Calculate the no. of mols of H_2 and I_2 reacted.

(iii) Calculate the concentration of $HI_{(g)}$ at equilibrium.

(iv) In the above graph plot the variation of no mols of $HI_{(g)}$ with time. Mark the values in above graph.

(v) Calculate K_C for above equilibrium.

(vi) Calculate K_P for above equilibrium.

(b) It was found that reaction between $H_{2(g)}$ and $I_{2(g)}$proceed through below mechanism.

Step 1: $I_{2(g)} \rightleftharpoons 2I_{(g)}$
Step 2: $H_{2(g)} + 2I_{(g)} \rightarrow 2HI_{(g)}$ slowest step

(i) Derive an expression for the rate of the reaction.

(ii) Sketch a graph, Rate Vs $[I_{2(g)}]$ for above reactions.

(c) Consider reaction between 2-bromopropane with $NaOH_{(aq)}$. It was found that the reaction proceeds through two steps via secondary carbocation Intermediate. First step is the slowest step.

$$(\Delta Hrxn = -ve)$$

Sketch an energy profile for above reaction.

(04)

(a) A, B and C are structural isomers with molecular formula $C_5H_{10}O$. They do not decolorize($Br_{2(\ell)}$). Only A shows optical isomerism. In the presence of $NaBH_4$/methanol, B gives a secondary alcohol D. A & C gives primary alcohol E and F respectively. Product obtained by treating D with anhydrous Al_2O_3 do not show geometrical isomerism. A and B can be subjected to aldol condensation while C do not.

Draw the structures of A-F in below boxes.

A B C

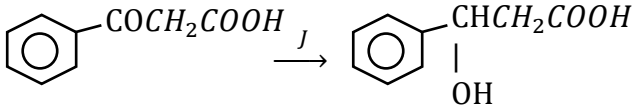
D E F

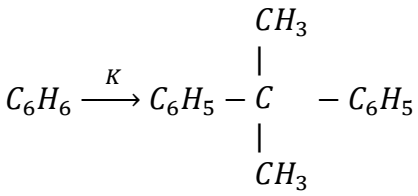
(b) Identify the suitable reagents / catalyst / conditions required for the below reaction.

(i) $CH_3 - C \equiv C - H \xrightarrow{G} CH_3CH = CH_2$

(ii) $CH_3 - CH_2\ OH \xrightarrow{H} CH_3COOH$

(iii) $CH_3C \equiv C - H \longrightarrow CH_3 - C = C^-Na^+$

(iv) 

(v) 

G-

J-

H- K-

I-

(c) Draw the structures of final product/s of below reaction in given boxes.

(1) $CH_3CH_2-\overset{\overset{O}{\|}}{C}-OC_2H_5 \xrightarrow[2.H^+/H_2O]{1.LiAlH_4/dry\ ether}$ P

(2) $CH_3-\underset{\underset{CH_3}{|}}{CH}-\overset{\overset{O}{\|}}{C}-H \xrightarrow{dil\ NaOH}$ Q

(3) $C_6H_5COCH_3 \xrightarrow{2,4-DNP}$ R

(4) $C_6H_5OH \xrightarrow{Br_2}$ S

(5) $CH_3CH_2CHO \xrightarrow{[Ag(NH_3)_2]^+OH^-}$ T

P Q R

S T

(d) Identify the mechanism through which reaction between $CH_3 - \overset{\overset{O}{||}}{C} - CH_3$ & HCN proceed through and write down. Identify Nucleophile / electrophile or free radical involved in mechanism

Part B Essay

(Answer two questions only)

(05)

(a) 20.00ml of 0.1M weak acid HA is titrated with 0.1M NaOH. Four stages of the titration are given below as A, B, C, & D

A- Initial HA solution
B- Adding 10ml of NaOH
C- Adding 20ml of NaOH
D- Adding 30.00ml of NaOH

$$Ka_{Acid} = 1 \times 10^{-5} moldm^{-3}$$

(i) Write an expression for acid dissociation constant (Ka) for acid HA. Show that, pH= $\frac{1}{2}$ pKa - $\frac{1}{2}$ $logC$ (Where C is the initial concentration of acid). Calculate pH at stage A.
(ii) Identify which of the above stage would act as a buffer and calculate pH at that stage.
(iii) Identify the equivalence point and calculate pH at that stage.
(iv) Calculate pH at remaining stage (other than three above).
(v) Using above calculated data sketch a graph for pH Vs burette reading (titration curve).
(vi) 100ml of above acid HA was mixed well with 100ml of CCl_4 solution. Then they were allowed to attain equilibrium. The distribution coefficient of HA between CCl_4 and water is 9. Calculate pH of aqueous layer.

(b)

(i) Liquids L & M forms an ideal binary mixture. At 298 K the saturated vapour pressure of L & M are $P°_L$& $P°_M$. Derive an expression for mole fraction of L in vapour phase (Y_L), in equilibrium with equimolar mixture of L & M.

(ii) At 298K saturated vapour pressure of L and M are 80kPa and 60kPa respectively. The mole fraction of L in vapour phase in equilibrium with a mixture of L and M is 0.2. Calculate the total pressure of the systems.

(iii) A certain solution mixture of L & M (S1) boils at 76℃. This solution was subject to fractional distillation. It was found that mole fraction of L in condensed liquid (S2) was 0.4. Calculate mole fraction of L & M in initial solution (S1). Saturated vapour pressure of L and M at 76℃ are $1.6 \times 10^5 Pa$ & $8 \times 10^4 Pa$.

(iv) Sketch the temperature Vs composition diagram for above L / M system under external pressure of one standard (1×10^5Pa) and label it fully. Mark clearly the boiling point of pure L & M as T_L & T_M and temperatures 76℃ and the composition of solutions $S1$ and $S2$ at 76℃.

(06)

(a)

(i) Define standard enthalpy of lattice dissociation enthalpy energy.

(ii) Below are some thermodynamic data.

Standard enthalpy of formation of $Ba_{(g)} = 180 kJmol^{-1}$
Standard enthalpy of atomization of $I_{(g)} = 106 kJmol^{-1}$
Sum of standard enthalpies of 1st and 2nd ionization of $Ba_{(g)} = 1145 kJmol^{-1}$
Standard hydration enthalpy $Ba^{2+}_{(g)} = 1275 kJmol^{-1}$
Standard hydration enthalpy $I^{-}_{(g)} = -308 kJmol^{-1}$
Standard enthalpy of dissolution of $BaI_{2(s)} = +252 kJmol^{-1}$

(1) Calculate lattice dissociation enthalpy change for $BaI_{2(s)}$
(2) Calculate standard enthalpy of formation of $BaI_{2(s)}$

(b) Standard enthalpy of dissolution of $Ba(OH)_2 = 28\ kJmol^{-1}$
Standard enthalpy change of neutralization (Strong acid - Strong base) = $-57 kJmol^{-1}$
Standard enthalpy change for precipitation of $BaSO_{4(s)} = -18 kJmol^{-1}$

Determine the temperature change occur when 17.1g of $Ba(OH)_{2(s)}$ was dissolved in 500cm^{3}of 1moldm^{-3} $H_2SO_{4(aq)}$ solution?

$(Ba(OH)_2 = 171 gmol^{-1})$
density of water$(d) = 1 g/cm^3$
Specific heal capacity (c) = 4200JKg^{-1}K^{-1}

(c)

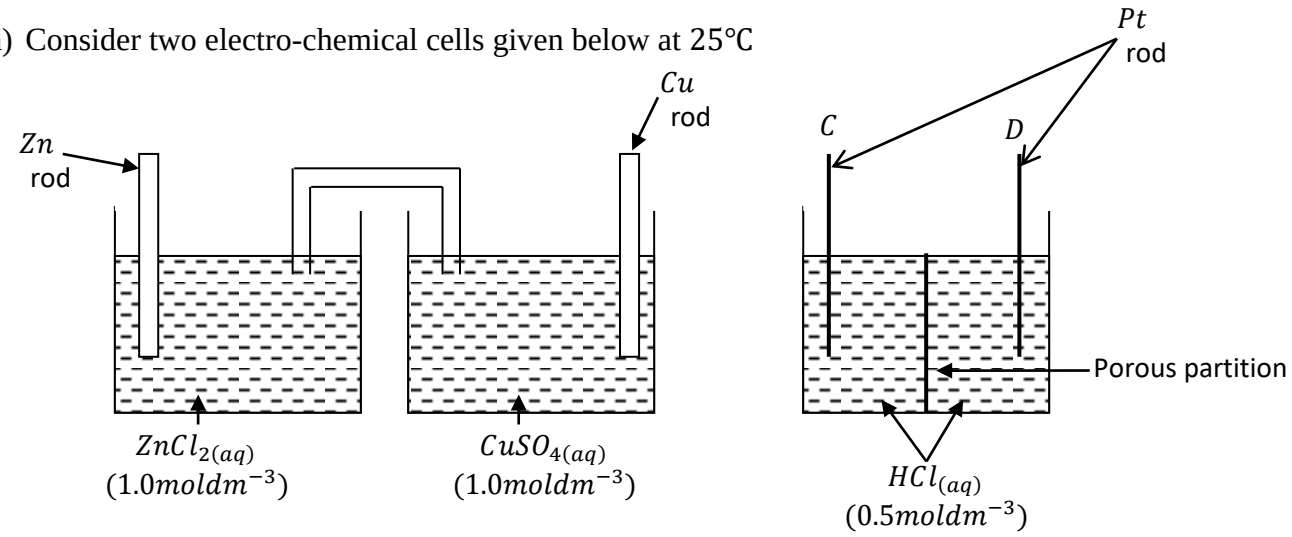
(i) A group of students at room temperature added excess of solid $Ca(OH)_2$ to a reagent bottle containing 100cm^3 of $0.1M$ HNO_3 acid. Then they shook the bottle well & allowed the system to attain equilibrium. Then they filtered the solution and pipetted out 25.00cm^3 from the filtrate and titrated with $0.1M$ HCl using phenolphthalein indicator. Burette reading was 15.00cm^3. Using above data calculate solubility product of $Ca(OH)_2$.

(ii) In another experiment $Ca(OH)_{2(s)}$ was dissolved in a $0.2M$ $NaOH$ solution and made saturated. Solution was then filtered and 100.00cm^3 of the filtrate was pipetted out and titrated with $0.1M$ HCl. End point reading was 20.00cm^3. Calculate the solubility of $Ca(OH)_2$ in above NaOH solution.

(iii) Calculate the maximum mass of Na_2CO_3 that can be added to 100cm^{3}of above solution in$(c(ii))$ without precipitating $CaCO_3$ ($K_{sp}CaCO_3 = 1.6 \times 10^{-7}$ mol^{2}dm^{-6})

(07)

(a) Consider two electro-chemical cells given below at 25℃



(A) **(B)**

At 25℃ $E°_{Zn2+/Zn} = -0.76V$ $E°_{Cu^{2+}/Cu} = 0.34V$

(i) Calculate the e.m.f of cell A.

(ii) State the purpose/uses of using a salt bridge.

(iii) Write the.

a) Cathodic reaction
b) Anodic reaction
c) Overall Cell reaction

When the two rods of cell A are connected with a Cu wire.

(iv) Another set up was made connecting Cu and Zn rods of cell A with rods C & D of cell B respectively. Identify reactions taking place at,

a) rod C b) rod D

(v)

(1) When a constant current is flowing in above (iv) set up, predict the change that would occur in the amount of products formed at D when HCl concentration is increased.

(2) A constant current of 3.7Awas passed through molten Al_2O_3 for 13min. The volume of gas produced at inert anode was 168.00cm^3 at S.T.P.

A) Calculate the mass or volume of product formed at inert cathode.

B) The same amount of current was passed through molten solution of MCl_n & mass of M obtain was 1.373g. Find out the (n+) charge on M cation.
(Al=27, O=16, M=137.3)

(b) A, B and C are three coordination compounds. They have an octahedral geometry. Four types of ligands are coordinated to the metal ion in one compound and three types of ligands are coordinated to metal ion in another compound. The atomic composition of the species in the coordination sphere in A, B and C are(not in order),

$CuI_2N_2H_9O_4$ **$CuI_2N_4H_{14}O$** **$CuN_2H_{12}O_{12}$**

One mole of A forms one mole of yellow colour precipitate when it is reacted with $AgNO_3/H^+$. B in the presence of Zn dust / NaOH, gives a gas that turns Nessler's reagent brown. But B alone with NaOH do not give above observation. C does not give rise to any of the above observations.

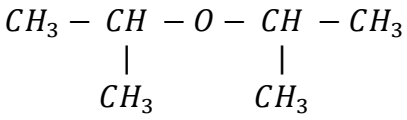
I. Identify A, B and C and write their structural formula.
II. Identify the anion of each compound and give a qualitative test (which is not given in above question) to identify their presence in a sample, along with the observations.
III. Give the IUPAC name of all three compounds.

Part C

Answer two questions only

(08)

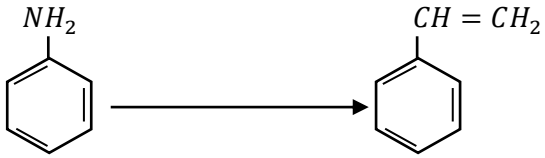
(a) Using $CH_3 - C \equiv CH$ as the only organic starting material and as reagents using only the ones given in below list, show how would you synthesize the following compound in not more than 5 steps.



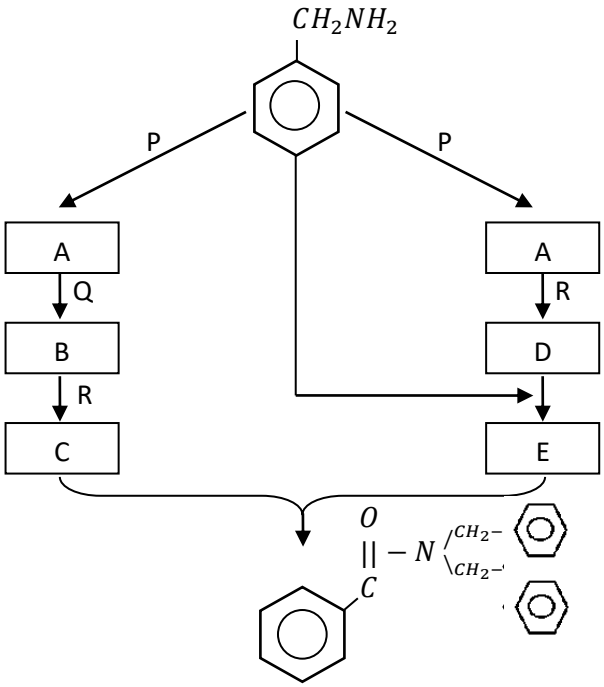
List of reagents:

Dil $H_2SO_4, HgSO_4, NaBH_4, Na,$ $PCl_3, Mg, dry\ ether, methanol,$ $ethanol$

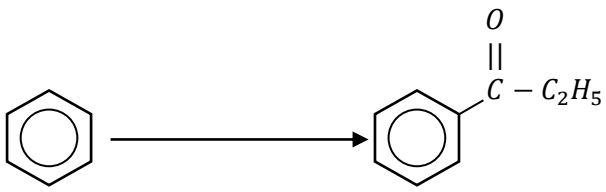
(b) Show how would you carry out below conversion in not more than 5 steps.



(c) Identify compounds A - E & reagents P, Q and R in below scheme of reaction.



(d)



(i) Identify the reagent needed for above reaction.
(ii) Identify the mechanism through which above reaction proceed?
(iii) Write down the mechanism.
(iv) Compare the basicity of primary aliphatic amines and aniline with reasoning.

(09)

(a) A is an inorganic salt. When $NaOH_{(aq)}$ is added it releases a gas B that turns red litmus blue and a solution C. When $Pb(NO_3)_2$ is added to C it forms a white precipitate D, that dissolve on heating and precipitate back on cooling.

i) Identify A, B,C and D.
ii) Write relevant chemical equations.

(b) Solution X consist of 4 cations. In order to identify them following tests were done.

Test	Observation
(1) Adding dil HCl to solution X	No change
(2) Bubbled $H_2S_{(g)}$ through solution obtained in (1)	Obtained a black colour precipitate (p)
(3) Precipitate P was filtered out and solution was boiled until all H_2S is removed. Few drops of HNO_3 were added and heated. Once the solution is cooled NH_4Cl / NH_4OH was added.	Obtain a green colour precipitate (Q)
(4) Q was filtered out and then H_2S gas was bubbled through filtrate.	Obtained a black colour precipitate (R)
(5) Precipitate R was filtered out and solution was boiled until all H_2S is removed. Then to the solution $(NH_4)_2CO_3$ was added	Obtained a white colour precipitate (S)

Precipitated P, R & S were subject to following test.

(6) Precipitated P was dissolved in hot concHNO_3 and excess NH_3 was added.	Deep blue solution obtained.
(7) When conc. HCl is added to the solution obtained by dissolving *R* in hot concHNO_3, solution S_1 was obtained. When conc NH_3 is added to S_1 solution S_2 was obtained.	S_1- Blue colour solution. S_2 - Yellow brown solution.
(8) S got dissolved in conc HCl & subjected to flame test.	Obtained Crimson red flame.

i) Identify the 4 cation present in solution X.
ii) Write chemical formulas of P, Q, R, and S.
iii) In experiment (3) why H_2S need to be boiled & removed?
iv) In experiment (3) why HNO_3 is added?

(c) A particular mineral sample contains Cu, Ag & some inert impurities. In order to find the mass percentages of Cu & Ag in above mineral sample following procedure was carried out.
0.525g of mineral was dissolved in concHNO_3 evolving a gas. Then to the obtained clear solution $NaCl_{(aq)}$ was added & a white precipitate X formed. X was filtered out. Precipitate X and filtrate Y were then subjected to below procedure for quantitative analysis.

<u>Precipitate (X)</u>

X was heated until constant mass of 0.287g was obtained.

<u>Filtrate (Y)</u>

Filtrate was neutralized and excess KI was added to it. Then titrated with 0.20 $moldm^{-3}$ $Na_2S_2O_3$ using starch indicator. Burette reading at end point was 24.00cm^3
(Ag - 108, Cu = 63, Cl-35.5)

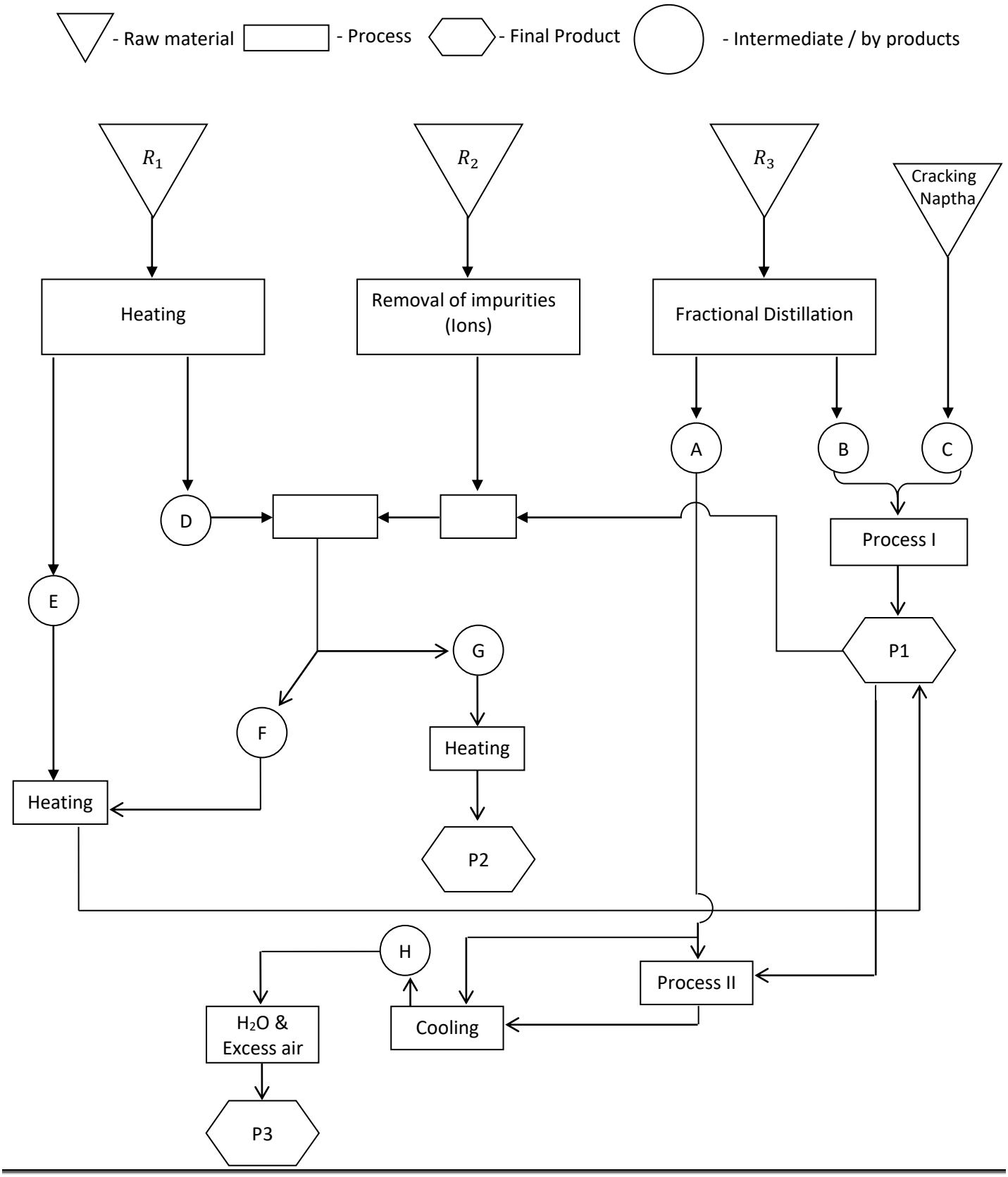
(i) Write relevant chemical equation.
(ii) Calculate the mass percentages of Ag and Cu in the mineral sample.

(iii)

1) Write two main sources of errors in titrations involving Iodine?
2) The starch indicator is not added at the beginning of the titration but added when solution turns intense yellow to straw colour. Give reason.

(10)

(a) The flow chart given below depicts 3 Industries that can be initiated in Sri Lanka due to availability of raw materials.



(i) State two facts that need to be considered when using a natural resource as a raw material for an industry.
(ii) Identify the raw materials R_1, R_2, & R_3.
(iii) Write the chemical formulas of A - H (with Physical States)
(iv) Write the chemical formulas of final product P_1, P_2, and P_3.
(v) State the reaction conditions, catalysts and catalytic promoters used for process I & II.

(b) Below questions are based on Iron extraction using blast furnace.
(i) State two types of ores that's used for iron extraction.
(ii) State the role of coke(C) in iron extraction using balanced equation.

(c) The most severe and non-reversible damages to the ozone layer are brought by human activities. This is mainly caused by volatile compound released to atmosphere.

(i) Give two examples for such volatile compounds.
(ii) State 4 anthropogenic activities / industries that leads to release of above volatile compounds.
(iii) Explain (using balanced chemical equations) how one of the compounds you mentioned in (i) above damages ozone Layer.
(iv) State 3 adverse effects of exposing to harmful UV radiation.

(d) A 200.0cm^3 sample of water was collected and tested for dissolved oxygen by the addition of $MnSO_4$ in basic medium, followed by the addition of acidified KI. It was found that 20.00cm^3 of 0.01$moldm^{-3}$ $Na_2S_2O_3$ was required to react with Iodine produced.

i) Write balanced chemical equation for the reactions taking in above process.
ii) Calculate DO of above water sample. ($mgdm^{-3}$)
iii) Write 1 cause for dropping DO level in water.

(iv) D Excess OH^- present, all acid titrated. - (2)

$$[OH^-_{(aq)}] = \frac{0.1 \times 10 \times 10^{-3} \times 10^3}{50} = 0.02 \text{ moldm}^{-3}$$ (2+1)

$$pOH = 1.6990 \quad - (3)$$

$$pH = 12.3010 \quad - (2)$$ [10]

(i) HA acid dissociate as follows.

$$HA_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$$

initial / moldm^{-3}	C	0	0
change / "	$-x$	$+x$	$+x$
at equil "	$C-x$	x	x

At equilibrium $x \ll C$, $\therefore C - x \approx C$ - (2)

$$K_a = \frac{[H_3O^+_{(aq)}][A^-_{(aq)}]}{[HA_{(aq)}]} \quad - (2)$$

$$= \frac{[H_3O^+_{(aq)}]^2}{[HA_{(aq)}]} \quad - (2)$$

$$[H_3O^+_{(aq)}] = \sqrt{K_a C} \quad - (2)$$

$$pH = -\log[H_3O^+_{(aq)}] = -\log K_a^{1/2} - \log C^{1/2} \quad -(2)$$

$$pH = -\frac{1}{2}\log K_a - \frac{1}{2}\log C$$ [14]

$$pH = -\frac{1}{2}\log 1\times10^{-5} - \frac{1}{2}\log 0.1 = 3 \quad (6)$$

(ii) Stage B. -(2)

Using Henderson Hasselbalch eq:

$$pH = pKa + \log \frac{[\text{conj base}]}{[\text{acid}]} \quad - (2)$$

~~Using Hende~~ $pH = pK_a$

$= -\log(1 \times 10^{-5})$

$= 5$

(iii) C - equivalence point only A^- hydrolyse (2) (3)

$NaA \rightarrow Na^+_{(aq)} + A^-_{(aq)}$

$\frac{0.1 \times 20}{1000}$ $0.1 \times 20 \times 10^{-3}$

$A^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HA_{(aq)} + OH^-_{(aq)}$ - (2)

initial/m	$\frac{0.1 \times 20}{1000} \times \frac{10^3}{40}$			(2+1)
change/m	$-x$	$+x$	$+x$	
equil/m	$\frac{0.1 \times 20 \times 10^3}{40 \times 10^3} - x$	x	x	(2+1)

$K_a \times K_b = K_w$

$K_b = K_w / K_a = 10^{-14} / 10^{-5} = 10^{-9}\ mol dm^{-3}$ (2+1)

$K_b = \frac{[HA_{(aq)}][OH^-_{(aq)}]}{[A^-_{(aq)}]}$ - (2)

$10^{-9} = \frac{x^2}{0.05 - x}$; $0.05 - x \approx 0.05$

$x = 7.07 \times 10^{-6}\ mol dm^{-3} = [OH^-_{(aq)}]$ (2+1)

$pOH = -\log(7.07 \times 10^{-6})$

$= 5.15$ - (2)

$pH = 8.85$ - (2)

[25]

$$pH = pK_a + \log \frac{[NaA]}{[HA]} \qquad [NaA] = [HA] \quad -(3)$$

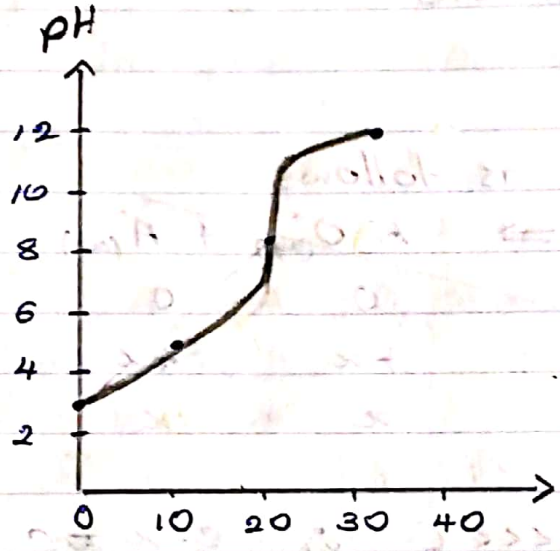
or

Half equivalence point

$$pH = pK_a = -\log(1 \times 10^{-5}) = 5 \quad -(3)$$

10

(v)



shape - 5
axis - 3 + 3

11

~~(vi) indicator N. -(3)~~

There colour change/pH range ~~overlap with~~ lie within/occuring near equivalence point/ sharp transition in pH -(3).

(vii)

	$HA_{(aq)}$	$\rightleftharpoons$	$HA_{(CCl_4)}$
initial/moldm^{-3}	0.1		
	$-x$		$+x$
	$0.1-x$		x

$$K_d = \frac{[x]}{[HA_{(aq)}]} \cdot \frac{[HA_{(CCl_4)}]}{[HA_{(aq)}]} = \frac{x}{0.1-x} = 9 \quad -(3)$$

$$x = 0.9 - 9x \quad -(2)$$

$$x = 0.09 \text{ moldm}^{-3} \quad -(2)$$

$$[HA_{(aq)}] = 0.1 - 0.09 = 0.01 \text{ moldm}^{-3} \quad -(2)$$

$HA_{(aq)} + H_2O \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$

$0.01 - x \qquad +x \qquad +x$

~~$[H_3O^+_{(aq)}]$~~ =

$pH = -\frac{1}{2}\log K_a - \frac{1}{2}\log C$

$= -\frac{1}{2}\log(1\times10^{-5}) - \frac{1}{2}\log(1\times10^{-2})$ -(3)

$= \frac{5}{2} + \frac{2}{2} = \frac{7}{2} = 3.5$ // -(3)

Q5 [15]

(b) (i) $P_T = P_L + P_m$ -(2) ; Using Dalton's law.

Using Roult's law,

$P_L = P^\circ_L X_L$ -(2)

$P_m = P^\circ_m X_m$ -(2)

$Y_L = \frac{P_L}{P_T} = \frac{P^\circ_L X_L}{P^\circ_L X_L + P^\circ_m X_m}$ -(2) $\qquad X_m = X_L = 0.5$

(2)

$= \frac{P^\circ_L}{P^\circ_L + P^\circ_m}$ -(5) [15]

(ii) $P_T = P_L + P_m$

$Y_L = 0.2 \quad Y_m = 0.8$ -(3)

$0.2 = \frac{80X_L}{80X_L + 60X_m}$ -(1) -(4) $\qquad 0.8 = \frac{60X_m}{80X_L + 60X_m}$ -(2) -(4)

$\frac{(1)}{(2)} \quad \frac{1}{4} = \frac{80X_L}{60X_m} = \frac{4X_L}{3X_m}$

$$\frac{1}{4} = \frac{4 X_L}{3 (1 - X_L)} = \frac{4 X_L}{3 - 3 X_L}$$

$$X_L = \frac{3}{19} \quad -(3)$$

$$X_m = \frac{16}{19} \quad -(3)$$

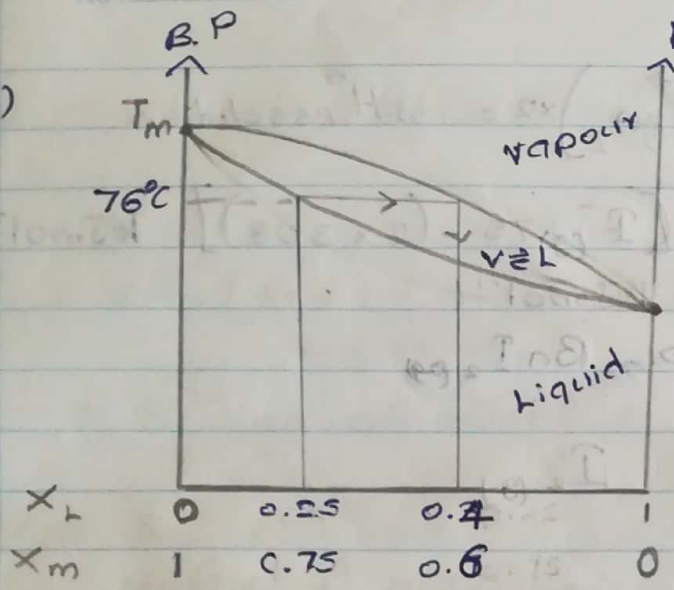
$$P_T = 80 kPa \times \frac{3}{19} + 60 kPa \times \frac{16}{19} \quad -(4)$$

$$= 12.63 kPa + 50.52 kPa \quad -(2)$$

$$= 63.16 kPa \quad -(2)$$

25

(iv)



two curves - 4
vapour - 1
liquid - 1
V≥L - 1
76°C - 2
S_1 - 2 (a)
S_2 - 2
B.P - (2)
X_L/X_m

15

(iii) $P_T = P_L + P_m$

$1 \times 10^5 P_a = P^\circ_L X_L + P^\circ_m X_m$ - 3

$= P^\circ_L X_L + P^\circ_m (1 - X_L)$

$= 11.6 \times 10^5 X_L + 8 \times 10^4 - 8 \times 10^4 X_L$

$1 \times 10^5 - 8 \times 10^4 = (16 - 8) \times 10^4 X_L$ -(3)

$\frac{2 \times 10^4}{8 \times 10^4} = X_L$

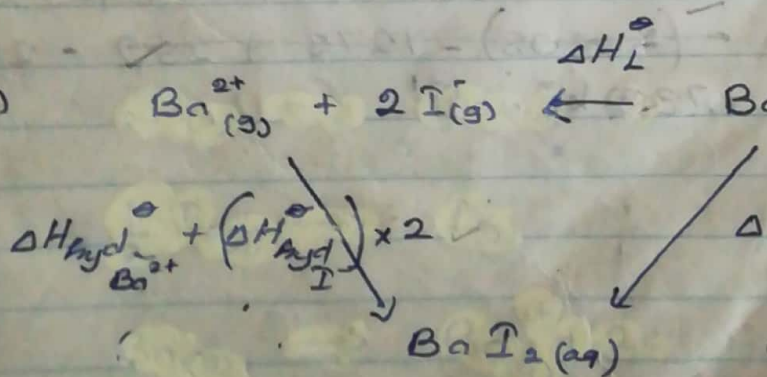
$0.25 = X_L$

$0.75 = X_m$ - (2)

10

(6) (a) (i) 10 (correct defin')

(ii) (1)



correct cycle

(12)

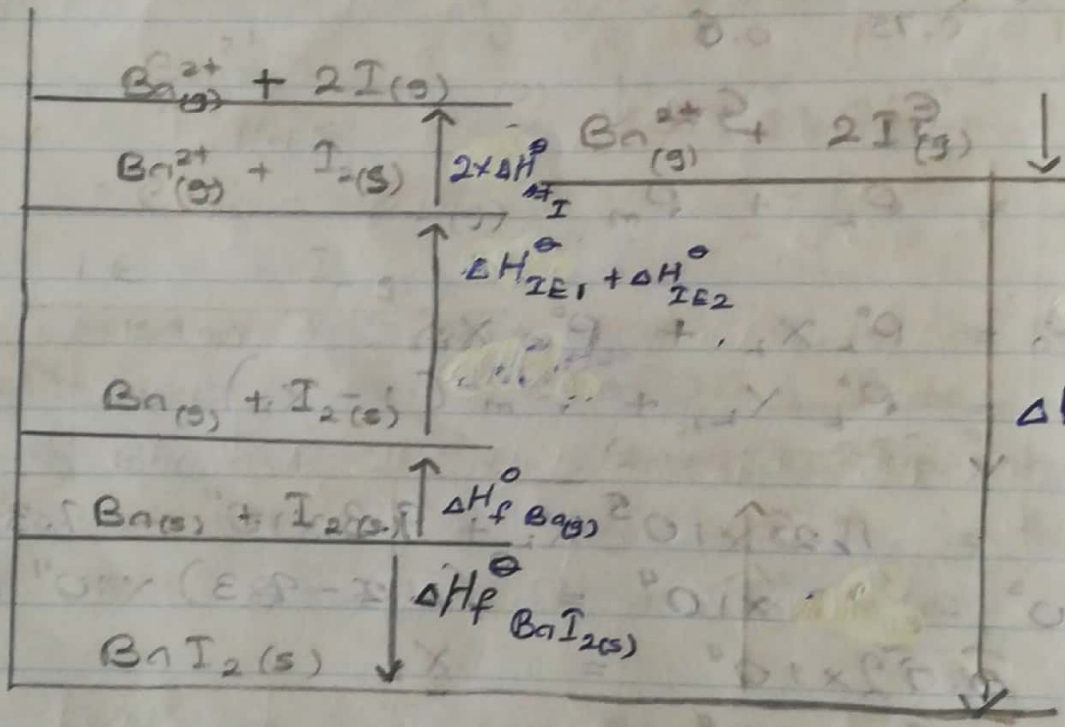
$$\Delta H_L^\ominus + \Delta H_{hyd\ Ba^{2+}}^\ominus + \left(\Delta H_{hyd\ I^-}^\ominus\right) \times 2 = \Delta H_{dissolution}^\ominus$$

$$\Delta H_L^\ominus = +252 - [-1275 - (2 \times 308)] \text{ kJ mol}^{-1}$$

$$= +2143 \text{ kJ mol}^{-1} \quad -(4+1)$$

17

(2)



$$\Delta H_f^\ominus = \Delta H_{f\ Ba(g)}^\ominus + \Delta H_{IE}^\ominus + \left(2 \times \Delta H_{at\ I}^\ominus\right) + \left(2 \times \Delta H_{EG\ I}^\ominus\right) - \Delta H_L^\ominus$$

~~$= \left(2 \times \Delta H_{hyd\ I^-}^\ominus\right) + \Delta H_{d.solution}^\ominus$~~

$$= [180 + 1145 + (2 \times 106) - (2 \times 318) - 2143] \text{ kJ mol}^{-1}$$

~~$= 180 + 62.4 + 1145 + (2 \times 106) - (2 \times 318) - (2 \times 308) - 1275 + 252 - 2143$~~ (4+1)

$$= -1242 \text{ kJ mol}^{-1} \quad (4+1)$$

30

(b) No. of moles of $Ba(OH)_2$ = $\frac{17.1\ g}{171\ g\,mol^{-1}}$ = 0.1 mol

$\Delta H^{\ominus}_{dissolution\ Ba(OH)_2}$ = −28 × 0.1 = −2.8 kJ. −(4+1)

H_2SO_4 no. of moles = $1.0\ mol\,dm^{-3} \times \frac{500\ dm^3}{1000}$

= 0.5 mol

$Ba(OH)_2 + H_2SO_4 \longrightarrow BaSO_4 + 2H_2O$

0.1 0.5 0.1 0.2

$\Delta H^{\ominus}_{neu}$ = 0.2 × −57 kJ mol^{-1} = −11.4 kJ (4+1)

enthalpy change for $BaSO_4$ ppt = −18 kJ mol × 0.1 mol

= −1.8 kJ (4+1)

Total heat change = −2.8 kJ − 11.4 kJ − 1.8 kJ

= −16.0 kJ. −(4+1)

$Q = mc\vartheta$

$\vartheta = \frac{Q}{mc} = \frac{Q}{dV\,c} = \frac{16000\ J}{1000\ kgm^{-3} \times 500 \times 10^{-6}\ m^3 \times 4200\ J\,kg^{-1}K}$ −(2)

= ~~7.6~~ 7.61 °C ↑. −(2+1)

[25]

$2HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$

2 : 1

(ii) no. of moles of HNO_3 in bottle $= \frac{0.1 \text{ moldm}^{-3} \times 100 \text{ dm}^3}{1000}$

$= 0.01 \text{ mol}$ -(3+1)

no. of moles of $Ca(OH)_2$ spent to neutralise HNO_3

$= \frac{0.01}{2}$

$= 0.005 \text{ mol}$ (4)

$Ca^{2+}_{(aq)}$ mols in solution due reac= with HNO_3 $= 0.005 \text{ mol}$ (2)

$[Ca^{2+}_{(aq)}] = \left(\frac{0.005}{100} \times 1000\right) M$

$= 0.05 \text{ M}$ -(4)

$HCl_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)} + Cl^-_{(aq)}$ (4)

no. of mols of HCl spent $= \frac{0.1 \times 15}{1000}$ mols (4)

OH^- mols present in $25 \text{cm}^3 = \frac{0.1 \times 15}{1000}$

$[OH^-_{(aq)}] = \frac{0.1 \times 15}{1000} \times \frac{1000}{25} = 0.06 \text{ moldm}^{-3}$ (4)

$Ca(OH)_{2(s)} \rightleftharpoons Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$

1 : 2

concentration 0.03 0.06 moldm^{-3} (2)

Total $[Ca^{2+}_{(aq)}] = 0.03 + 0.05 = 0.08 \text{ moldm}^{-3}$ (4)

$K_{sp} = [Ca^{2+}_{(aq)}][OH^-_{(aq)}]^2$ -(3)

$= (0.08 \text{ moldm}^{-3})(0.06)^2 \text{ mol}^2\text{dm}^{-6}$ (3)

$= 2.88 \times 10^{-4} \text{ mol}^3\text{dm}^{-9}$ -(3)

41

(ii) $NaOH_{(aq)} + HCl_{(aq)} \rightarrow H_2O_{(l)} + Cl^-_{(aq)}$ -(1)

$n_{HCl} = n_{OH^-} = 0.1\ mol dm^{-3} \times \frac{20.00}{1000}\ dm^3$

$= 2 \times 10^{-3}\ mol$ -(2)

$[OH^-_{(aq)}] = \frac{2 \times 10^{-3}\ mol}{100\ dm^3} \times 1000 = 2 \times 10^{-2}\ mol dm^{-3}$ -(3)

$K_{sp} = [Ca^{2+}_{(aq)}][OH^-_{(aq)}]^2$

$2.88 \times 10^{-4} = x\ (2 \times 10^{-2})^2$ -(3)

$x = \frac{2.88 \times 10^{-4}}{4 \times 10^{-4}} = 0.72\ mol dm^{-3}$ (2+1)

x = solubility = $[Ca^{2+}_{(aq)}]$

+13 free marks

(iii) $CaCO_{3(s)} \rightleftharpoons Ca^{2+}_{(aq)} + CO_3^{2-}_{(aq)}$

$y \qquad y$

$K_{sp\ CaCO_3} = [Ca^{2+}_{(aq)}][CO_3^{2-}_{(aq)}]$ -(5)

$1.6 \times 10^{-7}\ mol^2 dm^{-6} = 0.72\ [CO_3^{2-}_{(aq)}]$ -5

$[CO_3^{2-}_{(aq)}] = 2.2 \times 10^{-7}\ mol dm^{-3}$

$n_{Na_2CO_3} = 2.2 \times 10^{-7}\ mol dm^{-3} \times \frac{100}{1000}\ dm^3$

$m_{Na_2CO_3} = \frac{2.2 \times 10^{-7}}{10}\ mol \times 106\ g mol^{-1}$ -(5)

$= 2.33 \times 10^{-6}$

$= 2.33\ \mu g$ -4 free.

14

correct method

$\frac{I}{t} = Q = nF$

(7)

(a) (i) $E_{cell} = E_{cathode} - E_{anode}$ (1s)
$= 0.34 - (-0.76)$
$= 1.10\ V$

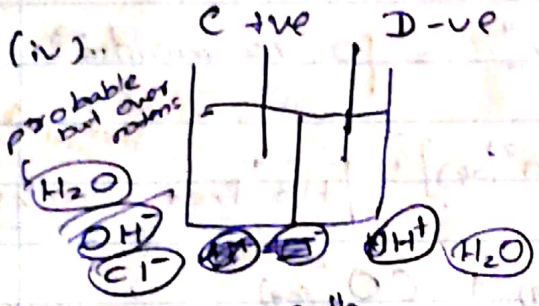
(ii) - (5) maintains electrical neutrality, complete the cell, prevent liquid junc...

(iii) a) $Cu^{2+}_{(aq)} + 2e \rightarrow Cu_{(s)}$

(b) $Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e$

(c) $Cu^{2+}_{(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$ (4 x 3)

(iv)..



Anode (a) $2Cl^- \rightarrow Cl_2 + 2e$ -(5)

(b) Cath $2e + 2H^+ \rightarrow H_2$ (5)

(V) ~~vi)(iv)~~(i) no. change (5)

2) (A)

no. of moles of O_2 formed = $\frac{168.00\ cm^3}{22.4 \times 10^3\ cm^3}$

$= 7.5 \times 10^{-3}\ mol$

$(2O^{2-} \rightarrow O_2 + 4e) \times 3$ -(3)

$(Al^{3+} + 3e \rightarrow Al) \times 4$ -(3)

$6O^{2-} + 4Al^{3+} \rightarrow 3O_2 + 4Al$ -(3)

3 : 4

Al mass = $7.5 \times 10^{-3} \times \frac{4}{3} \times 27$ -(3)

= ~~$.27 \times 10^{-3}$~~ g -(4 11)

0.27 g

B. $M^{n+} + ne \rightarrow M_{(s)}$ —(3)

no. of moles of M deposited = $\frac{1.373\ g}{137.3\ g\,mol^{-1}}$ = 0.01 mol (3)

$Q = It = nFe$

$3.7\ A \times (13 \times 60)\ s = e \times 96500 \times 0.01$

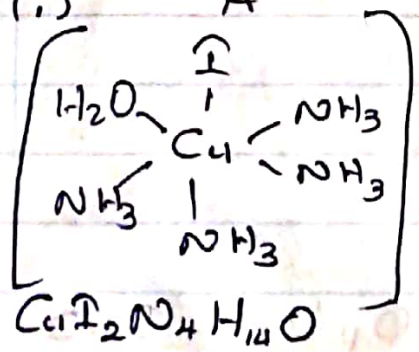
$\frac{(3.7 \times 13 \times 60)\ Q}{96500\ Q\,mol^{-1} \times 0.01\ mol} = e$ (3)

$n = 2.99 \approx \#+3$ —(4)

80

(b) (i)

A



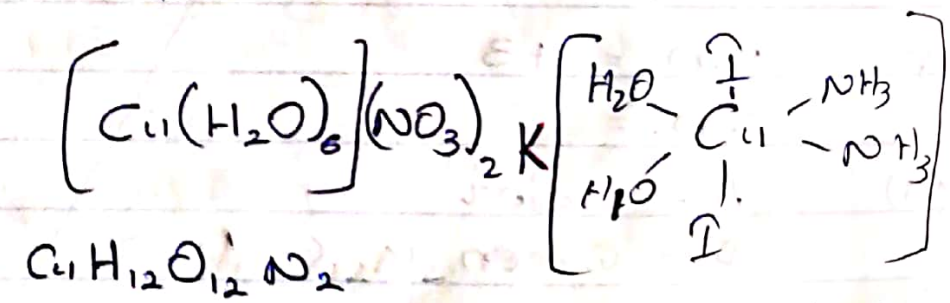
$C_uI_2N_4H_{14}O$

B

$[Cu(H_2O)_6](NO_3)_2$

$C_uH_{12}O_{12}N_2$

C



$KCuI_2N_2H_9O_2$

(ii) A - I
B - NO_3^-
C - none

(5)

(3 × 10 = 30)

~~(iii)~~ I^- - } method observ } (20)
NO_3^- - }

~~(iii)~~ A - aquatetraammine~~i~~odo copper(II) ~~a~~ iodide.

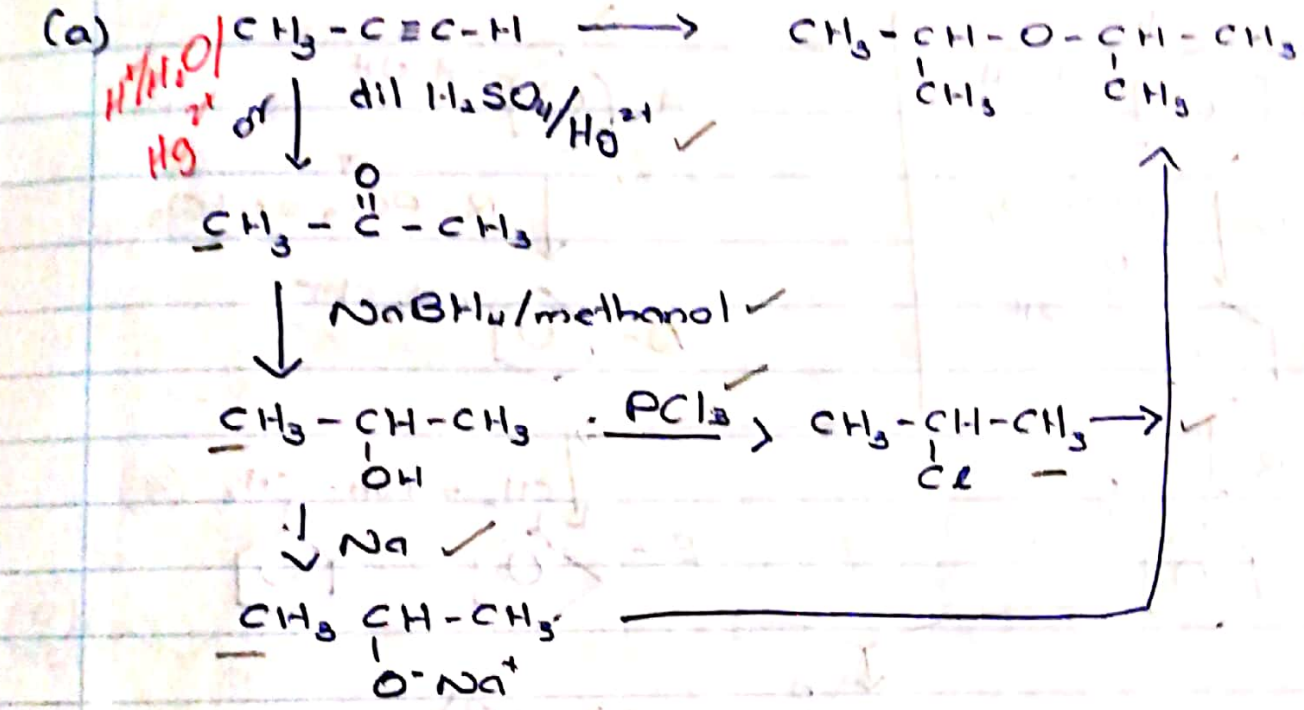
B - hexaaquacopper(II) nitrate

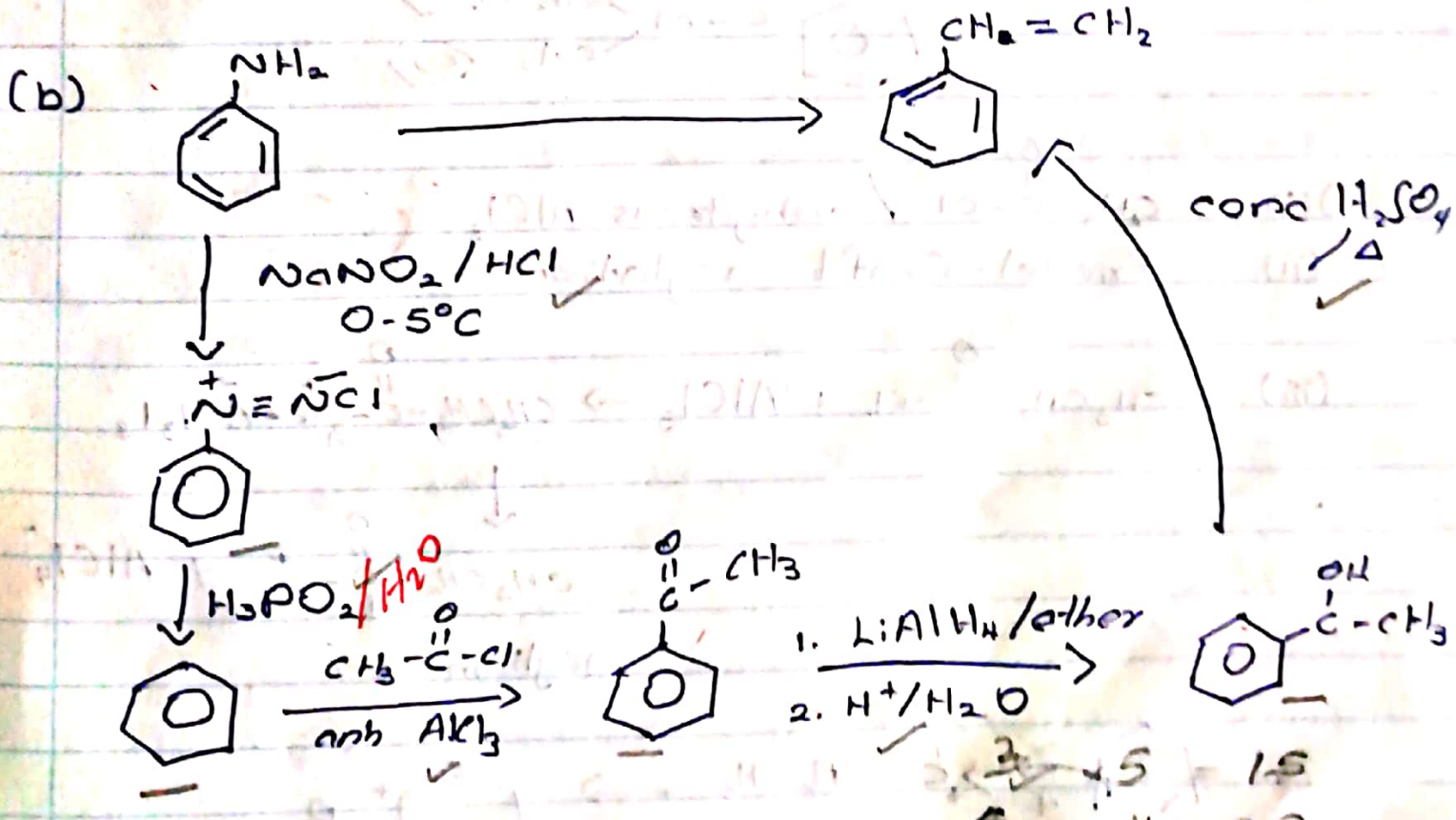
C - potassium ~~aqua~~diammine~~i~~odidohydroxidocuprate(II)

Potassium diammineaquahydroxidodiiodidocuprate(II)

(5 × 3 = 15)

8





$5 \times 4 = 20$

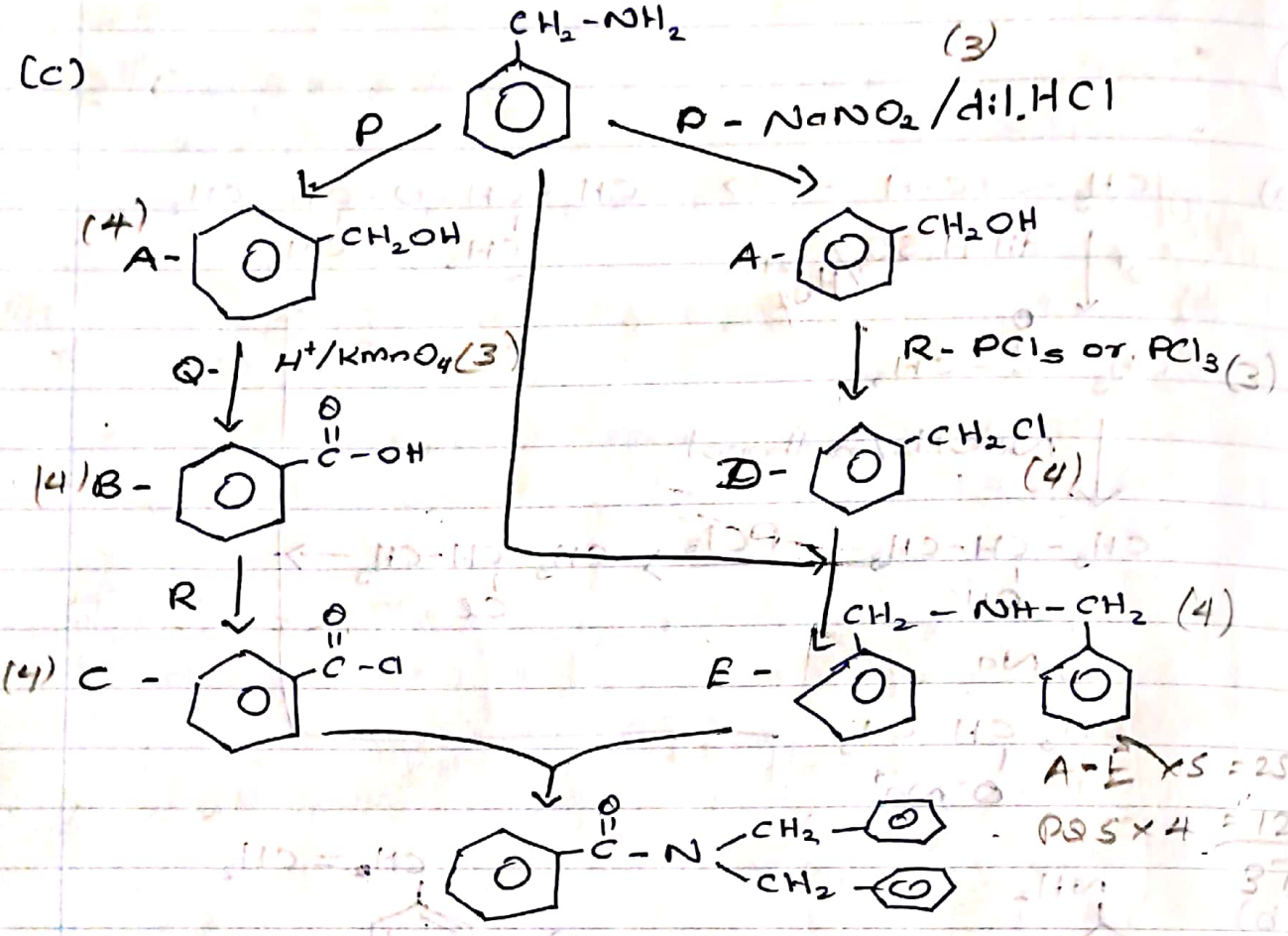
$5 \times 5 = 25$

$\frac{3}{5} \times 5 = 15$

$5 \times 4 = 20$

150

(c)



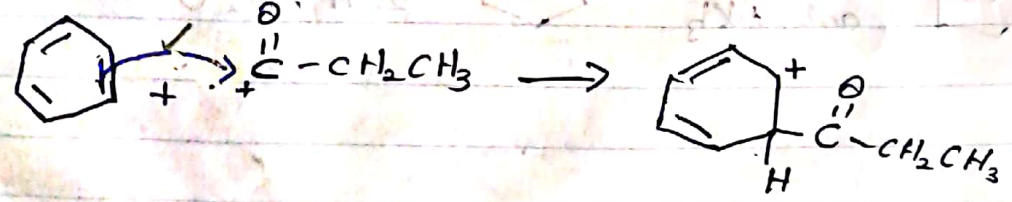
(d)(i) $C_2H_5-\overset{O}{\overset{\|}{C}}-Cl$ / anhydrous $AlCl_3$ } -2

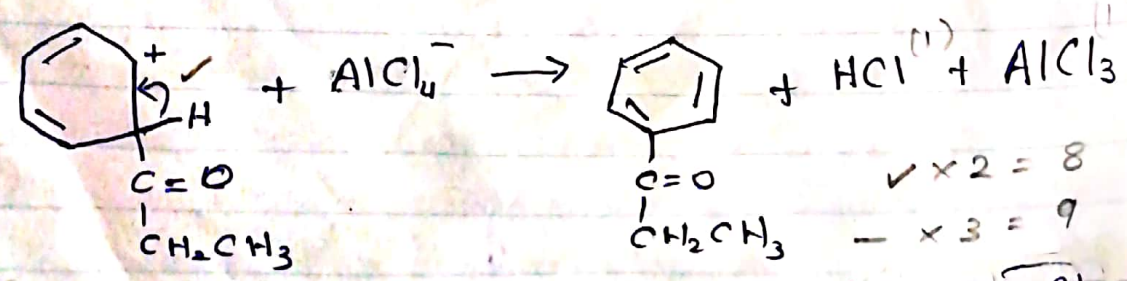
(ii) Friedel-Craft acylation -(1)

(iii) $CH_3CH_2-\overset{O}{\overset{\|}{C}}-Cl + AlCl_3 \rightarrow CH_3CH_2-\overset{O}{\overset{\|}{C}}-\overset{+}{C}l-\overset{-}{A}lCl_3$

$\rightarrow CH_3CH_2-\overset{O}{\overset{\|}{C}}{}^{+} + AlCl_4^-$ (1)

acylium ion



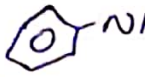


(1)

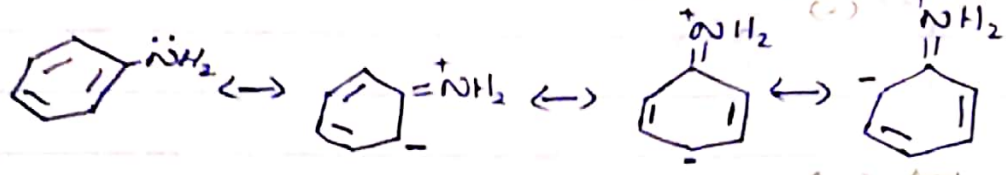
✓ × 2 = 8

— × 3 = 9

29

(iv) $R-NH_2$ more basic than  – (4)

In aniline lone pair dete on N is delocalised (2)
on to the aromatic ring due to resonance. or
There is lone pair is not easily available (2)
like in aliphatic amine. (+) charge on N stabilised by CH_3 in amine



(5) 13

(9) (a)(i) A - NH_4Cl C - $NaCl$
B - NH_3 D - $PbCl_2$. 3×4 = 12

(ii)

$$NH_4Cl + NaOH \rightarrow NH_3\uparrow + NaCl + H_2O$$

$$Pb(NO_3)_2 + 2NaCl \rightarrow NaNO_3 + PbCl_2\downarrow$$

4×2 = 8 20

(b)(i) Cu^{2+}, Cr^{3+}, Co^{2+}, Sr^{2+} 7½ × 4 = 30

(ii) P - CuS R - CoS
Q - $Cr(OH)_3$ S - $SrCO_3$ 4×4 = 16

(iii) To prevent precipitation of group IV cations (sulphides) along with gp⁰ III (hydroxides) OR
When HNO_3 is added if S^{2-} present they may get oxidised to S & get precipitated. (6)

(iv) To.. if Fe^{2+} present oxidise them to Fe^{3+} (5)

70 75

(c) $Ag^+_{(aq)} + NaCl_{(aq)} \rightarrow AgCl_{(s)} + Na^+_{(aq)}$

$Ag_{(s)} + HNO_3 \rightarrow AgNO_3$

$Cu_{(s)} + 4HNO_3 \longrightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$ (2)

$2Cu^{2+} + 4I^- \longrightarrow 2CuI + I_2$ (2)

$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$ (2)

$Cu^{2+} : S_2O_3^{2-}$

$1 : 1$ -(1)

Determining Ag mass %

mass of AgCl = 0.287 g

no. of moles of Ag^+ (2) = n_{AgCl} (3) = $\frac{0.287\ g}{143.5\ g\,mol^{-1}}$ = 0.002 mol

Mass of Ag in sample = 0.002 mol × 108 $g\,mol^{-1}$ -(s)

= 0.216 g (s)

Ag mass % = $\frac{0.216\ g}{0.525\ g} \times 100$ -(s)

= 41.1 % -(s)

Determining Cu mass %

No. of moles of $Na_2S_2O_3$ reacted = $0.20\ mol\,dm^{-3} \times \frac{24.00}{1000}$ (s)

$n_{Cu} = n_{S_2O_3^{2-}} = \left(\frac{0.20 \times 24.00}{1000}\right)$ mols

mass of Cu = $\frac{0.20 \times 24.00}{1000}$ mols × 63 $g\,mol^{-1}$ -(s)

= 0.3048 g or 0.305 g -(s)

Cu mass % = $\frac{0.305\ g}{0.525\ g} \times 100$ -(s)

= 58 % -(s)

(iii) 1) • Evaporation of I_2 due to it's volatility
• In H^+/medium I^- ions can get oxidised by O_2 in air. (s)

2) At high $[I_2]$ (intense yellow) / or begining of titrat if starch is added it forms a black solid & make I_2 ~~or~~ unavailable for titration.
∴ starch is added when $[I_2]$ is low
straw colour, where it forms a blue colour complex (Amylose in I_3^-) & ~~which~~ solution turns colourless at end point

75 (1) 6×2 = 12

10 (a) (i) ~~Purity~~
Easy to reach
occuring in large deposit for long term usage

(ii) R_1 - Limestone R_3 - Air 3×5 = 15
R_2 - Sea water ~~/Brine~~

(iii) A - $O_{2(g)}$ F - $NH_4Cl_{(aq)}$
B - $N_{2(g)}$ G - $NaHCO_{3(s)}$
C - $H_{2(g)}$ H - $NO_{2(g)}$
D - $CO_{2(g)}$ 3×8 = 24
E - $CaO_{(s)}$ (3×11) - 9 = 24

(iv) ~~PR1~~ - P_1 - $NH_{3(g)}$ P_3 - $HNO_{3(aq)}$
P_2 - $Na_2CO_{3(s)}$ (5×3) = 15/5

(v) PR1 - 250 - 300 atm ✓, 450 - 500°C ✓ ~~400 - 450°C~~
Fe Catalyst ✓
Al_2O_3 / K_2O " promoter ✓

PR 2 - 800 - 850°C ✓
Rh/Pt catalyst (3 × 6 = 18)

72

(b)(i) Iron pyride, siderite, hematite, magnetite, Limonite 2 × 2 = 4

(ii) As a fuel ✓

$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$ + heat (ΔH = -ve) ✓

As a reducing agent ✓

$C_{(s)} + FeO_{(s)} \longrightarrow Fe_{(s)} + CO_{2(g)}$ ✓

Generate main reductant CO ✓

$CO_{2(g)} + C_{(s)} \longrightarrow 2CO_{(g)}$ ✓

(2 × 6 = 12)

~~(iii)~~

(c)(i) CFC, NO, CBC (2 × 2 = 4)

(ii) any four (3 × 4 = 12)

(iii) Chloro fluro carbon $\xrightarrow[\text{at higher atm}]{UV}$ $^{\bullet}Cl$ (fission) ✓

$^{\bullet}Cl_{(g)} + O_{3(g)} \longrightarrow O_{2(g)} + {}^{\bullet}OCl_{(g)}$ ✓

$O_{3(g)} \longrightarrow O_{2(g)} + {}^{\bullet}O_{(g)}$ ✓

$^{\bullet}OCl_{(g)} + {}^{\bullet}O_{(g)} \longrightarrow O_2 + {}^{\bullet}Cl_{(g)}$ ✓ (2 × 4 = 8)

$2O_{3(g)} \longrightarrow 3O_{2(g)}$ = (1)

(iv) Skin cancers
Cataract
Mutaes
Bleaching (3 × 3) = 9

50

(4) (i) $2Mn(OH)_{2(aq)} + O_{2(aq)} \rightarrow 2MnO_{2(s)} + 2H_2O$

1 : 2

$MnO_{2(s)} + 2I^-_{(aq)} + 4H^+_{(aq)} \rightarrow Mn^{2+}_{(aq)} + I_{2(aq)} + 3H_2O_{(l)}$

2 1 : 1

$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

1 : 2 (3×3 = 9)

(ii) $O_2 : S_2O_3^{2-}$

1 : 4 – (1)

Amount $S_2O_3^{2-}$ moles consumed = $\frac{0.01 \times 20}{1000}$ (4)

" O_2 " radiated sample = $\frac{0.01 \times 20}{1000} \times \frac{1}{4}$ mols (4)

O_2 DO = $\frac{0.01 \times 20}{4 \times 1000}$ mol × $\frac{32 g mol^{-1}}{1000}$ × $\frac{1000 dm^3}{200 dm^3}$ (4)

= 8.0 mg dm^{-3} – (3)

(iii) Eutrophication – (3)

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