අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2016 අගෝස්තු

General Certificate of Education (Adv.Level) Examination, August 2016

Chemistry - I/Two hours

Instructions:

- *Periodic Table is Provided.*
- *This paper consists of* **08** *pages.*
- *Answer* ***all*** *the questions.*
- ***Use of calculators is not allowed.***
- *Write your* ***Index Number*** *in the space provided in the answer sheet.*
- *Follow the instructions given on the back of the answer sheet carefully.*
- *In each of the questions* **1** *to* **50**, *pick one of the alternatives form (1), (2), (3), (4), (5) which is* ***correct*** *or* ***most appropriate*** *and* ***mark your response on the answer sheet with a cross (x) in accordance with the instructions given on the back of the answer sheet.***

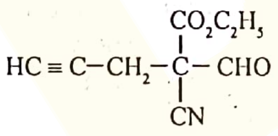
Universal gas constant	R	$= 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}$
Avogadro constant	N_A	$= 6.022 \times 10^{23}\ \text{mol}^{-1}$
Planck's constant	h	$= 6.626 \times 10^{-34}\ \text{J s}$
Velocity of light	c	$= 3 \times 10^{8}\ \text{m s}^{-1}$

---

1. Green light of wave length 4.42×10^{-7} m is observed in the emission spectrum of hydrogen. The energy of one photon of this green light is.
   (1) 4.5×10^{-19} kJ (2) 2×10^{-19} kJ
   (3) 1.5×10^{-19} kJ (4) 4.5×10^{-22} kJ
   (5) 19.9×10^{-26} kJ

2. Which one of the following atoms in its gaseous state will liberate the largest amount of energy when it gains an electron?
   (1) S (2) P (3) Na
   (4) Mg (5) Ne

3. What is the **IUPAC** name of the compound **X**?



$$HC\equiv C-CH_2-\underset{\displaystyle CN}{\overset{\displaystyle CO_2C_2H_5}{C}}-CHO$$

[X]

   (1) ethyl 2-formyl-2-nitrile-4-pentynoate
   (2) 2-cyano-2-ethoxycarbonyl-4-pentynal
   (3) 2-ethoxycarbonyl-2-nitrile-4-pentynal
   (4) ethyl-2-cyano-2-formyl-4-pentynoate
   (5) ethyl 2-cyano-2-formyl-4-pentynoate

4. Which of the following statements regarding sizes of ions formed by *s* and *p* block elements is **false**?
   (1) Cations are always smaller than their neutral atoms.
   (2) Anions are always larger than their neutral atoms.
   (3) The size of cations decreases from left to right across a period.
   (4) The size of anions increases from left to right across a period.
   (5) The size of anions formed by elements of second period are larger than cations formed by elements of third period.

5. The sets of quantum numbers associated with the last two eletrons of an atom in an element are (3, 0, 0, +½) and (3, 0, 0, -½). The elements is
   (1) Li (2) Na (3) Mg
   (4) Al (5) K

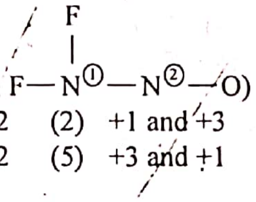
6. A 0.60 g sample of KIO_3 was dissolved in water and excess KI was added to it. The minimum amount of 3.0 mol dm^{-3} HCl required to completely convert KIO_3 to I_3^- is (O = 16, K = 39, I = 127)
   (1) 1.0 cm^3 (2) 4.7 cm^3 (3) 5.6 cm^3
   (4) 10.2 cm^3 (5) 33.6 cm^3

7. At 25 °C the solubility product, K_{sp} of MnS(s) is 5.0×10^{-15} mol^2 dm^{-6}. The acid dissociation constants K_1 and K_2 for $H_2S(aq)$ are 1.0×10^{-7} mol dm^{-3} and 1.0×10^{-13} mol dm^{-3} respectively. The equilibrium constant, K_c for the reaction, $MnS(s) + 2H^+(aq) \rightleftharpoons Mn^{2+}(aq) + H_2S(aq)$ is
   (1) 2.0×10^{-16} (2) 5.0×10^{-8} (3) 20
   (4) 5.0×10^{5} (5) 2.0×10^{7}

8. An organic compound **A** contains 39.97% of C, 6.73% of H and 53.30% of O, by weight. What is the empirical formula of **A**? (H = 1, C = 12, O = 16)
   (1) $C_6H_8O_2$ (2) $C_2H_4O_2$ (3) $C_3H_7O_3$
   (4) $C_3H_6O_3$ (5) CH_2O

9. Which of the following statements is **false** with regard to the chemistry of Lithium (Li) and its compounds?
   (1) Lithium reacts with oxygen gas to give Li_2O.
   (2) Lithium has the highest melting point among the group I metals.
   (3) The basicity of LiOH is less than that of NaOH.
   (4) Li_2CO_3 has the lowest thermal stability among the group I carbonates.
   (5) LiCl gives a blue colour when subjected to the flame test.

10. The oxidation states of N① and N② in the most stable Lewis structure of the F_2NNO molecule respectively are (skeleton,



$$F-\overset{\displaystyle F}{\overset{|}{N}}{}^{①}-N^{②}-O$$

)
   (1) +2 and +2 (2) +1 and +3 (3) +2 and +3
   (4) +1 and +2 (5) +3 and +1

11. Consider the reaction, $CH_4(g) + CO_2(g) \rightleftharpoons 2CO(g) + 2H_2(g)$. When 0.60 mol of $CH_4(g)$ and 1.00 mol of $CO_2(g)$ were introduced into a closed rigid container of volume 1.00 dm^3 at 25 °C and the system was allowed to reach equilibrium, 0.40 mol of CO(g) was formed. The value of the equilibrium constant, K_C ($mol^2\ dm^{-6}$) for the reaction is
(1) 0.04 (2) 0.08 (3) 0.67
(4) 1.20 (5) 8.00

12. The chemical formula of diamminebromidodicarbonylhydridocobalt (III) chloride according to **IUPAC** rules is.
(1) $[Co(CO)_2BrH(NH_3)_2]Cl$
(2) $[CoBr(CO)_2(NH_3)_2H]Cl$
(3) $[Co(NH_3)_2Br(CO)_2H]Cl$
(4) $[CoBr(CO)_2H(NH_3)_2]Cl$
(5) $[CoHBr(CO)_2(NH_3)_2]Cl$

13. The following procedure was used to determine the sulphur content in a coal sample. A coal sample of mass 1.60 g was burned in oxygen gas. The SO_2 gas formed was collected in a solution of H_2O_2. This solution was then titrated with 0.10 mol dm^{-3} **NaOH**. The volume of **NaOH** required to reach the end point was 20.0 cm^3. The percentage of sulphur in the coal sample is (S = 32)
(1) 1.0 (2) 2.0 (3) 4.0
(4) 6.0 (5) 8.0

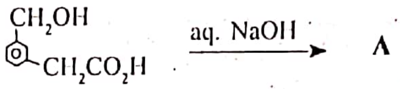
14. Combustion of **ethylene**, $C_2H_4(g)$ is shown in the following reaction.

$$C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(g) \quad \Delta H = -1323\ kJ\ mol^{-1}$$

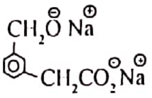
What is the value of ΔH (in kJ mol^{-1}) if the combustion produces water in the liquid state, $H_2O(l)$ rather than water in the gaseous state, $H_2O(g)$?
(ΔH for $H_2O(g) \longrightarrow H_2O(l)$ is - 44 kJ mol^{-1})
(1) -1235 (2) -1279 (3) -1323
(4) -1367 (5) -1411

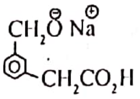
15. The vapour pressure of benzene at 25 °C is 12.5 kPa. When an unknown non-volatile substance was dissolved in 100 cm^3 of benzene at this temperature, the vapour pressure of the solution was found to be 11.25 kPa. The mole fraction of the unknown substance in the above solution is
(1) 0.05 (2) 0.10 (3) 0.50
(4) 0.90 (5) 0.95

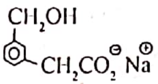
16. A buffer solution can be prepared by mixing a weak acid ($K_a = 4.0 \times 10^{-7}$ mol dm^{-3}) and a strong base. The ratio of the concentrations of acid to base (acid : base) needed to prepare a buffer solution at pH = 6 is.
(1) 1 : 1 (2) 2 : 1 (3) 2 : 5
(4) 5 : 1 (5) 5 : 2

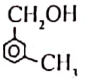
17.


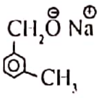
The major product **A** obtained from the reaction given above is

(1)


(2)


(3)


(4)


(5)


18. The rate law for the reaction $NO_2(g) + CO(g) \longrightarrow NO(g) + CO_2(g)$, is, Rate = $k[NO_2]^2$. If a small amount of CO(g) is introduced to a closed rigid container in which this reaction is taking place at a given temperature, which of the following statements is **true** regarding the changes that would take place?
(1) Both *k* and reaction rate increase.
(2) Both *k* and reaction rate remain unchanged.
(3) Both *k* and reaction rate decrease.
(4) *k* increases and reaction rate remains unchanged.
(5) *k* remains unchanged and reaction rate increases.

19. At 25 °C, given that.

$M(s) + 3Ag^+(aq) \longrightarrow 3Ag(s) + M^{3+}(aq)$ $E^0_{cell} = 2.46$ V
$Ag^+(aq) + e \longrightarrow Ag(s)$ $E^0 = 0.80$ V

The standard reduction potential for the half-reaction, $M^{3+}(aq) + 3e \longrightarrow M(s)$ at 25 °C is
(1) -1.66 V (2) -0.06 V (3) 0.06 V
(4) 1.66 V (5) 3.26 V

20. How many resonance structures can be drawn for the molecule N_2O_3 ?

$$\text{(skeleton, } O-\overset{\overset{\displaystyle O}{|}}{N}-N-O)$$

(1) 2 (2) 3 (3) 4
(4) 5 (5) 6

21. Which of the following statements is **true** with regard to transition metals and their compounds?
(1) The electronic configuration of copper is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}$.
(2) All elements that have *d*- electrons are 'transition elements.
(3) The electronic configuration of Ti in TiO_2 is the same as that of Sc in $ScCl_3$.
(4) Acidity of the oxides of a given transition metal decreases with increase in oxidation state of the metal ion.
(5) Transition metals in the 3*d* series can have the quantum number $m_l = \pm 3$

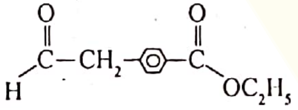
22. The equilibrium $PCl_3(g) + 3NH_3(g) \rightleftharpoons P(NH_2)_3(g) + 3HCl(g)$ exists in a closed container at a constant temperature. If the volume of the container is increased by keeping the temperature constant, which of the following is **true** regarding the changes that could take place in the rates of forward and reverse reactions?

	Forward reaction	**Reverse reaction**
(1)	increases	decreases
(2)	decreases	increases
(3)	decreases	decreases
(4)	increases	increases
(5)	no change	no change

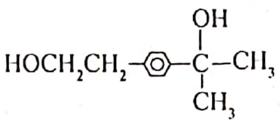
23. When solid ammonium chloride, $NH_4Cl(s)$ is dissolved in water at 25 °C, the temperature of the solution decreases. Which of the following is **true** of ΔH^0 and ΔS^0 for the process?

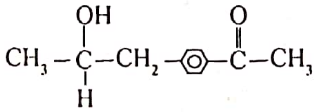
	ΔH^0	ΔS^0
(1)	positive	positive
(2)	positive	negative
(3)	positive	zero
(4)	negative	positive
(5)	negative	negative

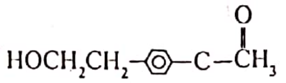
24. Which of the following statements is **false** regarding 3*d* transition metals and their compounds?
(1) Oxides of some metals are amphoteric.
(2) Some metals and metal oxides are used in industry as catalysts.
(3) Electronegativity of 3*d* transition metals is higher than 4*s* metals.
(4) Only one element shows the oxidation state of +7.
(5) Oxoions such as MnO_4^-, $Cr_2O_7^{2-}$ are resistant to reduction.

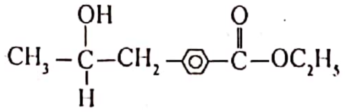
25. 

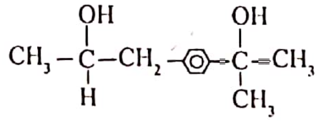
The major product obtained, when the compound above is reacted with excess CH_3MgBr, and then hydrolyzed is

(1) 

(2) 

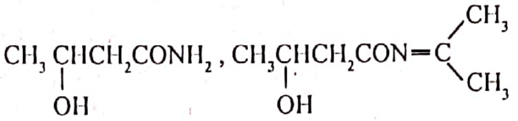
(3) 

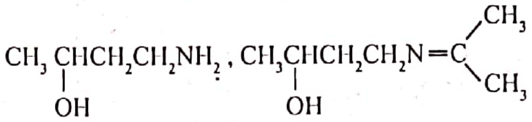
(4) 

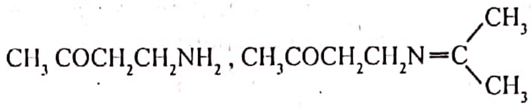
(5) 

26. $CH_3COCH_2CONH_2 \xrightarrow[(2)\ H^+/H_2O]{(1)\ LiAlH_4} X \xrightarrow{(1)\ CH_3COCH_3} Y$

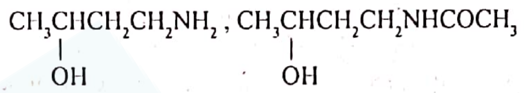
In the reaction scheme given above, the structures of **X** and **Y** respectively are

(1) 

(2) 

(3) 

(4) $CH_3COCH_2CH_2NH_2$, $CH_3COCH_2CH_2NHCOCH_3$

(5) 

$CH_3\underset{OH}{CH}CH_2CH_2NH_2$, $CH_3\underset{OH}{CH}CH_2CH_2NHCOCH_3$

27. Which of the following statements is **false** with regard to NH_3?
(1) NH_3 can act only as a base.
(2) NH_3 burns in oxygen to give N_2 gas.
(3) NH_3 gives a brown colour with Nessler's reagent.
(4) NH_3 reacts with Li to give Li_3N and H_2 gas.
(5) NH_3 has a bond angle less than 109° 28' but greater than that in NF_3.

28. An electrochemical cell was constructed using $Zn^{2+}(aq)/Zn(s)$ and $Sn^{2+}(aq)/Sn(s)$ electrodes. Which of the following statements correctly describes the operation of the cell?

$E^o_{Zn^{2+}(aq)/Zn(s)} = -0.76$ V, $E^o_{Sn^{2+}(aq)/Sn(s)} = -0.14$ V

(1) Zn electrode is the cathode, Zn in oxidized, electrons flow from Sn to Zn.
(2) Zn electrode is the cathode, Sn is oxidized, electrons flow from Sn to Zn.
(3) Sn electrode is the anode, $Zn^{2+}(aq)$ is reduced, electrons flow from Zn to Sn.
(4) Zn electrode is the anode, Zn is oxidized, electrons flow from Zn to Sn.
(5) Zn electrode is the anode, $Sn^{2+}(aq)$ is reduced, electrons flow from Sn to Zn.

29. Which one of the following statements about $C_6H_5NH_2$ is **false**?
(1) Reacts with CH_3COCl to form an amide.
(2) Evolves ammonia when heated with aqueous NaOH.
(3) Reacts with bromine water to give a white precipitate.
(4) Gives a phenol when reacted with nitrous acid.
(5) Less basic than $C_6H_5CH_2NH_2$.

30. Four saturated solutions of silver acetate in contact with $CH_3COOAg(s)$ are placed in four beakers. How does the solubility of silver acetate change, when the following solutions are added separately to each of the beakers?

CH_3COONa, dil. HNO_3 , NH_4OH , $AgNO_3$

	CH_3COONa	dil. HNO_3	NH_4OH	$AgNO_3$
(1)	increases	increases	increases	increases
(2)	decreases	decreases	decreases	decreases
(3)	decreases	increases	increases	decreases
(4)	decreases	increases	decreases	decreases
(5)	decreases	decreases	increases	decreases

- For each of the questions **31** to **40**, one or more responses out of the four responses *(a)*, *(b)*, *(c)* and *(d)* given is/are correct. Select the correct response/responses. In accordance with the instructions given on your answer sheet, 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 *(d)* and *(a)* are correct.
  - (5) if **any other** number or combination of responses is correct.

Summary of above Instructions

(1)	(2)	(3)	(4)	(5)
Only *(a)* and *(b)* are correct	Only *(b)* and *(c)* are correct	Only *(c)* and *(d)* are correct	Only *(d)* and *(a)* are correct	**Any other** number of combination of responses is correct

31. Consider the reaction given below.

$$2HI(g) \rightleftharpoons I_2(s) + H_2(g) \quad \Delta H^0 = -52.96 \text{ kJ mol}^{-1}$$

Which of the following statements is/are **correct** when the reaction takes place in a closed container?

(a) Increasing the temperature and decreasing the pressure drives the equilibrium to the right.
(b) Increasing the temperature and decreasing the pressure drives the equilibrium to the left.
(c) Decreasing the temperature and increasing the pressure drives the equilibrium to the right.
(d) Decreasing the temperature and increasing the pressure drives the equilibrium to the left.

32. Which of the following statements is/are **true** regarding the molecule $CH_2{=\!=}CHCHO$?

(a) All three carbon atoms are sp^2 hybridized.
(b) All three carbon atoms lie in a straight line.
(c) All three carbon atoms do not lie in the same plane.
(d) All three carbon atoms lie in the same plane.

33. Some of the reactions associated with the Solvay process are

(a) $CaCO_3 \xrightarrow{\Delta} CaO + CO_2$
(b) $NaCl + NH_3 + H_2O + CO_2 \longrightarrow NaHCO_3 + NH_4Cl$
(c) $Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$
(d) $Ca(OH)_2 + 2NH_4Cl \longrightarrow CaCl_2 + 2NH_4OH$

34. Which of the following statements is/are always **true** regarding the rate of an elementary reaction?

(a) The rate can be increased by increasing temperature.
(b) The rate can be increased by removing the products from the reaction medium.
(c) The rate of the reaction depends on the rate of the slowest step.
(d) Rate of the reaction can be increased by making $\Delta G < 0$.

35. Which of the following statements is/are **true** regarding 4-pentenal?

(a) Shows geometric isomerism.
(b) The compound obtained when reacted with HBr does not show optical isomerism.
(c) The compound obtained when reacted with HBr shows optical isomerism.
(d) The compound obtained when reacted with CH_3MgBr shows optical isomerism.

36. Which of the following statements is/are **false** with regard to nitric acid?

(a) Pure nitric acid is a light yellow liquid.
(b) All N – O bond lengths in nitric acid are equal.
(c) Nitric acid cannot act as a reducing agent.
(d) It is used in the manufacture of an important fertilizer, ammonium nitrate.

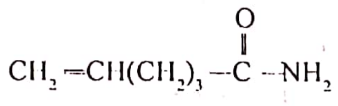
37. C(s) reacts with $O_2(g)$ to produce 0.40 mol of $CO_2(g)$, with the release of 40 kJ of heat. Which of the following statements is/are **true** for the above system?
(C = 12, O = 16)

(a) 100 kJ of heat is required to decompose one mole of $CO_2(g)$ into C(s) and $O_2(g)$.
(b) 25 kJ of heat is required to form 11 g of $CO_2(g)$.
(c) Sum of enthalpies of products is less than the sum of enthalpies of reactants.
(d) Sum of enthalpies of products is greater than the sum of enthalpies of reactants.

38. Which of the following statements is/are **true** for a balanced chemical equation of an elementary reaction?

(a) The order of reaction is the same as molecularity.
(b) The order of reaction is less than the molecularity.
(c) The order of reaction is higher than the molecularity.
(d) Molecularity cannot be zero.

39. Which of the following statements is/are **true** regarding the molecule given below?



$$CH_2{=}CH(CH_2)_3{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}NH_2$$

(a) Decolourizes bromine water.
(b) Liberates ammonia when warmed with an aqueous NaOH solution.
(c) Gives an orange cloured precipitate with 2,4-DNP reagent.
(d) Gives a primary amine when treated with $NaBH_4$.

40. Consider the compounds given below.

(A) HCHO	**(B)** NH_2CONH_2
(C) C_6H_5OH	**(D)** $HO_2C(CH_2)_4CO_2H$
(E) $H_2N(CH_2)_6NH_2$	

Which of the pairs given below will produce thermo setting polymers when reacted under the appropriate conditions?

(*a*) A and B (*b*) A and C

(*c*) C and D (*d*) D and E

- In question Nos. **41** to **50**, two statements are given in respect of each question.
  From the Table given below, select the response out of the responses (1), (2), (3), (4) and (5) that **best** fits the two statements and mark appropriately on your answer sheet.

Response	**First Statement**	**Second Statement**
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does **not** explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

	First Statement	**Second Statement**
41.	Sucrose when treated with concentrated H_2SO_4 gives a black mass.	Concentrated H_2SO_4 is a strong oxidizing agent.
42.	In the addition reaction between $CH_3CH = CH_2$ and HX, the $CH_3CH_2CH_2^{\oplus}$ carbocation is formed easily as an intermediate.	Alkyl groups attached to a positively charged carbon atom release electrons through C – C, σ–bonds towards the positively charged carbon and increase the stability of the carbocation.
43.	The average molecular speed of $H_2(g)$ at 80 °C is lower than that of $N_2(g)$ at 40 °C.	Average molecular speed is directly proportional to the square root of temperature and inversely proportional to the square root of molar mass.
44.	Reactivity of alkali metals with water increases on going down the group.	Strong metallic bonds are formed when the size of the metal atom increases.
45.	$CH_3C{\equiv}CH$ give a red precipitate when treated with ammoniacal Cu_2Cl_2.	The acidic terminal hydrogen in alkynes can be displaced by metals.
46.	All spontaneous reactions are exothermic.	For any reaction $\Delta G = \Delta H + T \Delta S$
47.	The reactin between $N_2(g)$ and $H_2(g)$ to produce $NH_3(g)$ is endothermic.	$NH_3(g)$ is used in the synthesis of nitric acid and urea.
48.	Mirror images of bromochloromethane are enantiomers.	Enantiomers are non superimposable mirror images of each other.
49.	The solubility of barium oxalate, $BaC_2O_4(s)$ is less in acidic aqueous medium than in water.	The conjugate acid of $C_2O_4^{2-}$ is the weak acid $H_2C_2O_4$.
50.	Enzymes present in root nodules of certain plants are capable of fixing N_2.	N_2 molecule is unreactive mainly because of the presence of the N–N triple bond.

The Periodic Table

1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La- Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac- Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut	...				

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2016 අගෝස්තු
General Certificate of Education (Adv.Level) Examination, August 2016
Chemistry II - Three hours

PART A - STRUCTURED ESSAY

*Answer **all four** questions on this paper itself. (Each question carries 10 marks.)*

1. (*a*) You are provided with the following list of some *p*-block elements in the Periodic Table.

B	**C**	**N**	**O**	**F**	**Ne**
Al	**Si**	**P**	**S**	**Cl**	**Ar**

From the list;

(i) identify the non-metallic element that forms a homoatomic covalent lattice of high hardness.

(ii) identify the element that exhibits the widest range of oxidation states.

(iii) identify the element that has the highest first ionization energy.

(iv) identify the element that exhibits amphoteric properties.

(v) identify the element that has two gaseous allotropes.

(vi) identify the element that is considered to be the strongest oxidizing agent.

(2.4 marks)

(*b*) The following parts (i) to (v) are based on the molecule CN_4. It has the following skeleton.

N–C–N–N–N

(i) Assuming that N–N bond lengths are approximately equal, draw the **most acceptable** Lewis structure for this molecule.

(ii) Draw **three** resonance structures for this molecule (excluding the structure drawn in part (i) above)

(iii) Based on the Lewis structure drawn in (i) above, state the following regarding the **C** and **N** atoms given in the table below.

I. VSEPR pairs around the atom.
II. electron pair geometry around the atom.
III. Shape around the atom.
IV. hybridization of the atom.

The nitrogen atoms of CN_4 are numbered as follows :

$N^1–C–N^2–N^3–N^4$

		C	N^2	N^3
I.	VSEPR pairs	2	3	2
II.	Electron pair geometry	Linear	trigonal planar	linear
III.	Shape	Linear	Angular/v	linear
IV.	Hybridization	SP	SP^2	SP

(iv) In the Lewis structure drawn in part (i) above, indicate whether N^2 or N^3 has the highest electronegativity. Give reasons for your choice [Numbering of atoms is as in part (iii)]

(v) Identify the atomic/hybrid orbitals involved in the formation of the following σ bonds in the Lewis structure drawn in part (i) above. [Numbering of atoms is as in part (iii)]

I. N^1 - C N^1 ...., C ....
II. C - N^2 C ...., N^2 ....
III. N^2 - N^3 N^2 ...., N^3 ....
IV. N^3 - N^4 N^3 ...., N^4 ....

(5.6 marks)

(*c*) State whether the following statements are **true** or **false.** (Reasons are **not** required.)

(i) SF_6 and OF_6 are both stable molecules.

(ii) Although the electron pair geometry of $SiCl_4$, NCl_3 and SCl_2 is tetranedral, their bond angles are different.

(iii) The boiling point of **Kr** is greater than that of **Xe**.

(iv) The solubility of group II sulphates decreases down the group primarily due to decrease in hydration enthalpy of the cations.

(2.0 marks)

2. (*a*) **X** and **Y** are s-block elements of the Periodic Table. They react with water to form hydroxides. The hydroxide of **X** is more basic than that of **Y**. The hydroxide of **X** is used in the manufacture of baby soap. The hydroxide of **Y** is commonly used to identify the gas **Z** that is one of the main gases responsible for global warming.

(i) Identify **X** and **Y**.

X ☐ **Y** ☐

(ii) Write the electronic configerations of **X** and **Y**.

X =
Y =

(iii) Write the colour of the flame given by salts of **X** and **Y** in the flame test.

X =
Y =

(iv) Indicate the relative magnitudes of the following in respect of **X** and **Y**.

I. Atomic Size ☐ > ☐

II. Density ☐ > ☐

III. Melting Point ☐ > ☐

IV. First ionization energy ☐ > ☐

(v) Identify **Z**.

(vi) Using balanced chemical equations **only**, indicate how the hydroxide of **Y** could be used to identify **Z**.

Note: Indicate precipitates, if any, using "↓" and colours of precipitates / solutions used in the identification.

(vii) A natural source of **Y** in which it is present as a carbonate is used as a raw material in the manufacture of a disinfectant.

I. Name the natural source.

II. Identify the disinfectant.

III. Write the steps in the manufacturing process of the disinfectant, using balanced chemical equations **only**.

(5.0 marks)

(*b*) (i) Complete the reactions given below by selecting the appropriate solution from the given list and writing in the box.

List of solutions (not in order)

$Na_2S_2O_3$(aq), $AgNO_3$(aq), K_2SO_4(aq), $(NH_4)_2CO_3$(aq), $BaCl_2$ (aq), KI (aq)

Note: A solution should be used **only once**.

I. $BaCl_2$(aq) + ☐ → A (White precipitate that dissolves in dil. HCl to give a clear solution.)

II. $Pb(NO_3)_2$(aq) + ☐ → B (Yellow precipitate that dissolves in hot water.)

III. $AgNO_3$(aq) + ☐ → C (White precipitate that turns black on standing.)

IV. K_2SO_3(aq) + ☐ → D (White precipitate that dissolves in dil. HCl.)

V. NaBr(aq) + ☐ → E (Pale yellow precipitate that dissolves completely in conc. ammonia.)

VI. $Ba(NO_3)_2$(aq) + ☐ → F (White precipitate that does not dissolve in dil. HCl)

(ii) Write the chemical formulae of the precipitates **A** to **F**.

A : ....

B : ....

C : ....

D : ....

E : ....

F : ....

(iii) Write balanced chemical equations for the dissolution of precipitates **A, D** and **E** in b (i) above.

(A) : ....

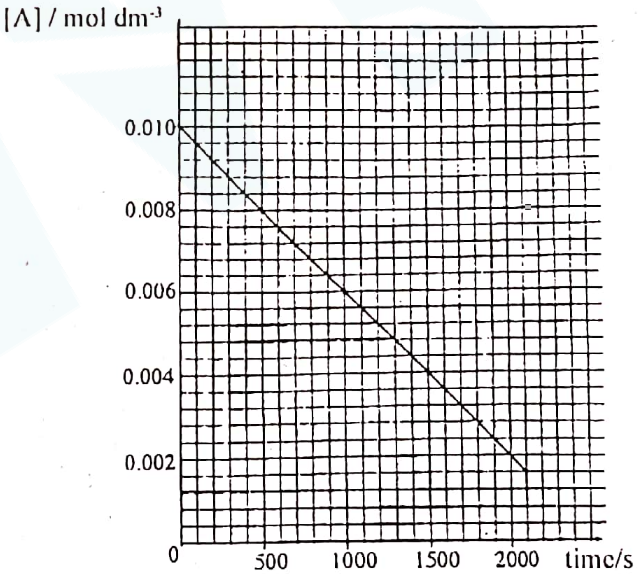
(D) : ....

(E) : .... **(5.0 marks)**

3. (*a*) When 0.010 moles of gas **A** is placed in a 1.0 dm^3 evacuated closed rigid container in the presence of a small amount of a solid catalyst, at 227 °C, it decomposes as shown below.

$$A(g) \longrightarrow B(g) + C(g)$$

The concentration of A(g) was measured over time. The results are shown in the following graph.



(i) Taking the order and the rate constant of the reaction as *a* and *k* respectively, write the rate expression for the above reaction.

(ii) Giving reasons, determine the value of *a*.

(iii) Calculate the rate constant, *k* at 227 °C.

(iv) Calculate the pressure in the container when half the initial of A(g) has decomposed. Assume that the volume of the catalyst can be neglected.

(6.0 marks)

(*b*) In the presence of a solid catalyst, the gas X decomposes according to the following chemical equation.

$$X(g) \xrightarrow[\Delta]{\text{Catalyst}} 2\,Y(g) + Z(g)$$

1.0 mole of gas X was introduced to an evacuated container. The initial volume of the gas was measured to be V_0. The reaction was initiated by introducing a small amount of catalyst (volume is negligible). The rate constant of the catalysed reaction is k_1 and order of the reaction with respect to X is *b*. The initial rate of the reaction was measured as R_0. The Pressure of the system was maintained at a constant value by allowing the container to expand. The temperature of the system was also maintained at a constant value.

(i) Write an expression for R_0 using the terms b, k_1 and V_0.

(ii) It was observed that the rate of the reaction was $0.25R_0$ and the volume of the container was doubled when 50% of X(g) was consumed. Calculate the order *b* of the reaction.

(4.0 marks)

4. (*a*) (i) **A**, **B**, **C** and **D** are structural isomers with the molecular formula $C_4H_{10}O$. All four isomers reacted with metallic sodium to evolve H_2 gas. Of the four isomers, only **A** exhibited optical isomerism. When **B**, **C** and **D**, were added separately to conc. HCl containing $ZnCl_2$, the mixture containing **B** became turbid very rapidly. The development of terbidity with **C** and **D** was very slow. When **C** and **D** were heated with conc. H_2SO_4, **E** and **F** were respectively obtained. **E** and **F** are structural isomers with the molecular formula C_4H_8. Neither **E** nor **F** exhibited geometric isomerism. When **E** and **F** were treated with HBr, **G** and **H** were respectively obtained. Only **G** exhibited optical isomerism. Draw the strucures of **A**, **B**, **C**, **D**, **E**, **F**, **G** and **H** in the boxes given below. (It is **not necessary** to draw stereoisomeric forms.)

A **B** **C**

D **E** **F**

G **H**

(4.0 marks)

(i) When **A** and **C** were reacted with PCC, **I** and **J** were respectively obtained. Draw the structures of **I** and **J** in the boxes given below. (PCC = Pyridinium chlorochromate)

(ii)

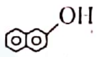
I **J**

(5.0 marks)

(*b*) Draw the structure of the **major** organic products **K, L, M, N, O, P, Q, R, S** and **T** of the following reactions in the relevent boxes given on page 10.

(i) $CH_3CH = CH_2 \xrightarrow[\text{Peroxide}]{\text{HBr}}$ **K**

(ii) $C_6H_5CHO \xrightarrow[\text{② dehydration}]{\text{① 2, 4 - DNP}}$ **L**



(iii) $C_6H_5N_2^+Cl^- \xrightarrow[\text{NaOH, 0 - 5 e}]{}$ **M**

(iv) $C_6H_5COCl \xrightarrow{NH_3}$ **N**

(v) $C_6H_5CO_2H \xrightarrow[\text{Conc. }H_2SO_4]{\text{Conc. }HNO_3}$ **O**

(vi) $CH_3COC_2H_5 \xrightarrow[\text{Conc. HCl}]{Zn|Hg}$ **P**

(vii) $CH_3CHO \xrightarrow{Ag(NH_3)_2^+\,OH^-}$ **Q**

(viii) $CH_3C{\equiv}CH \xrightarrow{NaNH_2}$ **R**

(ix) $CH_3C{\equiv}CCH_3 \xrightarrow{H_2|Pd}$ **S**

(x) $C_6H_5OH \xrightarrow{Br_2}$ **T**

K L M

N O P

Q R S

T

(3.0 marks)

(*c*) Write the mechanism for the reaction between $C_2H_5CH=CHC_2H_5$ and $Br_2(CCl_4)$.

(2.0 marks)

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2016 අගෝස්තු
General Certificate of Education (Adv.Level) Examination, August 2016
Chemistry II

- Universal gas constant $R = 8.314\ \mathrm{J\,K^{-1}\,mol^{-1}}$
- Avogadro constant $N_A = 6.022 \times 10^{23}\ \mathrm{mol^{-1}}$

PART B - ESSAY

*Answer **two** questions only. (Each question carries* **15 marks.***)*

5. (*a*) The procedure given below was followed to determine the partition coefficient, K_D of butanedioic acid (BDA, $HOOCCH_2CH_2COOH$) between ether and water at 25 °C.

Initially, 20 g of solid BDA was shaken well with a mixture of approximate volumes of 100 cm³ of ether and 100 cm³ of water in a reagent bottle and the layers were allowed to separate. At this stage, some undissolved BDA was seen remaining at the bottom of the reagent bottle. Thereafter, a 50.00 cm³ volume of ether layer and a 25.00 cm³ volume of water layer were titrated with 0.05 mol dm⁻³ NaOH solution. The volumes taken from the ether and water layers required 4.80 cm³ and 16.00 cm³ of the NaOH solution respectively.

(i) Calculate the partition coefficient, K_D for the distribution of butanedioic acid between ether and water at 25 °C.

(ii) Calculate the solubility of butanedioic acid in ether, given that the solubility of this acid in water is 8.0 g dm⁻³.

(4.0 marks)

(*b*) Consider the following reactions. Thermodynamic data supplied are **not** for the standard state.

	ΔH/kJ mol⁻¹	ΔS/J K⁻¹ mol⁻¹
$C(s) + H_2O(g) \longrightarrow CO(g) + H_2(g)$	130	140
$CO_2(g) + H_2(g) \longrightarrow CO(g) + H_2O(g)$	40	50

(i) Calculate ΔH and ΔS for the reaction $2CO(g) \longrightarrow C(s) + CO_2(g)$. State giving reasons whether the sign of ΔS agrees with the reaction taking place.

(ii) By means of a suitable calculation, predict whether the reaction given in part (i) above is spontaneous at 27 °C.

(4.0 marks)

(*c*) An excess amount of C(s) and 0.15 mol of $CO_2(g)$ were placed in a closed rigid 2.0 dm³ container and the system was allowed to reach equilibrium at a temperature of 689 °C. Once the equilibrium was achieved, the pressure in the container was found to be 8.0×10^5 Pa. (Take RT = 8000 J mol⁻¹ at 689 °C)

(i) Write an expression for the equilibrium constant, K_p for the reaction $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$.

(ii) Calculate K_p and K_C at 689 °C.

(iii) In another experiment, the container described above contains an excess of C(s) together with CO(g) and $CO_2(g)$ at 689 °C. The initial partial pressure of each gas is 2.0×10^5 Pa. Explain, with the aid of a calculation, the change in partial pressure of $CO_2(g)$ when the system reaches equilibrium.

(7.0 marks)

6. (*a*) A 0.10 mol dm⁻³ solution of a weak acid, **HA** was prepared by diluting an appropriate amount of the pure weak acid to 25.00 cm³ with distilled water in a volumetric flask at 25 °C. The pH of this solution was 3.0.

(i) Considering the equation, $HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$, calculate the dissociation constant, K_a of the weak acid.

(ii) A dilute solution of this weak acid, **HA** was titrated with a strong base, **BOH**. It was found that the pH of the titration mixture after reaching the equivalence point was 9.0. Calculate the concentration of the salt, **AB** in the titration mixture. ($K_w = 1.0 \times 10^{-14}$ mol² dm⁻⁶ at 25 °C)

(iii) The above titration mixture was diluted hundred times by adding distilled water. Calculate the **pH** of the diluted titration mixture.

(5.0 marks)

(*b*) AgBr(s) is a pale-yellow coloured salt sparingly soluble in water.
Its solubility product, K_{sp} is 5.0×10^{-13} mol² dm⁻⁶ at 25 °C.

(i) Calculate the concentration of $Ag^+(aq)$ in a saturated solution of AgBr in equilibrium with solid AgBr at 25 °C.

(ii) Solid AgBr together with 100.0 cm³ of the solution described in part (i) above were placed in a beaker. A volume of 100.0 cm³ of distilled water was added to the beaker and the mixture was stirred well until the equilibrium is reached. At this stage, some solid AgBr was still left at the bottom of the beaker. What could be the concentration of $Ag^+(aq)$ in this solution? Explain your answer.

(iii) Using a suitable calculation, predict the observation expected when 10.0 cm³ of a 1.5×10^{-4} mol dm⁻³

$AgNO_3$ solution and 5.0 cm^3 of a 6.0×10^{-4} mol dm^{-3} NaBr solution are mixed at 25 °C.

(5.0 marks)

(*c*) (i) The pressure of the vapour phase in equilibrium with an ideal binary solution is P. The liquid phase mole fractions of the two components are X_1 and X_2, and their respective saturated vapour pressures are P_1^0 and P_2^0. Show that

$$X_1 = \frac{P - P_2^0}{P_1^0 - P_2^0}$$

(ii) The pressure of the vapour phase in equilibrium with a binary solution containing methanol and ethanol is 4.5×10^4 Pa at 50 °C. At this temperature the saturated vapour pressures of methanol and ethanol are 5.5×10^4 Pa and 3.0×10^4 respectively. Consider that the solutions behave ideally.

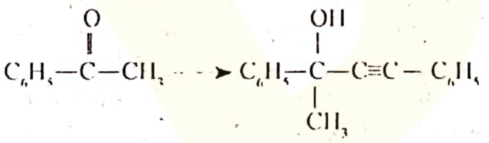
I. Calculate the mole fractions of methanol and ethanol in the liquid phase.

II. Calculate the mole fractions of methanol and ethanol in the vapour phase.

(iii) Based on the above calculations and given information, draw the vapour pressure - composition diagram of the methanol - ethanol mixture at 50 °C. Consider that the solutions behave ideally.

(5.0 marks)

7. (*a*) Using **only** the chemicals given in the list, show how you would carry out the following conversion.



$$C_6H_5-\overset{\overset{\large O}{\|}}{C}-CH_3 \dashrightarrow C_6H_5-\underset{\underset{\large CH_3}{|}}{\overset{\overset{\large OH}{|}}{C}}-C\equiv C-C_6H_5$$

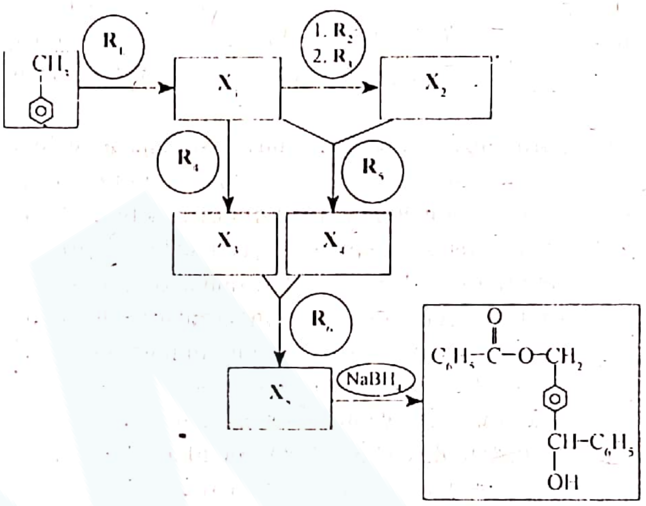
List of chemicals

H_2O, alcoholic KOH, Br_2, Conc. H_2SO_4, $NaBH_4$, C_2H_5MgBr/dry ether

Your conversion should not exceed 9 steps.

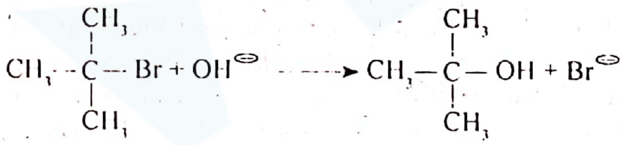
(6.0 marks)

(*b*) Identify $\mathbf{R_1}$ - $\mathbf{R_6}$ and $\mathbf{X_1}$ - $\mathbf{X_5}$ in order to complete the following reaction scheme.



(7.0 marks)

(*c*) (i) Give the mechanism for the following reaction.



$$CH_3-\underset{\underset{\large CH_3}{|}}{\overset{\overset{\large CH_3}{|}}{C}}-Br + OH^{\ominus} \dashrightarrow CH_3-\underset{\underset{\large CH_3}{|}}{\overset{\overset{\large CH_3}{|}}{C}}-OH + Br^{\ominus}$$

A **B**

(ii) The reaction of **A** with NaOH, gives in addition to **B** another product **C**. Give the structure of **C**.

(2.0 marks)

PART C - ESSAY

Answer two questions only. (Each question carries **15** *marks.)*

8. (*a*) The compound **A** (**A** = MX_n, M = a transition element that belongs to the 3*d*-block, X = ligands of the same type) when treated with excess dilute NaOH followed by H_2O_2 gives a compound **B**. When an aqueous solution of **B** is acidified with dil. H_2SO_4 compound **C** is produced. **C** when reacted with NH_4Cl gives compound **D** as one of the products. Heating solid **D** gives a blue coloured compound **E**, water vapour and an inert diatomic gas **F**. Ca metal when burnt in gas **F** gives a white solid **G**. The reaction of **G** with water liberates a gas **H**. This gas forms white fumes with HCl gas. The metal Na reacts with liquid **H** to give a colourless diatomic gas **I** as one of the products. When an aqueous solution of **A** is treated with excess Na_2CO_3, a coloured precipitate is formed. The precipitate is filtered and the filtrate is acidified with dil HNO_3. Addition of $AgNO_3$(aq) to this solution gives a white precipitate which is soluble in dilute NH_4OH.

(i) Identify **A**, **B**, **C**, **D**, **E**, **F**, **E**, **G**, **G** and **I**.

(ii) What will you observe when a solution containing **C** is treated with dil. NaOH? Give the balance chemical equation relevant to this observation.

(5.0 marks)

(*b*) An aqueous solution T contains **three** metal ions. The following experiments were carried out to identify these metal ions.

Experiment	**Observation**
(1) T was acidified with dilute HCl. and H_2S was bubbled through the clear solution obtained.	A black precipitate Q_1 was formed.
(2) Q_1 was removed by filtration. The filtrate was boiled till all the H_2S was removed. The solution was cooled, and NH_4Cl and NH_4OH were added. H_2S was bubbled through the solution.	A clear solution was obtained. A black precipitate Q_2 was formed.
(3) Q_2 was removed by filtration. The filtrate was boiled till all the H_2S was removed, and a solution of $(NH_4)_2CO_3$ was added.	A white precipitate Q_3 was formed.

Experiments for precipitates Q_1, Q_2 and Q_3.

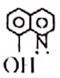
Experiment	**Observation**
(1) Q_1 was dissolved in hot dilute HNO_3. After cooling, the solution was neutralized and **KI** was added.	A precipitate and a brown solution were formed.
(2) Q_2 was dissolved in warm dilute **HCl**. The solution was cooled, and dilute NH_4OH was added. More dilute NH_4OH was added to this mixture.	A green precipitate was formed. The green precipitate dissolved giving a deep blue solution.
(3) Q_3 was dissolved in conc. **HCl** and the solution was subjected to the flame test.	A green flame was obtained.

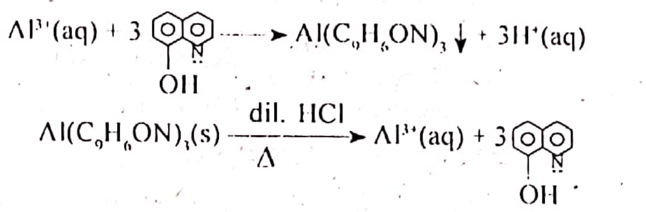
(i) Identify the **three** metal ions in solution T. **(Reasons are not required.)**

(ii) Write the chemical formulae of the precipitates Q_1, Q_2 and Q_3.

(5.0 marks)

(*c*) The following procedure was used to determine the concentration of Al^{3+} ions in solution U.

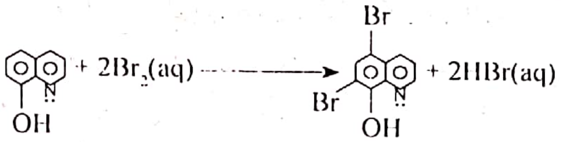
Excess 8-hydroxyquinoline (commonly known as oxine,  . C_9H_7ON) was added to 25.0 cm^3 of solution U at pH = 5 to precipitate Al^{3+} ions as aluminium oxinate, $Al(C_9H_6ON)_3$. The precipitate was filtered, washed with distilled water and dissolved in warm dilute HCl containing excess KBr. Thereafter, 25.0 cm^3 of 0.025 mol dm^{-3} $KBrO_3$ was added to this solution. The reactions taking place in the above procedure are as follows.


$Al^{3+}(aq) + 3$ … $\longrightarrow Al(C_9H_6ON)_3\downarrow + 3H^+(aq)$

$Al(C_9H_6ON)_3(s) \xrightarrow[\Delta]{\text{dil. HCl}} Al^{3+}(aq) + 3$ …

KBrO_3 is a primary standard for the generation of Br_2 in acidic medium.

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(aq) + 3H_2O(l)$$

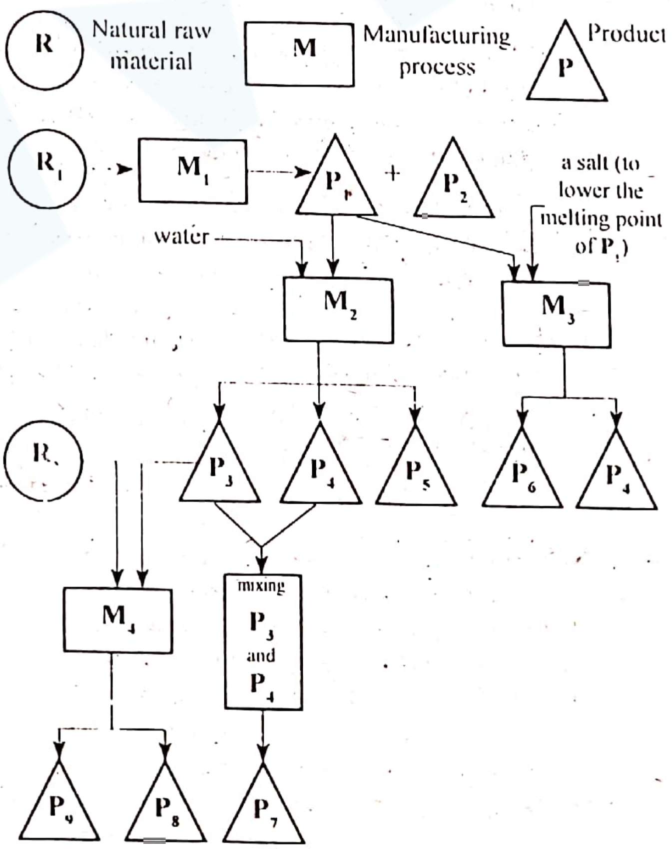

+ $2Br_2(aq)$ ⟶ + $2HBr(aq)$

The excess Br_2, is reacted with KI to give I_3^-. Then I_3^- was titrated with 0.05 mol dm^{-3} $Na_2S_2O_3$ using starch as the indicator. The volume of $Na_2S_2O_3$ required to reach the end point was 15.00 cm^3. Calculate the concentration of Al^{3+} in solution U in mg dm^{-3}. (Al = 27)

(5.0 marks)

9. (*a*) A flow chart drawn by a final year university student to establish a chemical industry in the future in Sri Lanka is given below.

The following symbols are used to represent natural raw materials, menufacturing processes and products.



P_2 is used to produce a halogen that exists as a liquid at room temperature.

P_7 is used as a bleaching agent/strong oxidizing agent.

P_8 is used daily to maintain good hygiene.

(i) Identify the **two** natural raw materials $\mathbf{R}_1$ and **R**

(ii) Identify the **four** manufacturing processes $\mathbf{M}_1$, $\mathbf{M}_2$, $\mathbf{M}_3$, and $\mathbf{M}_4$ [*e.g.* manufacture of ammonia or Haber process]

(iii) Identify the products $\mathbf{P}_1$ to $\mathbf{P}_9$.

(iv) Briefly describe the steps involved in processes $\mathbf{M}_1$ and $\mathbf{M}_3$ (diagrams of equipment **not** required.)

(v) Draw and label the equipment used in the process $\mathbf{M}_2$.

(vi) Identify the salt used in the process $\mathbf{M}_3$.

(vii) Give **one** use for each of $\mathbf{P}_5$, $\mathbf{P}_6$ and $\mathbf{P}_9$.

(7.5 marks)

(*b*) Answer these questions using the list given below.

CO_2, CH_4, volatile hydrocarbons, NO, NO_2, N_2O, NO_3^-, SO_2, H_2S, CFC, $CaCO_3$, liquid petroleum and coal.

(i) Identify **two** gaseous species that are responsible for acid rain and briefly explain, with the aid of balanced chemical equations, how these species cause acid rain.

(ii) Acid rain has harmful effects on the environment. Briefly discuss this statement.

(iii) Identify **three** species that are emitted to the environment due to the burning of fossil fuel, along with one adverse environmental issue for each.

(iv) "The existence of trace amounts of industrial synthetic species in the atmosphere can cause adverse environmental issues." Explain this statement using CFC as an example.

(v) Identify **five** greenhouse gases and state a human activity by which each of these gases enters the atmosphere.

(vi) Briefly explain using balanced chemical equations, how a natural substance (select from the list) can be used to remove acidic gases emitted during the burning of fossil fuel.

(7.5 marks)

10. (*a*) **X**, **Y** and **Z** are coordination compounds. They have an octahedral geometry. The atomic composition of the species in the coordination sphere (i.e. metal ion and the ligands coordinated to it) in **X**, **Y** and **Z** are $FeH_{10}CNO_5S$, $FeH_8C_2N_2O_4S_2$ and $FeH_6C_3N_3O_3S_3$ respectively. The oxidation state of the metal ion in all three compounds is the same. In each compound, **two types** of ligands are coordinated to the metal ion. If these compounds contain **non-coordinated** anions, they are of the same type.

An aqueous solution **S** contains **X**, **Y** and **Z** in the molar ratio 1 : 1 : 1 The concentration of **each** compound in solution **S** is 0.10 mol dm^{-3}. When excess $AgNO_3$ solution was added to 100.0 cm^3 of **S**, a yellow precipitate was formed. The precipitate was washed with water and oven dried to a constant mass. The mass of the precipitate was 7.05 g. This precipitate does not dissolve in conc. NH_4OH.

(Relative molecular mass of the chemical compound in the yellow precipitate = 235)

(i) Identify the ligands coordinated to the metal ions in **X**, **Y** and **Z**.

(ii) Write the chemical formula of the yellow precipitate.

(iii) Giving reasons, determine the structures of **X**, **Y** and **Z**.

(iv) Given below is the structure of ethylenediamine (en).

$$H_2\ddot{N}-CH_2-CH_2-\ddot{N}H_2$$

Ethylenediamine coordinates to the metal ion M^{3+} through the two nitrogen atoms, to form the complex ion **Q** (i.e. metal ion and ligands coordinated to it). **Q** has an octahedral geometry.

Write the structural formula of **Q** and draw its structure.

Note: Consider that only ethylenediamine is coordinated to the metal ion. Use the abbreviation 'en' to denote ethylenediamine in your structural formula.

(7.5 marks)

(*b*) You are provided with the following.

- 1.0 mol dm^{-3} aqueous solutions of $Al(NO_3)_3$, $Cu(NO_3)_2$ and $Fe(NO_3)_2$
- **Al**, **Cu** and **Fe** metal rods
- Chemicals required to use in salt bridges
- Conducting wires and beakers

In addition to the above, the following data is also provided.

$$E^{\circ}_{Fe^{2+}/Fe} = -0.44\ V,\quad E^{\circ}_{Al^{3+}/Al} = -1.66\ V,\quad E^{\circ}_{Cu^{2+}/Cu} = +0.34\ V.$$

(i) Diagram the **three** electrochemical cells that can be contructed using the above materials. Indicate the anode and cathode along with their signs in each cell.

(ii) For each electrochemical cell drawn in part (i) above

I. give the cell notation.

II. determine E°_{cell}.

III. give balanced chemical equations with physical states for the electrode reactions

(iii) Giving reasons, explain which of the following compounds is/are appropriate to use in salt bridges.

NaOH, $NaNO_3$, acetic acid

(iv) Consider the electrochemical cell which shows the highest E^0_{cell} initially. Assume that this electrochemical cell has been constructed using equal volumes of the relevant solutions in each compartment and their volumes do not change during the experiment.

The two electrodes of this cell were connected using a conducting wire and after some time, the concentration of metal ions in the anode compartment was found to be **C** mol dm^{-3}. Express the concentration of metal ions in the cathode compartment in terms of **C**.

(7.5 marks)

The Periodic Table

1	1 H																	2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
6	55 Cs	56 Ba	La- Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
7	87 Fr	88 Ra	Ac- Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub	113 Uut					

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
89 Ac	90 Th	91 Pa	92 U	93 Np	[illegible] Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, අගෝස්තු 2016
General Certificate of Education (Adv.Level) Examination, August 2016
Chemistry - I

2016 - ANSWERS

01	1	2	3	[✓ 4]	5
02	[✓ 1]	2	3	4	5
03	1	2	3	4	[✓ 5]
04	1	2	3	[✓ 4]	5
05	1	2	[✓ 3]	4	5
06	1	2	[✓ 3]	4	5
07	1	2	3	[✓ 4]	5
08	1	2	3	4	[✓ 5]
09	1	2	3	4	[✓ 5]
10	[✓ 1]	2	3	4	5
11	1	[✓ 2]	3	4	5
12	1	2	3	[✓ 4]	5
13	1	[✓ 2]	3	4	5
14	1	2	3	4	[✓ 5]
15	1	[✓ 2]	3	4	5
16	[✓ 1]	[✓ 2]	[✓ 3]	[✓ 4]	[✓ 5]
17	1	2	[✓ 3]	4	5
18	1	[✓ 2]	3	4	5
19	[✓ 1]	2	3	4	5
20	1	2	[✓ 3]	4	5
21	1	2	[✓ 3]	4	5
22	1	2	[✓ 3]	4	5
23	[✓ 1]	2	3	4	5
24	1	2	3	4	[✓ 5]
25	1	2	3	4	[✓ 5]
26	1	[✓ 2]	3	4	5
27	[✓ 1]	2	3	4	5
28	1	2	3	[✓ 4]	5
29	1	[✓ 2]	3	4	5
30	1	2	[✓ 3]	4	5
31	1	[✓ 2]	3	4	5
32	1	2	3	[✓ 4]	5
33	[✓ 1]	2	3	4	[✓ 5]
34	1	2	3	4	[✓ 5]
35	1	2	[✓ 3]	4	5
36	[✓ 1]	2	3	4	5
37	1	2	3	4	[✓ 5]
38	1	2	3	[✓ 4]	5
39	[✓ 1]	2	3	4	5
40	[✓ 1]	2	3	4	5
41	1	[✓ 2]	3	4	5
42	1	2	3	[✓ 4]	5
43	1	2	3	4	[✓ 5]
44	1	2	[✓ 3]	4	5
45	[✓ 1]	[✓ 2]	3	[✓ 4]	5
46	1	2	3	4	[✓ 5]
47	1	2	3	[✓ 4]	5
48	1	2	3	[✓ 4]	[✓ 5]
49	1	2	3	4	[✓ 5]
50	1	[✓ 2]	3	[✓ 4]	5

අධ්‍යයන පොදු සහතික පත්‍ර (උසස් පෙළ) විභාගය, 2016 අගෝස්තු
General Certificate of Education (Adv.Level) Examination, August 2016
Chemistry - II

PART A - STRUCTURED ESSAY

1. (a) (i) C

(ii) N / S / P / Cl / C

(iii) Ne

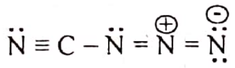
(iv) Al

(v) O

(vi) F (04 × 6 = marks)

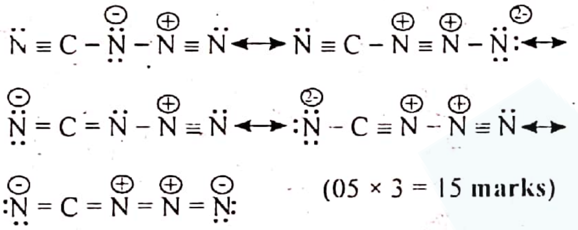
(1(a) : 24 marks)

(b) (i)



$\ddot{N} \equiv C - \ddot{N} = \overset{\oplus}{N} = \overset{\ominus}{\underset{..}{\ddot{N}}}$ (10 marks)

(ii)



$\ddot{N} \equiv C - \overset{\ominus}{\underset{..}{\ddot{N}}} - \overset{\oplus}{N} \equiv \dot{N} \longleftrightarrow \ddot{N} \equiv C - \overset{\oplus}{N} \equiv \overset{\oplus}{N} - \overset{2-}{\underset{..}{\ddot{N}}}: \longleftrightarrow$

$\overset{\ominus}{\underset{..}{\ddot{N}}} = C = \ddot{N} - \overset{\oplus}{N} \equiv \ddot{N} \longleftrightarrow :\overset{2-}{\underset{..}{\ddot{N}}} - C \equiv \overset{\oplus}{N} - \overset{\oplus}{N} \equiv \ddot{N} \longleftrightarrow$

$:\overset{\ominus}{\underset{..}{N}} = C = \overset{\oplus}{N} = \overset{\oplus}{N} = \overset{\ominus}{\underset{..}{N}}:$ (05 × 3 = 15 marks)

(Consider first three responses)

(iii)

		C	N^2	N^3
I.	VSEPR Pairs	2	3	2
II.	Electron pair geometry	linear	trigonal planar	linear
III.	Shape	linear	Angular / V	linear
IV.	Hybridization	SP	SP^2	SP

(01 × 12 = marks)

(iv) $N^3 > N^2$ or N^3 has higher electronegativety than N^2

N^3 - SP and carries a positive charge

OR

Oxidation state is + 1

N^2 - SP^2 and carries zero charge or oxidation state is - 1

Higher the positive charge / higher the electronegativeity / higher the positive oxidation state.

Higher the s - character, higher the electronegativity.

(v) I. $N^1 - C$ N^1 SP or 2P , C SP

II. $C - N^2$ C SP , N^2 SP^2

III. $N^2 - N^2$ N^2 SP^2 , N^3 SP

IV. $N^3 - N^4$ N^3 SP , N^4 SP^2 or 2P

(01 × 8 = marks)

(1 (b) : 56 = marks)

(c) (i) False (ii) True

(iii) False (iv) True (05 × 4 = 20 marks)

(1 (c) : 20 marks)

2. (a) (i) X = K or potassium (03)

Y = Ca or calcium (03)

(ii) X = $1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^6\ 4S^1$

Y = $1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^6\ 4S^2$ (03+03)

(iii) X = Lilac / violet / reddish - violet

Y = brick red / yellow-red / orange red / orange (03+03)

(iv) I. $\boxed{X} > \boxed{Y}$

II. $\boxed{Y} > \boxed{X}$

III. $\boxed{Y} > \boxed{X}$

IV. $\boxed{Y} > \boxed{X}$ (03 × 4)

(v) Z : CO_2 (03)

(vi) $CO_2 + Ca(OH)_2 \longrightarrow CaCO_3\downarrow + H_2O$ (01 + 01 + 01)

(white / milky white)

$CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$ (02 + 01)

(colourless)

(If Y has been identified correctly, Y could be used instead of Ca.)

(vii) I. Limestone / marble / oyster shells (03)

II. $Ca(OCl)_2 . Ca(OH)_2 . CaCl_2 . 2H_2O$ (s) / $Ca(OCl)_2$ / Bleaching Powder (03)

III. $CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$ (02)

$CaO(s) + H_2O(l) \longrightarrow Ca(OH)_2(s)$ (02)

$3Ca(OH)_2(s) + 2Cl_2(g) \longrightarrow Ca(OCl)_2 . Ca(OH)_2 . CaCl_2 . 2H_2O(s)$ (01)

(2 (a) : 50 marks)

(b) (i) I. $(NH_4)_2CO_3$ II. KI

III. $Na_2S_2O_3$ IV. $BaCl_2$

V. $AgNO_3$ VI. K_2SO_4

(04 × 6 = 24 marks)

(ii) A : $BaCO_3$ B : PbI_2

C : Ag_2S_2O3 D : $BaSO_3$

E : AgBr F : $BaSO_4$

(03 × 6 = 18 **marks**)

(iii)(A) $BaCO_3 + 2HCl \longrightarrow BaCl_2 + H_2O + CO_2$ or H_2CO_3 (03)

(B) $BaSO_3 + 2HCl \longrightarrow BaCl_2 + H_2O + SO_2$ or H_2SO_3 (03)

(C) $AgBr + 2NH_3 \longrightarrow Ag(NH_3)_2Br$ or $[Ag(NH_3)_2]^+ + Br^-$ (02)

(2 (b) . 50 **marks**)

3. (a) (i) Rate = k $[A]^2$ (10)

OR

$$\left[-\frac{\Delta[A]}{\Delta t}\right] = k\,[A]^a \quad \text{OR} \quad -\frac{d[A]^a}{dt} = k\,[A]^a$$

(ii) Rate = k $[A]^0$ OR order = a = o (10)

Rate = constant (gradient is constant) OR

Rate is independent of concentration (05)

(iii)Rate constant. k = |Rate| (05)

$$k = \frac{(0.002 - 0.01)\ \text{mol dm}^{-3}}{2000\ \text{s}}$$ (04+01)

OR any two points

$k = 4.0 \times 10^{-6}$ mol dm^{-3} s^{-1} (04+01)

(iv)Volume of the container = 1.0 dm^3

$A \longrightarrow B + C$

after 50% completion

$0.01(1 - x) \longrightarrow \quad 0.01x \quad 0.01x$

[concentrotions in mol md^{-3}]

Amount of gas at t = 0 = 0.01 mol

Amount of gas sfter 50% is decomposed

= $(0.005 + 0.005 + 0.005)^{md}$

= 0.015 mol (05)

Assuming ideal gas behaviour, aplly pv = nRT

$$\text{Pressure} = \frac{0.051\text{mol} \times 8.314\text{J k}^{-1}\text{ mol}^{-1}\ 500\text{ K}}{10^{-3}\text{ m}^3}$$ (08+02)

= 6.23×10^4 Pa (04+01)

(3 (a) : 60 **marks**)

(b) (i) Initial rate, $R_0 = k_1[x]^b$

$$R_0 = k_1\left(\frac{1.0\ \text{mol}}{V_0}\right)^b \text{ ------ (1)}$$ (10)

(units are not required)

(ii) After 50% decomposition,

$$[X] = \left(\frac{0.05\text{mol}}{2V_0}\right)$$ (05)

At this stage, Rate = 0.25 R_0

$$0.25\,R_0 = k_1\left(\frac{0.5\text{mol}}{2V_0}\right)^b \text{ ------ (2)}$$ (10)

(2)/(1) From

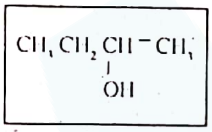
$$\frac{0.25R_0}{R_0} = \frac{k_1\left(\frac{0.5\ \text{mol}}{2V_0}\right)^b}{k_1\left(\frac{1.0\ \text{mol}}{V_0}\right)^b}$$ (10)

$0.25 = (0.25)^b$

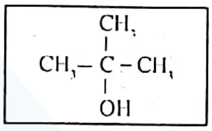
$b = 1$ (05)

(3 (b) : 40 **marks**)

4. (a) (i)


$CH_3CH_2\underset{\displaystyle OH}{\underset{|}{CH}}-CH_3$

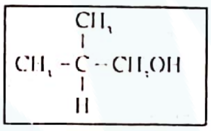
A


$CH_3-\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle OH}{\underset{|}{C}}}}-CH_3$

B

$CH_3CH_2CH_2CH_2OH$

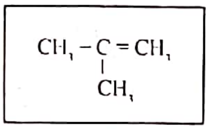
C


$CH_3-\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle H}{\underset{|}{C}}}}-CH_2OH$

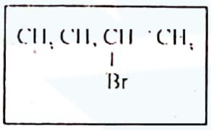
D.

$CH_3CH_2CH = CH_2$

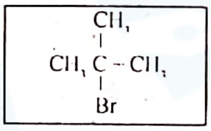
E


$CH_3-\underset{\displaystyle CH_3}{\underset{|}{C}} = CH_2$

F


$CH_3CH_2\underset{\displaystyle Br}{\underset{|}{CH}}-CH_3$

G


$CH_3\overset{\displaystyle CH_3}{\overset{|}{\underset{\displaystyle Br}{\underset{|}{C}}}}-CH_3$

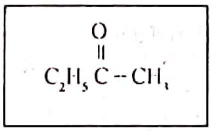
H

(05 × 8 = 40 **marks**)

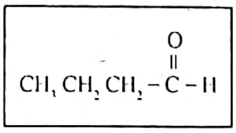
If A is incorrect, no mards for I.

If C is incorrect, no marks for J.

(ii)


$C_2H_5\overset{\displaystyle O}{\overset{||}{C}}-CH_3$

I


$CH_3CH_2CH_2-\overset{\displaystyle O}{\overset{||}{C}}-H$

J

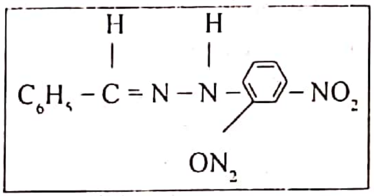
(05 × 2 = 10 **marks**)

(4 (a) : = 50 **marks**)

(b) (i) $CH_3CH_2CH_2Br$

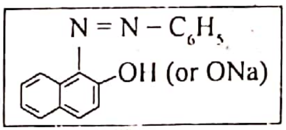
(K)

(ii)



(L)

(iii)

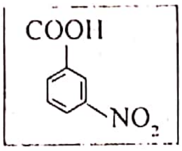


(M)

(iv) $\boxed{C_6H_5CONH_2}$

(N)

(v)



(O)

(vi) $\boxed{CH_3CH_2C_2H_5}$

(P)

(vii) $CH_3CO_2^-$

OR

CH_3COOH

(Q)

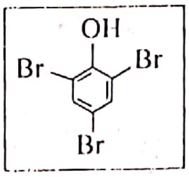
(viii) $\boxed{CH_3C \equiv C^{\ominus}\ Na^{\oplus}}$

(R)

(ix) $\boxed{CH_3CH_2CH_2CH_3}$

(S)

(x)



(T)

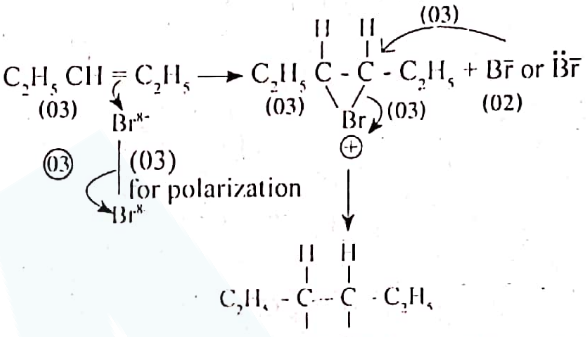
(No mards for the following structures)

$CH_3C \equiv C^{\ominus}\ Na^{\ominus}$ OR $CH_3C \equiv C - Na$

(03 × 10 = 30 marks)

(4 (b) : = 30 marks)

(c)



(4(c):= 20 marks)

PART B - ESSAY

5. (a) (i) $\frac{^{n}\text{butanedioic acid}}{^{n}\text{NaOH}} = \frac{1}{2}$ OR for the identification of stoichiometry (05)

Butanedioic acid – BDA

Ether layer

$C_{\text{BDA ether}} = \frac{1}{2} \times 0.05\ \text{mol dm}^{-3} \times 4.8\ \text{cm}^3 / 50.00\ \text{cm}^3$ (03)

$= 2.4 \times 10^{-4}\ \text{mol dm}^{-3}$ (04+01)

Aqueous layer;

$C_{\text{BDA - aq}} = \frac{1}{2} \times 0.05\ \text{mol dm}^{-3} \times 16.0\ \text{cm}^3 / 25.00\ \text{cm}^3$ (02)

$1.6 \times 10^{-2}\ \text{mol dm}^{-3}$ (04+01)

$K_D = \frac{[\text{BDA}]\ \text{ether}}{[\text{BDA}]\ \text{aqueous}}$ (05)

$= 2.4 \times 10^{-3}\ \text{mol dm}^{-3} / 1.6 \times 10^{-2}\ \text{mol dm}^{-3}$

$= 0.015\ ^{3}/_{20}$ (04+01)

OR

$K_D{}' = \frac{[\text{BDA}]\ \text{aqueous}}{[\text{BDA}]\ \text{ster}}$

$= 1.6 \times 10^{-2}\ \text{mol dm}^{-3} / 2.4 \times 10^{-3}\ \text{mol dm}^{-3}$

$= 6.67$ OR $^{20}/_{3}$

(ii) Solubility

$[\text{BDA}]_{\text{ether}} = K_D\ [\text{BDA}]_{\text{water}}$

Consider a mixture having 1.0 dm³ of ether layer and 1.0 dm³ of aqueous layer.

$\frac{X}{M_{\text{BDA}}} = \frac{0.15\ (8.0\ \text{g dm}^{-3})}{M_{\text{BDA}}}$ (05)

(Equation can be accepted without M_{BDA})

$X = 1.2\ \text{g dm}^{-3}$ (04+01)

(5 (a) : = 40 marks)

(b) (i) Write the two reactions as follows and add.

$CO(g) + H_2(g) \longrightarrow C(s) + H_2O(g)$ (02)

$CO(g) + H_2O(g) \longrightarrow CO_2(g) + H_2(g)$ (02)

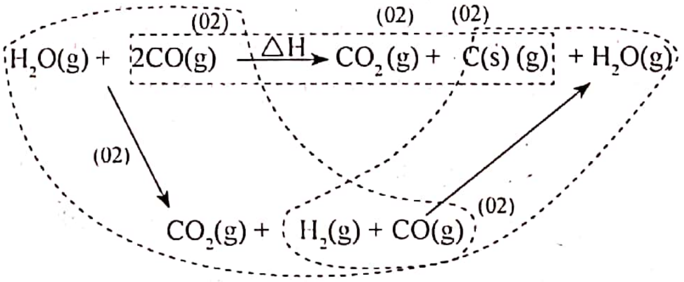
$2CO(g) \longrightarrow C(s) + CO_2(g)$

(02) (02) (02)

(Overall reaction must be generated by adding the two reactions for awarding marks.)

(Physical states are required.)

Alternate calculation using a thermodynamic cycle.



$\Delta H = -130\ \text{kJ mol}^{-1} - 40\ \text{kJ mol}^{-1} = -170\ \text{kJ mol}^{-1}$ (04+01)

$\Delta S = -140\ \text{kJ}^{-1}\ \text{mol}^{-1} - 50\ \text{kJ}^{-1}\ \text{mol}^{-1} = -190\ \text{kJ}^{-1}\ \text{mol}^{-1}$ (04+01)

(If standard states are written, do not award marks.)

Sign of ΔS is negative. This agrees with the reduction of entropy, mainly due to the reduction of the number of moles of gasses as the forward reaction progresses.) (05)

(ii) Find ΔG at 27 °C.

$\Delta G = \Delta H - T\Delta S$ (02)

(If standard states are written, do not award marks) (04+01)

$\Delta G = -170\ \text{kJ mol}^{-1} - 300\ \text{K} \times (-190 \times 10^{-3}\ \text{kJ K}^{-1}\ \text{mol}^{-1})$ (04+01)

$\Delta G = -113\ \text{kJ mol}^{-1}$ (04+01)

Forward reaction is spontaneous. (03)

(Calculation must be shown for last 03 marks.)

(5 (b) : 40 **marks**)

(c) (i) $C(s) + CO_2(g) \rightleftharpoons 2\,CO(g)$

$K_p = \dfrac{P^2_{co}}{P_{co_2}}$ (05)

(ii) $C(s) + CO_2(g) \rightleftharpoons 2CO(g)$ initial (mol) 0.15 -

At equilibrium (mol) 0.15 - x 2x (04+01)

Total number of gas moles = 0.15 + x (05)

Apply Pv = nRT assuming ideal behaviour.

$0.15 + x = \dfrac{8.0 \times 10^5\ \text{Pa} \times 2.0 \times 10^{-3}\ \text{m}^3}{8 \times 10^3\ \text{J mol}^{-1}}$ (04+01)

$x = 0.05$ mol (04+01)

$n_{CO} = 0.1$ mol $n_{CO_2} = (0.15 - 0.05)$ mol $- 0.10$ mol

(03) (02)

Therefore,

$P_{CO} = 2 \times 0.05 \times 8.0 \times 10^5\ \text{Pa} / 0.2$

$= 4.0 \times 10^5$ Pa (04+01)

$P_{CO_2} = 0.1 \times 8.0 \times 10^5\ \text{Pa} / 0.2$

$= 4.0 \times 10^5$ Pa (04+01)

$K_p = \dfrac{(4.0 \times 10^5\ \text{Pa})^2}{4.0 \times 10^5\ \text{Pa}}$ (04+01)

$= 4.0 \times 10^5$ Pa (04+01)

Alternate Calculation

$n_{total} = 0.20$ md ; $X_{CO} = X_{CO_2} = ½$ (05)

$P_{CO} = 8 \times 10^5 \times ½ = 4 \times 10^5$ Pa (04+01)

$P_{CO_2} = 8 \times 10^5 \times ½ = 4 \times 10^5$ Pa (04+01)

$K_p = (4 \times 10^5\ \text{Pa})^2 / 4 \times 10^5$ Pa (04+01)

$K_p = 4 \times 10^5$ Pa (04+01)

$K_C = K_p(RT)^{-\Delta n}$ OR $K_p = K_C(RT)^{\Delta n}$ (03)

$\Delta n = 1$

$K_C = 4.0 \times 10^5\ \text{Pa} \times (8 \times 10^5\ \text{J mol}^{-1})^{-1}$

$= 50\ \text{mol m}^{-3}$ OR $0.05\ \text{mol dm}^{-3}$ (04+01)

Alternate Calculation

$K_C = [CO]^2 / [CO_2]$ (05)

$= 0.10 / (2 \times 10^{-3})^2 / [0.10 / (2 \times 10^5)]$

$= 50\ \text{mol m}^{-3}$ ($0.05\ \text{mol dm}^{-3}$) (04+01)

(iii) Calculate Q using the pressures.

$Q = \dfrac{(2.0 \times 10^5\ \text{Pa})^2}{2.0 \times 10^5\ \text{Pa}}$

$= 2 \times 10^5$ Pa (05)

Q is smaller than Kp, Therefore, P_{CO_2} decreases and P_{CO} increase until $Q = K_p$ (05)

Alternative Calculation

$C(s) + CO_2(g) \rightleftharpoons 2\,CO(g)$

$2 \times 10^5 - x$ $2 \times 10^5 - 2x$ pre ssures (pa)

$K_p = 4.0 \times 10^5 = \dfrac{(2 \times 10^5 + 2x)^2}{2 \times 10^5 - x}$ (05)

Solving the quadratic equation and predicting that P_{CO_2} decreases and P_{CO} increases. (05)

(5 (b) : 40 **marks**)

6. (a) (i) PH = 3

$[H^+] = 1.0 \times 10^{-3}\ \text{mol dm}^{-3}$ (04+01)

$HA(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + A^-(aq)$

$K_a = \dfrac{[H_3O^+(aq)]\,[A^-(aq)]}{HA(aq)}$ (02)

$= \dfrac{(1.0 \times 10^{-3-5}\ \text{mol dm}^{-3})^2}{0.1\ \text{mol dm}^{-3}}$ (02+01)

$= 1.0 \times 10^{-5}\ \text{mol dm}^{-3}$ (02+01)

(ii) $A^-(aq) + H_2O(l) \rightleftharpoons HA(aq) + OH^-(aq)$ (05)

consider, $\dfrac{K_a}{K_w} = \dfrac{\dfrac{[H_3O^+(aq)]\,[A^-(aq)]}{[HA(aq)]}}{[H_3O^+(aq)]\,[OH^-(aq)]}$

At the equivalance point $[HA(aq)] \approx [OH^-(aq)]$

$\dfrac{K_a}{K_w} = \dfrac{[A^-(aq)]}{[OH^-(aq)]^2}$ (05)

$[OH^-(aq)] = [A^-(aq)]\,\dfrac{K_w}{K_a}\,]^{½}$ .... (1)

At the equivalance point $[A^-(aq)] = [\text{salt}]$

Since PH = 9.0 at the equivalance point,

$[OH^-] = 10^{-5}\ \text{mol dm}^{-3}$

$[\text{salt}] = ([OH^-(aq)])^2\,\dfrac{K_a}{K_w}$ (02)

$[\text{salt}] = ([1.0 \times 10^{-5}\ \text{mol dm}^{-3}])^2\,\dfrac{1 \times 10^{-5}\ \text{mol dm}^{-3}}{1.0 \times 10^{-14}\ \text{mol}^2\ \text{dm}^{-6}}$ (04+01)

$= 0.1\ \text{mol dm}^{-3}$ (04+01)

(iii)Using the equation (1)

$$[OH^-(aq)]_{new} = \left[\frac{[A^-(aq)]}{100}\frac{k_w}{k_a}\right]^{½} \qquad (05)$$

$$[OH^-(aq)]_{new} = \frac{1}{10}\left[\frac{[A^-(aq)]}{1}\frac{k_w}{k_a}\right]^{½}$$

$$[OH^-(aq)]_{new} = \frac{1}{10}\left[\frac{[0.1\,mol\,dm^{-3}}{1}\;\frac{1 \times 10^{-14}\,mol^2\,dm^{-6}}{1 \times 10^{-5}\,mol\,dm^{-3}}\right]^{½}$$

(04+01)

$[OH^-(aq)] = 1.0 \times 10^{-6}$ mol dm^{-3}

$[H_3O^+] = 1.0 \times 10^{-8}$ mol dm^{-3}

Therefore, PH = 8.0 (05)

(iii)Alternate Calculation

$$A^-(aq) + H_2O(l) \rightleftharpoons HA(aq) + OH^-(aq)$$

C(1 - ∝) C∝ C∝

By Ostwalds law,

$$K_b = ∝^2C = \frac{∝^2 C^2}{C} = \frac{[OH^-]^2}{C}$$

$$[OH^-] = \sqrt{K_bC} = \sqrt{\frac{K_w}{K_a}C} \qquad (05)$$

[Salt] = [A$^-$] = C = 0.1 mol dm / 100

$$[OH^-] = \frac{1 \times 10^{-14}\,mol^2\,dm^{-4}}{1 \times 10^{-3}\,mol^{-1}\,dm^{-3}} \times \frac{1 \times 10^{-6}\,mol\,dm^{-3}}{100}$$

(04+01)

POH = 6.00

PH = 8.00 (05)

(6 (a) : 50 **marks**)

(b) (i) $AgBr(s) \rightleftharpoons Ag^+(aq) + Br^-(aq)$ (05)

$K_{sp} = [Ag^+(aq)]\,[Br^-(aq)]$ (03)

$[Ag^+(aq)] = [Br^-(aq)] = x$

$K_{sp} = X^2$ (02)

Therefore, $[Ag^+(aq)] = (5.0 \times 10^{-13})$ ½

$= 7.07 \times 10^{-7}$ mol dm^{-3}

OR 7.1×10^{-7} mol dm^{-3}

(04+01)

(ii) The solution is a saturated solation of AgBr (05)

Therefore, $[Ag^+(aq)]$ is as same as above, 7.07×10^{-7} mol dm^{-3} (05)

(iii)The product of concentrations of Ag^+ and Br^- must be calculated and compared with K_{sp}.

$[Ag^+(aq)] = 1.5 \times 10^{-4}$ mol dm^{-3} × 10cm^3 / 15.00 cm^3

$= 1.0 \times 10^{-4}$ mol dm^{-3} (04+01)

$[Br^-(aq)] = 6.0 \times 10^{-4}$ mol dm^{-3} 5.00 cm^3 / 15.00 cm^3

$= 2.0 \times 10^{-4}$ mol dm^{-3} (04+01)

$[Ag^+(aq)]\,[Br^-(aq)] = 2.0 \times 10^{-8}$ mol^2 dm^{-6} > K_{SP} (10)

Therefore, AgBr will precipitate (Slightly yellow precipitate will form.) (05)

(6 (b) : 50 **marks**)

(c) (i) Applying Raoult's law to the ideal binary mixture,

$P_i = X_i P_i^0$ (05)

$P = P_1 + P_2$ (05)

$P = X_1 P_1^0 + X_2 P_2^0$ (05)

$X_2 = 1 - X_1$

$P = X_1 P_1^0 + (1 - X_1) P_2^0$

$$X_1 = \frac{(P - P_2^0)}{(P_1^0 - P_2^0)} \qquad (05)$$

(ii)I. Mole fractions in the liquid phase,

$X_{meoH} = (4.5 - 3.0)10^4$ Pa / $(5.5 - 3.0)10^4$ Pa = 0.6 (04+01)

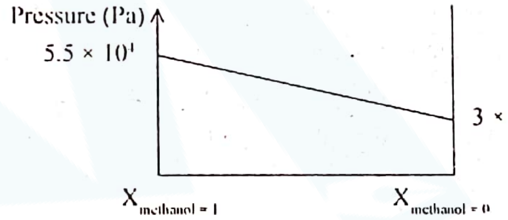
$X_{etoH} = 1 - 0.6 = 0.4$ (04+01)

II.Mole fractions in the gas phase,

$X_{methanol\ gas} = 0.6 \times 5.5 \times 10^4$ Pa / 4.5×10^4 Pa = 0.73 (04+01)

$X_{etohanol\ gas} = 1 - 0.73 = 0.27$ (04+01)

(iii)Pressure composition diagram (ideal mixture)



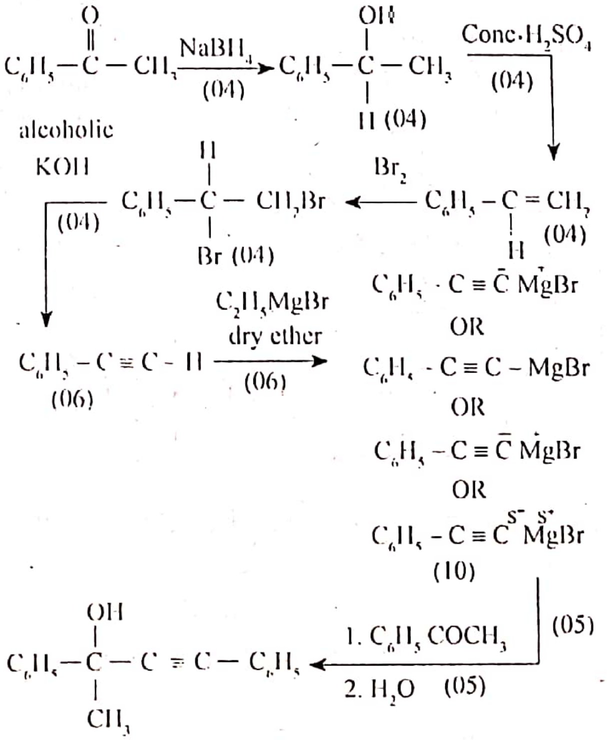
mole fractions on horizontal axis. (02)

Saturated vapour pressures corresponding to mole fractions. (04)

Straight line showing P total with correct slope. (04)

(If more than one line is drawn, P total line must be labeled. (6 (c) : 50 **marks**)

7. (a)



Alternate step (05)

$C_6H_5C\equiv C-H \xrightarrow[\text{(No marks)}]{NaBH_4} C_6H_5-C\equiv \bar{C}Na^+ \xrightarrow[2.\ H_2O(05)]{1.\ C_6H_5COCH}$

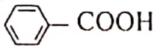
final product (05)

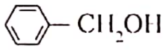
OR

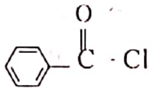
$C_6H_5C\equiv C-H \xrightarrow[\text{(No marks)}]{KOH} C_6H_5-C\equiv \bar{C}K^+ \xrightarrow[2.\ H_2O(05)]{1\ C_6H_5COCH_3}$

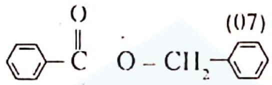
final product

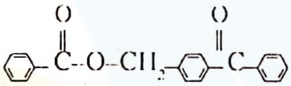
(7 (a) : 60 **marks**)

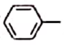
(b) R_1 $KMnO_4/H^+$ (06) X_1 =  (07)
OR $K_2Cr_2O_7/H^+$
OR CrO_3

R_2 $LiAlH_4$ (06) X_2 =  (07)

R_3 H^+ OR dil HCl (05) X_3 =  (07)
OR dil H_2SO_4
OR H_2O

R_4 PCl_5 OR PCl_3 (06) X_4 =  (07)
OR $SOCl_2$

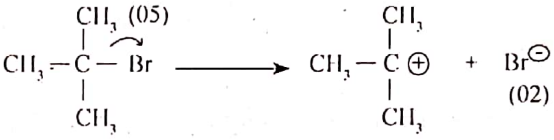
R_5 Conc. H_2SO_4 (06) X_5 = 
(07)

R_6 anhydrous $AlCl_3$(06)(— OR C_6H_5)

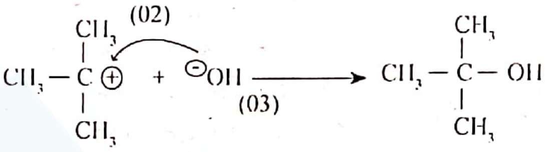
For X_5, all aromatic rings must be shown for award of marks. .

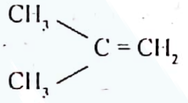
(7 (b) : 70 **marks**)

(c) (i) Step I



Step II



(ii)  (05)

(7 (c) : 20 **marks**)

PART C - ESSAY

8. (a) (i) A : $CrCl_3$ OR $CrCl_3\ H_2O$ OR $Cr(H_2O)_6$ Or $[Cr(H_2O)_6]\,3Cl^-$
B : Na_2CrO_4
C : $Na_2Cr_2O_7$
D : $(NH_4)_2Cr_2O_7$
E : Cr_2O_3 (Aword 05 for only chromium compound)
F : N_2
G : Ca_3N_2
H : NH_3
I : H_2 05 × 9 : 45 **marks**

(8 (a) (i) : 45 **marks**)

(ii) Orange solution C turns yellow. (01+01)

$Cr_2O_7^{2-} + 2OH^- \longrightarrow 2CrO_4^{2-} + H_2O$ (03)

(b) (i) T contains : Cu^{2+}, Ni^{2+}, Ba^{2+} (10+10+10)

(ii) Q_1 : CuS Q_2 = NiS Q_3 = $BaCO_3$
(07+07+06)

(8 (b) : 50 **marks**)

(c) $I_3^- + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 3I^-$ OR
$I_2 + 2S_2O_3^{2-} \longrightarrow S_4O_6^{2-} + 2I^-$ (02)
$Br_2 + 2I^- \longrightarrow S_4O_6^{2-} + 2Br^-$ (02)

Moles of $S_2O_3^{2-}$ = $\frac{0.05}{1000} \times 15.0$ (03)

Therefore, moles of I_2 = ½ × $\frac{0.05}{1000} \times 15.0$ (03)

Therefore, moles of excess Br_2 = ½ × $\frac{0.05}{1000} \times 15.0$ (03)
= 3.75×10^{-4} (02)

$BrO_3^- + 5Br^- + 6H^+ \longrightarrow 3Br_2 + 3H_2O$

Moles of BrO_3^- = $\frac{0.025}{1000} \times 25.0$ (03)

Therefore, moles of Br_2 produced by the above reaction = 3 × $\frac{0.025}{1000} \times 25.0$ (03)
= 18.75×10^{-4} (02)

Amount of I, Br_2 reacted with oxine (03)
= $(18.75 \times 10^{-4}) - (3.75 \times 10^{-4})$
= 15×10^{-4} (02)

Therefore, moles of oxine = ½ × 15 × 10^{-4} (03)
= 7.5×10^{-4} (02)

Therefore, moles of Al^{3+} $= \frac{1}{3} \times 7.5 \times 10^{-4}$ (03)

$= 2.5 \times 10^{-4}$ (02)

$[Al^{3+}]$ $= \frac{2.5 \times 10^{-4} \times 1000 \text{ mol dm}^{-3}}{25.0}$ (03)

$= \frac{2.5 \times 10^{-4} \times 1000 \times 27 \text{ g dm}^{-3}}{25.0}$ (03)

$= \frac{2.5 \times 10^{-4} \times 1000 \times 27 \times 1000 \text{ mg dm}^{-3}}{25.0}$ (03)

$= 270 \text{ mg dm}^{-3}$ (03)

(8 (c) : 50 marks)

9. (a) (i) R_1 : sea water (03)

R_2 : oils / fats / coconut oil / vegetable oil (03)

(9 (a) : 06 marks)

(ii) M_1 : manufacture of salt (03)

M_2 : manufacture of NaOH (03)

M_3 : manufacture / extraction of Na (Downs cell method) (03)

M_4 : manufacture of soap (03)

(9 (a) (ii) : 12 marks)

(iii) P_1 : NaCl (03)

P_2 : Bittern solution / mother liquor / $MgBr_2$ (03)

P_3 : NaOH (03)

P_4 : Cl_2 (03)

P_5 : H_2 (03)

P_6 : Na (03)

P_7 : NaOCl / Milton Solution (03)

P_8 : Soap (03)

P_9 : glycerol / glycerine (03)

(9 (a) (iii) : 27 marks)

(iv) Process M_1

Sea water evaporated in three tanks. (01)

1st tank : $CaCO_3$ precipitates (01) Remaining solution transferred to 2nd tank. (01)

2nd tank : $CaSO_4$ precipitates (01) remaining solution transferred to 3rd tank. (01)

3rd tank : NaCl precipitates (01) remaining solution (Bihevn) is removed. (01)

(Explanation could be given as a diagram.)

Process M_3

Electrolysis of molten NaCl with added $CaCl_2$ (01)

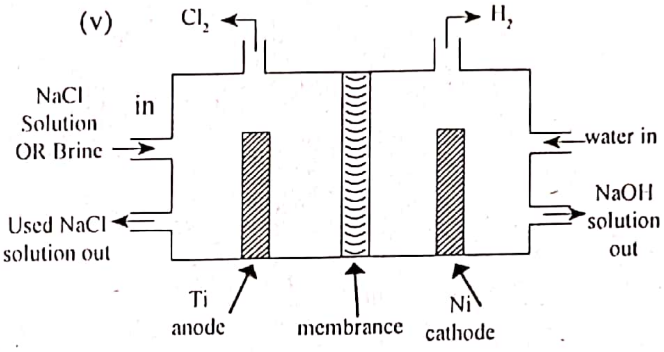
At the cathode $Na^+ (l) + e \longrightarrow Na (l)$ (02)

At the anode $2Cl(l) \longrightarrow Cl_2 (g) + 2e$ (02)

Cathode and anode are seperated by a steel gauze diaphragm to prevent Na from reacting with Cl_2 gas. (02)

(9 (a) (iv) : 14 marks)

(v)



(01 × 9 + 01 for correct sketch of cell = 10 marks.)

(9 (a) (v) : 10 marks)

(vi) $CaCl_2$ **(9 (a) (vi) : 03 marks)**

(vii) P_5 : fuel / to monfacture HCl / to manufacture margarine / in weather balloons / manufacture of NH_3 (01)

P_6 : Sodium vapour lamps / synthesis fo $NaNH_2$ / to dry organic solvants / as a coolant in nuclear reactors. (01)

P_9 : to manufacture cosmetics / to manufaxcure TNG. (explovives) (01)

(9 (a) (vii) : 03 marks)

(9 (a) : 75 marks)

(b) (i) NO_2, SO_2, NO (any two) (02+02)

From No

$2NO (g) + O_2 (g) \longrightarrow 2NO_2 (g)$ (02)

$4NO_2 (g) + O_2 (g) + 2H_2O (l) \longrightarrow 4HNO_3 (aq)$ (02)

$HNO_3 (aq) \longrightarrow H^+ (aq) + NO_3^- (aq)$ (01)

From NO_2

$4NO_2 (g) + O_2 (g) + 2H_2O (l) \longrightarrow 4HNO_3 (aq)$ (03)

$HNO_3 (aq) \longrightarrow H^+ (aq) + N\bar{O}_3 (aq)$ (02)

From SO_2

$2SO_2 (g) + O_2 (g) \longrightarrow 2SO_3 (g)$ (02)

$SO_3 (g) + H_2O (l) \longrightarrow H2SO_3 (aq)$ (02)

$H_2SO_4 (aq) \longrightarrow 2H^+ (aq) + SO_4^{2-} (aq)$ (01)

OR

$2SO_2 (g) + O_2 (g) + 2H_2O(l) \longrightarrow 2H_2SO_4 (aq)$ (03)

$H_2SO_3 (aq) \longrightarrow 2H^+ (aq) + SO_3^{2-} (aq)$ (02)

(Physical states are not required)

(9 (b) (i) : 14 marks)

(ii) Points to be included :

- Damage to plants.
- HNO_3 / H_2SO_4 dissolves aluminosilicates on Earth to give free Al^{3+} which leaches into

water and interferes with the operation of fist gills resulting in the death of fish.

- Washes out nutrients from soil.
- Degrades metallic structures (e. g. vehicles, statues, bridges, buildings)
- Hardness of water increases.
- Concentration of heavy metals in water increases.
- Composition of Earth's surface changes (e. g. due to solubility of dolomite, limestone, marble, sand and rock / oxidation of minerals such as sulfides any five (02 × 5)

(9 (b) (ii) : 10 **marks**)

(iii) SO_2, NO, NO_2, CO_2, volatile hydrocarbons (any three) (02+02+02)

Global warming - CO_2, volatile hydrocarbons (02+01)

Acid rain - SO_2, NO, NO_2 (02+01)

Photochemical smog - NO, hydrocarbons (02+01)

(9 (b) (iii) : 15 **marks**)

(iv)
- CFC_S are industrial gases that are used as coolants in refrigerators, air conditioners and spray cans.
- CFCs are released into the atmosphere during usage and repair of these equipment.
- CFCs are highly stable trace gasses in the atmosphere.
- Therefore, CFC_S are persistant gasses in the atmosphere.

AND

- CFC_S produce $\dot{Cl}$ in the higher atmosphere (stratosphere) in the presence of high energy UV radiation.
- The $\dot{Cl}$ increases the rate of depletion of ozone by acting as a catalyst.
- The reduction of ozone allows hormful UV rays to reach the surface of the planet.
- Exposure to harmful UV radiation results in cancers, gene mutations and cataracts.

OR

- CFC is a strong greenhouse gas.
- CFC_S contribute to global warming.
- CFC_S absorb IR radiation emitted from the surface of the planet.
- Global warming results in climate change.

(02 × 08)

(9 (b) (iv) : 16 **marks**)

(v) CO_2 - (fossil) fuel burning (01+01)

CH_4 - wet land agriculture / animal farms / improper waste disposal. (01+01)

NO_2 - Burning at high temperatures. (01+01)

CFCs - air conditioners / refrigerators / spray guns. (01+01)

N_2O - agriculture (use of nitrogen fertilizer) (01+01)

H_2S - Anaerobic digestion of sulfur containing substances such as coconut husks. (01+01)

SO_2 - Fossil fuel burning (01+01)

Volatile hydrocarbons - fossil fuel burning, natural gas extraction, transporation (01+01)

(any five 02 × 5) (9 (b) (v) : 10 **marks**)

(vi) Limestone ($CaCO_3$) decomposes to get CaO (lime) and CO_2 (02)

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$ (03)

CaO then reacts with the SO_2 (02)

$CaO + SO_2 \longrightarrow Ca\ SO_3$ (03)

(If only equation is given 05 marks)

OR

slurvy of lime stone is used to absorb or scrub SO_2 (05)

$Ca\ CO_3 + SO_2 \longrightarrow Ca\ SO_3 + CO_2$ (05)

(9 (b) (vi) : 10 **marks**)

(9 (b) : 75 **marks**)

10. (a) (i) SCN^- / NCS^- and H_2O (05+05)

(10 (a) (i) : 10 **marks**)

(ii) AgI (05)

(10 (a) (ii) : 05 **marks**)

(iii) Based on the atomic composition;

Coordination sphere of X : $[Fe\ (H_2O)_5\ (SCN)]$ OR $[Fe\ (SCN)\ (H_2O)_5]$ (05)

Coordination sphere of Y : $[Fe\ (H_2O)_4\ (SCN)_2]$ OR $[Fe\ (SCN)_2\ (H_2O)_4]$ (05)

Coordination sphere of Z : $[Fe\,|\,(H_2O)_3\,|\,(SCN)_3]$ OR $[Fe\ (SCN)_3\ (H_2O)_3]$ (05)

Note :

(NCS) could be used instead of (SCN). Could be written as either H_2O or OH_2.

Number of moles of each compound (i. e. x, y, z) in 100 cm^3

$$= \frac{0.1}{1000} \times 100$$

$$= 0.01$$ (05)

Relative molecular mass of AgI = 235

Therefore, number of moles AgI (or I^-)

in the precipitate $= \frac{7.05}{235}$

$= 0.03$ (05)

<u>If oxidation state of Fe is +3 ;</u>

X : Charge of comflex is +2 , Hence, two I^- (02)

Y : Charge of comflex is +1, Hence, one I^- (02)

Z : Complex has no charge. Hence, no I^- (02)

Therefore, oxidation state fo Fe has to be +3 (04)

OR

<u>If oxidation state of Fe is + 2</u>

X : Charge of complex is +1. Hence, one I^- (02)

Y : Charge of complex is zero. Hence will not have any I^- (02)

Z : Charge of complex is -1. Hence, will not have any I^- (02)

Therefore, oxidation state of cannot be +2. It has to be +3 (04)

Structural formula :

X : $[Fe(H_2O)_5(SCN)]I_2$ OR $[Fe(SCN)(H_2O)_5]I_2$ (05)

Y : $[Fe(H_2O)_4(SCN)_2]I$ OR $[Fe(SCN)_2(H_2O)_4]I$ (05)

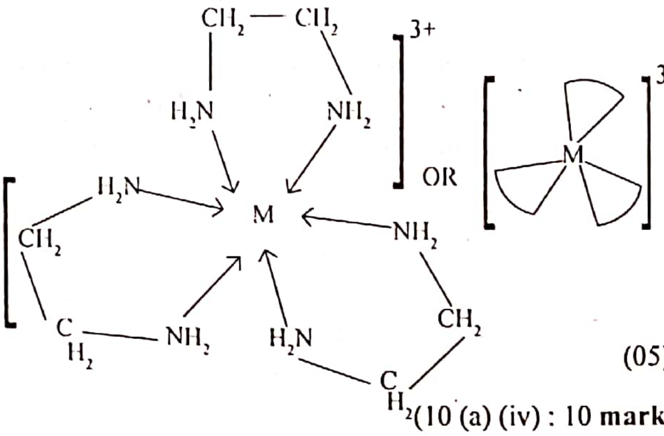
Z : $[Fe(H_2O)_3(SCN)_3]$ OR $[Fe(SCN)_3(H_2O)_3]$ (05)

Note :

- (NCS) could be used instead of (SCN).
- NO marks for (CNS) / (CSN).
- H_2O ,could be written as OH_2.
- If the coordination spheres of X, Y, Z are not written but the structural formula of X, Y, Z are written, award the 05 + 05 + 05 for the correct structural formula and the marks allocated for the respective coordination sphere (05 + 05 + 05)

(10 (a) (iii) : 50 **marks**)

(iv) $[M(en)_3]^{3+}$ (05)



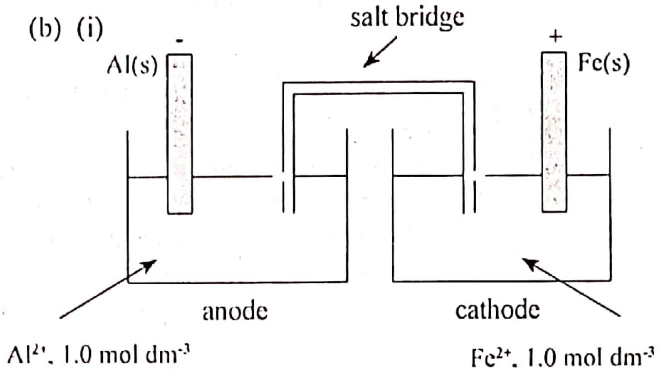
(05)

(10 (a) (iv) : 10 **marks**)

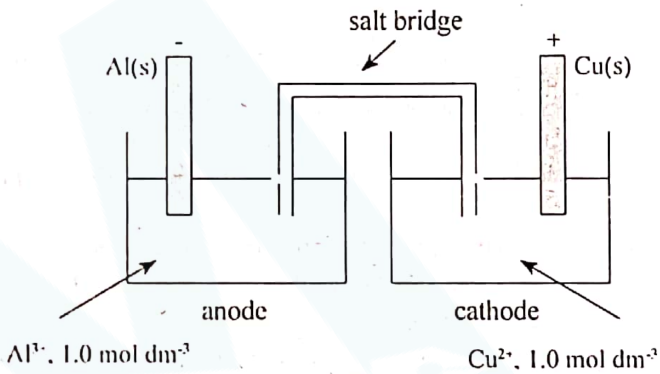
Note :

Charge of the complex is required for the award of marks. (10 (a) : 75 **marks**)

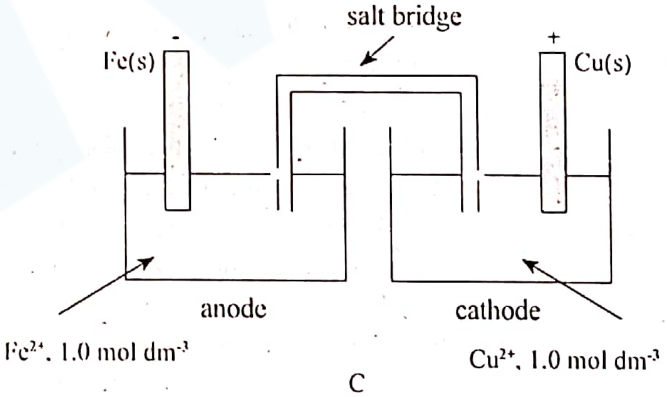
(b) (i)



A



B



C

For each electrode,

Display and identification of metal strip	(01)
Identification of the solution.	(01)
Display of correct charge	(01)
Correct labeling as anode or cathode	(01)
Display of the salt bridge	(01)

Note :

Mark each electrode individually.

If a battery or an external voltage source is connected, do not award marks.

If the electrodes are connected by a wire deduct 02 marks. (For three cells = 27 Marks)

(ii) I. Cell A : $Al(s)|Al^{3+}(aq, 1.0\ mol\ dm^{-3})||$

$Fe^{2+}(aq), 1.0\ mol\ dm^{-3})|Fe(s)$ (02)

Cell B : $Al(s)|Al^{3+}(aq, 1.0\ mol\ dm^{-3})||$

$Cu^{2+}(aq)\ 1.0\ mol\ dm^{-3})|Cu(s)$ (02)

Cell C : $Fe(s)|Fe^{3+}(aq, 1.0\ mol\ dm^{-3})||$

$Cu^{2+}(aq)\ 1.0\ mol\ dm^{-3})|Cu(s)$ (02)

II. $E^0_{cell} = E^0_{cathode} - E^0_{anode}$ fyda $E^0_{cell} = E^0_{RHS} - E^0_{LHS}$

Cell A, (03)

$E^0_{cell} = -0.44\ V - (-1.66\ V)$ (02)

$= 1.22\ V$ (01+01)

Cell B,

$E^0_{cell} = 0.34\ V - (-1.66\ V)$ (02)

$= 2.00\ V$ (01+01)

Cell C,

$E^0_{cell} = 0.34\ V - (-0.44\ V)$ (02)

$= 0.78\ V$ (01+01)

III. Cell A : $Al(s) \rightleftharpoons Al^{3+}(aq) + 3e$ (01)

$Fe^{2+}(aq) + 2e \rightleftharpoons Fe(s)$ (01)

Cell B : $Al(s) \rightleftharpoons Al^{3+}(aq) + 3e$ (01)

$Cu^{2+}(aq) + 2e \rightleftharpoons Cu(s)$ (01)

Cell C : $Fe(s) \rightleftharpoons Fe^{2+}(aq) + 2e$ (01)

$Cu^{2+}(aq) + 2e \rightleftharpoons Cu(s)$ (01)

Do not marks if $\rightarrow$ is used instead of $\rightleftharpoons$, physical states are required.

(iii) $NaOH$ - not suitable, metal hydroxides can be formed. (02)

$NaNO_3$ - suitable, good ionic conductivity (02)

Acetic acid - not suitable, weakly ionized, low conductivity. (02)

Alternate answer - 1 for (iii)

None of the given compound is suitable (03)

$NaOH$ - metal hydroxide can be formed (01)

$NaNO_3$ - mobility / conductivity of two inons are different (01)

Acetic acid - weakly ionized / low conductivity. (01)

Alternate answer - 2 for (iii)

Only $NaNO_3$ - is suitable. (03)

Due to its good ionic conductivity, doen not participate in electrode reactions. (03)

(iv) Selection of the correct pair of elecrodes (03)

$2Al(s) + 2Cu^{2+}(aq) \longrightarrow 2Al^{3+}(aq) + 3\ Cu(s)$ (02)

(physical states and stiochiometry must be correct.)

initial ($mol\ dm^{-3}$)	1.0	1.0
After time, t ($mol\ dm^{-3}$)	$(1 - 3x/v)$	$(1 + 2x/v)$

(02)

Where V = volume (02)

$[Al^{3+}] = 1 + 2x/v = C$ (03)

$x/v = (c - 1) / 2$

$[Cu^{2+}] = 1 - 3(c - 1)$ (03)

$= (5 - 3c) / 2$

OR

Selection of the correct pair of electrodes (03)

Assume the concentration of $[Al^{3+}]$ increased during time t $= C_1\ mol\ dm^{-3}$

Then $[Al^{3+}] = 1 + C_1 = C$ (03)

Concentration of $[Cu^{2+}]$ increased during time t $= 3^{C_1}/_2\ mol\ dm^{-3}$ (03)

Therefore, $[Cu^{2+}] = 1 - 3\ ^{C_1}/_2$ (03)

$= 1 - 3\ ^{(C-1)}/_2$ (03)

$= (5 - 3C)/_2$

(10 (b) : 75 **marks**)