G.C.E. (A/L) Examination
New Syllabus
2012 August - Chemistry I / Two hours

Instructions .

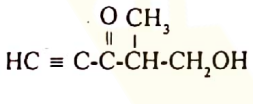
- *This paper consists of 07 pages*
- *Answer all the questions.*
- *Use of calculators **is not allowed.***
- ***Write your Index Number** in the space provided in the answer sheet.*
- *Follow the instructions given on the back of the answer sheet caarefully.*
- *In each of the questions 1 to 50, pick one of the alternatives. from (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. $R = 8.314\ JK^{-1}\ mol^{-1}$
Avogadro Constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$
Planck's constant $= 6.626 \times 10^{-34}\ Js$
Velocity of light $= 3 \times 10^{8}\ ms^{-1}$

1. The number of elements that can exist in liquid state at room temperature (25 °C) and atmospheric pressure ($1.0 \times 10^5\ Nm^{-2}$) is.
(1) 1 (2) 2 (3) 3 (4) 4 (5) 5

2. The correct **increasing** order of atomic radii of C,O,Al,, P and Ca is.
(1) O < C < Al < P < Ca (2) O < C < P < Al < Ca
(3) C < O < P < Al < Ca (4) C < O < Al < P < Ca
(5) C < O < Al < Ca < P

3. What is the IUPAC name of the following comopound?



(1) 1- hydroxy-2-methylpent-4-yn-3-one
(2) 2-methyl-3-oxopent-4-yn-1-ol
(3) 2-methyl-4-pentyn-1-ol-3-one
(4) 5-hydroxy-4-methylpent-1-yn-3-one
(5) 5-hydroxy-4-methyl-1-yne-3-pentanone

4. Which of the following statements is **not** true with regard to elements in the second period from Li to F?
(1) The highest negative electron affinity is shown by F.
(2) The highest positive electron affinity is shown by Be.
(3) The highest odxidation state is exhibited by C.
(4) Atomic radii decrease from Li to F.
(5) The ability to form cations and to act as reducing agents decreases from Li to **F**

5. The identity of an electron in an atom can be expressed using four quantum numbers (n,l,m_l,m_s). Identify which set of numbers given below is **not** acceptable as a set of quantum numbers for an electron in an atom.

(1) $\left[4, 2, 0, +\frac{1}{2}\right]$ (2) $\left[3, 1, -1, +\frac{1}{2}\right]$

(3) $\left[3, 2, -3, +\frac{1}{2}\right]$ (4) $\left[2, 1, 1, +\frac{1}{2}\right]$

(5) $\left[4, 0, 0, -\frac{1}{2}\right]$

6. Which row of the following table gives the correct information with regard to the NSF molecule?

	Oxidation state of S	Charge on S	Hybridization of S	$\hat{NSF}$ bond angle	Nature of S-F bond
(1)	-4	-2	sp	180°	S(sp h.o) - F(2p a.o)
(2)	-1	-1	sp^2	< 120°	S(sp^2 h.o) - F(2p a.o)
(3)	0	+1	sp^2	>120°	S(sp^2 h.o) - F(2p a.o)
(4)	+1	0	sp^3	90°	S(sp^3 h.o) - F(2p a.o)
(5)	+4	0	sp^2	between 90° -120°	S(sp^2 h.o) - F(2p a.o)

(h.o. = hybrid orbital, a.o. = atomic orbital)

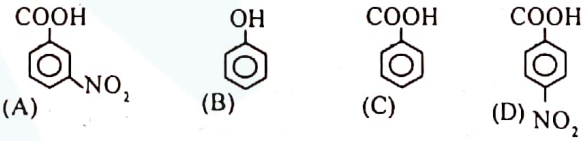
7. A gaseous hydride of nitrogen, N_aH_b (20 cm^3) was burnt in excess O_2 to give 10cm^3 of N_2 and 30 cm^3 of water vapour. The formula of the gaseous hydride is,
(1) NH_3 (2) N_2H_2 (3) N_2O_4 (4) N_3H (5) N_3H_5

8. Thermal decomposition of 15.6 g of a hydrated metal carbonate. $MCO_3.4H_2O$ produces 4.0 g of the metal oxide. The relative atomic mass of the metal M is, (H = 1, C = 12, O = 16)
(1) 63.5 (2) 56 (3) 40 (4) 26 (5) 24

9. Choose the molecule that **does not** have a dipole moment.
(1) SF_2 (2) PCl_4F (3) SF_4 (4) PCl_3
(5) SF_6

10. A solution has been prepared by mixing 250cm^3 of a Na_2SO_4 solution of concentration 0.150 mol dm^{-3} and 750 cm^3 of a NaCl solution of concentration 0.100 mol dm^{-3}. The composition of this solution in terms of ppm Na is (O = 16, Na = 23, S = 32, Cl = 35.5)
(1) 3450 (2) 2588 (3) 1725 (4) 3.45 (5) 0.15

11



The acidities of the above compounds **increase** in the order.
(1) A < D < B < C (2) B < C < A < D
(3) B < C < D < A (4) C < B < A < D
(5) D < A < B < C

12. The IUPAC name of $[Cr(NH_3)_6]\ [Fe(CN)_6]$ is,
(1) Hexaamminechromium(III) ionhexacyanoferrate (II) ion
(2) Hexaamminechromium(III) hexacyanoferrate (II)
(3) Hexaamminechromium(III)hexacyanoferrate (III)
(4) Hexaamminechromium(III) hexacyanoferrate (III)
(5) Hexaamminechromium(II) hexacyanoferrate (II)

13. $CH_3^{a}\text{-}CH_2\text{-}^{b}C \overset{c}{\equiv} C\text{-}^{d}CH \overset{e}{=} CH_2$

Which of the following arrangements gives the correct **increasing** order of the bond lengths of the bonds labelled as **a, b, c, d** and **e** in the above molecule?
(1) a < b < d < e < c (2) c < d < e < b < a
(3) c < e < d < a < b (4) c < e < d < b < a
(5) d < c < e < b < a

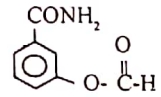
14. Vessel **A** contains helium gas at 27°C, Vessel **B** contains oxygen gas at 127°C. The ratio of the root mean square velocities of the gases in vessel A and vessel B, $\frac{\sqrt{\overline{C_A^2}}}{\sqrt{\overline{C_B^2}}}$ is. (He= 4, O = 16)
(1) 0.4 (2) 1.7 (3) 2.4 (4) 4.9 (5) 25

15. (A) $CH_3CH_2CH_2CH_2OH$ (B) $CH_3CH_2CH_2CH_2Cl$
(C) $HOCH_2CH_2CH_2CH_2OH$ (D) $CH_3CH_2CH_2CHO$

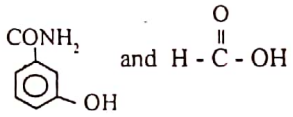
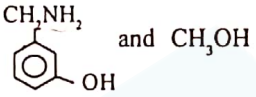
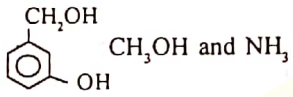
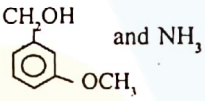
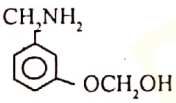
Which of the following arrangements shows the correct **increasing** order of solubilities of the above compounds in water?

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

16. Which of the following systems liberates the largest amount of heat upon mixing 1.0 dm^3 of each of the following solutions?
(1) 0.100 mol dm^{-3} HCl and 0.200 mol dm^{-3} NaOH
(2) 0.100 mol dm^{-3} H_2SO_4 and 0.200 mol dm^{-3} NaOH
(3) 0.200 mol dm^{-3} CH_3COOH and 0.200 mol dm^{-3} KOH
(4) 0.400 mol dm^{-3} CH_3COOH and 0.200 mol dm^{-3} KOH
(5) 0.100 mol dm^{-3} HNO_3 and 0.200 mol dm^{-3} NaOH

17. 

What are the products obtained when the above compound is reacted with $LiAlH_4$ followed by neutralization of the reaction mixture?

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

- Questions **18** and **19** are based on the following paragraph. Read the paragraph carefully and select the answers for the questions.

When light strikes on certain metal surfaces, electrons can be ejected from it. The energy carried by the photons in light is transferred to electrons in the metal and if an electron acquires sufficient energy to overcome its attractive forces with the positively charged nucleus, it may escape from the surface as a photoelectron. The minimum energy required for the electron to escape varies from one metal to another.

18. The energy required for photoelectrons to be ejected from the surface of barium is 240 kJ per mole of electrons. The minimum frequency of light capable of producing a photoelectron in barium is,

(1) $5 \times 10^{12} s^{-1}$ (2) $6 \times 10^{12} s^{-1}$ (3) $2 \times 10^{14} s^{-1}$
(4) $6 \times 10^{14} s^{-1}$ (5) $5 \times 10^{15} s^{-1}$

19. The maximum wavelength of light that can produce this effect in barium is,

(1) 450 nm (2) 480 nm (3) 500 nm
(4) 530 nm (5) 550 nm

20. The molecular shape and electron pair geometry of $XeOF_4$ are respectively.

(1) trigonal bipyramidal and octahedral
(2) square pyramidal and trigonal bipyramidal
(3) trigonal bipyramidal and square pyramidal
(4) squrare pyramidal and octahedral
(5) octahedral and square pyramidal.

21. Which one of the following statements is **correct** with regard to elements from Sc to Zn in the Periodic Table and their compounds?
(1) They have lower densities than K and Ca.
(2) Some of them exhibit non-metallic properties.
(3) $Cr_2O_7^{2-}$ (aq) is converted to CrO_4^{2-}(aq) and Cr^{3+}(aq) upon addition of dilute NaOH.
(4) They have electronegativities lower than s block elements in the same period.
(5) Mn forms acidic, amphoteric and basic oxides.

22. The standard enthalpies of combustion of C(s), S(s) and $CS_2(l)$ are -394 kJ mol^{-1}, -296 kJmol^{-1} and -1072 kJ mol^{-1} respectively. The standard enthalpy of formation of $CS_2(l)$ is,

(1) -86 kJ mol^{-1} (2) 86 kJ mol^{-1}
(3) 382 kJ mol^{-1} (4) -1762 kJ mol^{-1}
(5) 1762 kJ mol^{-1}

23. (A) $CH_3CH_2CH=CH_2$ (B) $CH_2 = CH_2$
(C) $CH_2=CH-CO_2H$ (D) $(CH_3)_2C=CH_2$

Which of the following arrangements gives the correct **increasing** order of the reactivities of the above compunds towards HBr?

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

24. Ammoniacal CuCl can be used to distinguish between $CH_3C{\equiv}CH$ and $CH_3CH=CH_2$ because,
(1) $CH_3C \equiv CH$ is oxidized by CuCl faster than $CH_3CH=CH_2$
(2) $CH_3C \equiv CH$ is reduced by CuCl faster than $CH_3CH=CH_2$
(3) $CH_3C \equiv CH$ can oxidize Cu^+ to Cu^{2+} while $CH_3CH=CH_2$ cannot
(4) $CH_3C \equiv CH$ contains an acidic hydrogen which can be displaced by Cu^+ while $CH_3CH=CH_2$ does not.
(5) $CH_3C \equiv CH$ undergoes an electrophilic addition reaction with CuCl while $CH_3CH=CH_2$ does not.

25. An aqueous saturated solution of $M(OH)_2$ has a pH of 10.0 at 25°C. The solubility product of $M(OH)_2$ at the same temperature is,

(1) 2.0×10^{-30} mol^3 dm^{-9} (2) 4.0×10^{-30} mol^3 dm^{-9}
(3) 5.0×10^{-13} mol^3 dm^{-9} (4) 2.0×10^{-12} mol^3 dm^{-9}
(5) 4.0×10^{-12} mol^3 dm^{-9}

26. The correct **decreasing** order of N-O bond distances in NH_2OH, NO, NO_2^- and NO_3^- is,

(1) $NO_2^- > NO_3^- > NO > NH_2OH$
(2) $NO_3^- > NO_2^- > NO > NH_2OH$
(3) $NO > NO_2^- > NO_3^- > NH_2OH$
(4) $NH_2OH > NO_3^- > NO_2^- > NO$
(5) $NO > NO_3^- > NO_2^- > NH_2OH$

27. Which of the following statements is **correct** with regard to the chemistry of Group I and II elements (s block elements) and their compounds?
(1) All Group I and II elements react with cold water to give H_2 and their metal hydroxides.
(2) $LiNO_3$ decomposes on heating to give NO_2 and O_2 as gases.
(3) The solubility of Group II sulphates decreases down the group.
(4) The basic strength of Group II hydroxides decreases down the group.
(5) The oxides of Group II elements can be obtained on heating their carbonates.

28. A sample of NaOH is contaminated with an inert impurity. 4.00 g of this NaOH sample was dissolved in 1.0 dm^3 of water, and a 50.0 cm^3 sample of the resulting solution was allowed to react with 50.0 cm^3 of 0.10 mol dm^{-3} HCl solution. The pH of the reaction mixture was found to be 2.0. The percentage purity of the NaOH sample is. (H = 1, O = 16, Na = 23)

(1) 12 (2) 20 (3) 60 (4) 80 (5) 90

29. At room temperature, a solution of 0.10 mol dm^{-3} HCl was slowly added to 100.0 cm^3 of a $Pb(NO_3)_2$ solution until the reaction was complete. The resulting solution was filtered, and the residue was dried to a constant mass. The mass of the dry residue was 0.139 g. The concentration of the $Pb(NO_3)_2$ solution is. (N = 14, O = 16, Cl = 35.5, Pb = 207)

(1) 1.0×10^{-2} mol dm^{-3} (2) 8.4×10^{-3} mol dm^{-3}
(3) 5.0×10^{-3} mol dm^{-3} (4) 4.2×10^{-3} mol dm^{-3}
(5) 5.0×10^{-4} mol dm^{-3}

30. Which of the following compounds gives/ give a basic gas on heating?

(A) $(NH_4)_2CO_3$ (B) NH_4Cl (C) NH_4NO_2
(D) NH_4NO_3 (E) $(NH_4)_2Cr_2O_7$
(1) **A** only (2) **B** only (3) **E** only
(4) **A** and **B** only (5) **C** and **D** only

For each of the questions **31** to **40**, one or more responses out of the four responses (a), (b), (c) and (d) are given is/are correct. Select the correct response/ responses. In accordance with the instrutions 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 or combination of responses is correct.

31. Which of the following statements is /are **true** regarding electro chemical reactions and electrode potentials?
(a) Electrode potential is an intensive property.
(b) Half-cell reactions are reversible.
(c) standard electrode potential changes its sign (+ or -) for the reverse reaction.
(d) Electrode potentials are independent of the temperature.

32. Which of the following statements is/are **true** regarding compound **A**?

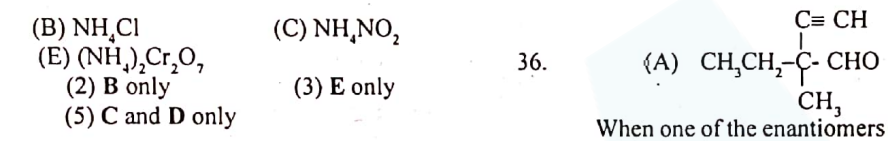
(A) $HC \equiv C - CH_2CH_2CH_2NH_2$

(a) **A** forms an aldehyde upon treatment with dil. H_2SO_4 in the presence of $HgCl_2$
(b) **A** liberates H_2 when reacted with sodium.
(c) **A** liberates N_2 when reacted with $NaNO_2$/aq. HCl
(d) **A** liberates CO_2 when treated with aq. $NaHCO_3$.

33 Which of the following statemets is/are **true** regarding the polymers, polystyrene, polyvinychloride, phenol-formaldelyde and nylon?
(a) Only polystyrene and polyvinychloride are thermoplastic polymers.
(b) Only polystyrene, polyvinylchloride and nylon are thermo setting polymers.
(c) Only phenol-formaldehyde and nylon are prepared by condensation polymerization.
(d) Only polystyrene, polyvinychloride and nylon are prepared by condensation polymerization.

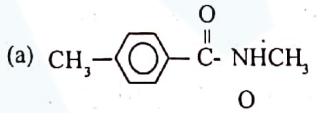
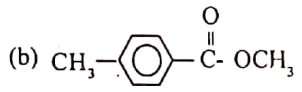
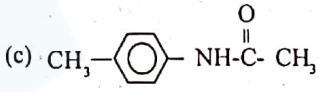
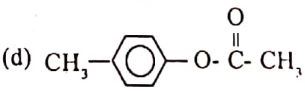
34. Which of the following statements is /are **true** regarding natural rubber?
(a) The relative molecular mass of natural rubber is around 750 000.
(b) Ebonite is formed when natural rubber is heated with a large amount of sulphur.
(c) Although cis and trans isomers are possible in natural rubber due to the presence of double bonds, natural rubber has a trans configuration.
(d) Vulcanization of natural rubber reduces its hardness.

35. An ideal solution is prepared by mixing two miscible pure liquids Which of the following statements is/are **true** regarding the above?
(a) THe enthalpy change during mixing is zero.
(b) Raoult's Law cannot be applied to the above ideal solution.
(c) The vapour pressure of the solution is equal to the sum of the partial pressures of the two liquids.
(d) The vapour pressure of the solution varies linearly with the mole fraction of each of the liquids.

36. 

When one of the enantiomers of **A**,
(a) is treated with Zn(Hg)/conc. HCl, the product does not show optical activity.
(b) is treated with $LiAlH_4$, the product does not show optical activity.
(c) is treated with ammoniacal $AgNO_3$, the product does not show optical activity.
(d) is treated with H_2/Pd, the product does not show optical activity.

37 Compound **B** was heated with aq. NaOH and the cooled reaction mixture was neutralized. When bromine water was added to the reaction mixture, it was decolorized. According to this observation. which of the following compunds could be **B**?

(a) 
(b) 
(c) 
(d) 

38. Which of the following statements is/are **true** regarding equilibrium systems?
(a) The unit of the equilibrium constant of a chemical reaction can be deduced from the balanced chemical equation.
(b) Equilibrium constants of both exothermic and endothermic reactions change with temperature.
(c) Both gas phase nad liquid phase chemical reactions can reach equilibrium in open systems.
(d) If an equilibrium reaction can be expressed as the sum of two or more equilibrium reactions , the equilibrium constant for the overall reaction is given by the sum of the equilibrium constants of the individual reactions?.

39. Which of the following statements is/are **true** regarding NH_3?
(a) NH_3 can act as both an oxidizing agent and a reducing agent.
(b) NH_3 is produced in large scale using the Haber process which employs N_3 and H_2 under high pressures and high temperatures.
(c) When NH_3 reacts with excess Cl_2 gas. the products are N_2O and HCl.
(d) NH_3 is used in the rubber industry to prevent premature coagulation of latex.

40. The only Group IA element to react with nitrogen gas is Li. In an experiment, 51 g of Li is allowed to react with 39 g of N_2. which of the following statements is/are **true**? (Li = 7, N= 14)
(a) Li will react completely and some N_2 will remain.
(b) N_2 will react completely and some Li will remain
(c) Neither Li nor N_2 will react completely.
(d) Theoretically, the amount of product formed will be 85 g.

- In questions No. **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.

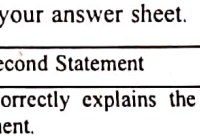
Response	First Statement	Second Statement
(1)	True	True, and correctly explains the first statement.
(2)	True	True, but does **not** explain the first statement correctly.
(3)	True	False
(4)	False	True
(5)	False	False

First Statement	Second Statement
41. NH_3 acts as a Lewis base, while BF_3 acts as a Lewis acid.	A Lewis base accepts protons, while a Lewis acid donates protons.
42. The two N-O bond lengths in NO_2Cl are equal.	Two acceptable stable resonance structures can be drawn for NO_2Cl.
43. The boiling point of butanoic acid is higher than the boiling point of 1-butanol.	No hydrogen bonds are present in 1-butanol.
44. Enthalpy of mixing of an ideal solution is zero.	Attraction forces amongst different types of molecules and attraction forces amongst the same types of molecules are equal in an ideal solution.
45. All three carbon atoms in propenal lie on the straight line.	All three carbon atoms in propenal are sp hybridized.
46. Contribution to photo-chemical smog cannot be reduced by attaching catalytic converters to the tail pipes of vehicles.	In a catalyhtic converter, carbon monoxide and partially combusted hyddrocarbons are oxidized to CO_2, and nitrogen oxides are reduced to N_2.
47. The order of the reaction $2\,N_2O_5(g) \rightarrow 4NO_2(g) + O_2(g)$ can be determined by monitoring the volume change of the system with time when a sample of $N_2O_5(g)$ is heated.	The order of a chemical reaction with rspect to a reactant does not depend on the concentration of the reactant.
48. H_2S found in petroleum deposits is used in the large scale manufacture of sulphur.	Large underground deposits are the principal sources of elemental sulphur.
49. If a yellow precipitate forms when $Pb(NO_3)_2$ solution is added to an aqueous solution, the only possible conclusion is that I^- ions are present.	The only water insoluble yellowish compound that Pb forms is PbI_2.
50. Hydrochloroflurorocarbons are used as an alternative for chlorofluorocarbons to protect the ozone layer.	Hydrochloroflurorocarbons are not harmful to the ozone layer.

G.C.E. (A/L) Examination
New Syllabus
2012 August - Chemistry II / Three hours

- A Periodic Table is provided on page 15.
- **Use of calculators is not allowed.**

Universal gas constant, R = 8.314 $JK^{-1}\,mol^{-1}$
Avogadro constant N_A = 6.022 x $10^{23}\,mol^{-1}$

e.g.  may be shown as CH_3CH_2 -

PART A - Structured Essay (Pages 2-7)
- Answer all the questions on this paper itself.
- Write your answer in the space provided for each question. Please note that the space provided is sufficient for the answer and that etensive answers are not expected.

PART B and PART C - Essay (pages 8-14)

Answer **four** questions selecting two questions from each part. Use the paper supplied for this purpose.

At the end of the time allotted for this paper, tie the answers to three parts A, B and C together so that Part A is on top and hand them over to the Supervisor.

You are permitted to remove **only** Parts **B** and C of the question paper from the Examination Hall.

PART A - STRUCTURED ESSAY

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

1. (a) Answer the questions given below in the space provided

(i) Of the three isolated ions Fe^{3+}, Cr^{3+} and CO^{2+}, which one **three** unpaired electrons? .....

(ii) Of the three 3d block elements Ti, V and Cr. which one has a maximum of **five** electrons that can participate in bonding? .....

(iii) Of the three elements C,N and Si, which one has the **lowest** electronegativity? .....

(iv) Of the three elements Na, Mg and Al, which one has the **highest** first ionization energy? .....

(v) Of the three isoelectronic anions N^{3-}, O^{2-} and F^- which one has the **largest** ionic radius? .....

(vi) Of the three cations Na^+, Ca^{2+} and Al^{3+} which one has the **smallest** ionic radius? .....(3:0 marks)

(b) Peroxonitrous acid (HOONO) is formed as an intermediate during the oxidation of acidfied aqueous solutions of nitrites to nitrates using H_2O_2. Answer the parts (i) to (vii) which are based on the peroxonitrite ion, $[OONO]^-$. Its skeleton is given below.

O - O - N - O

(i) Draw the **most** acceptable Lewis structure for this ion

(ii) Draw resonance structures for this ion. Giving reason/s comment on their relative stabilities.

(iii) Deduce the shapes around the following atoms using the VSEPR theory.

I. **N**. .....

.....

.....

.....

II. **O** attached to both **N** and **O**.

.....

.....

.....

.....

(iv) State the following :

I. electron pair geometry (arrangement of electron pairs) around the atoms

II. hybridization of the atoms

given in the table below

	N	**O** attached to both **N** and **O**
I. electron pair geometry		
II. hybridization		

(v) Sketch the shape of the Lewis structure drawn in Part (i) above showing approximate bond angles.

(vi) Idetify the atomic/hybrid orbitals involved in te formation of the following bonds in the Lewis structrue drawn in Part (i) above. Oxygen atoms are labelled 1,2 and 3 as given below.

O^1-O^2-N-O^3

I. O^1 and O^2 .....

II, O^2 and N .....

(vii) Give an isomer of peroxonitrous acid

.....

(5.0 marks)

(c) (i) Select **two** polar species from the list given belwo.

H_2CO (formaldehyde). SF_6, COS, ICl_4^-, $SiCl_4$

..... and .....

(ii) State the **type**(s) of intermolecular forces that exist between the molecules in each of the following pairs.

I. HBr(g) and H_2S(g) .....

II. Cl_2(g) and CCl_4(g) .....

III. CH_3OH(*l*) and H_2O (*l*) .....

(2.0 marks)

2 (a) (i) Give the formulae of the oxides with the highest oxidation state formed by the elements in the third period. Comment on their acidic/amphoteric/ basic nature using the following list.

very strongly acidic, strongly acidic, weakly acidic. very weakly acidic weakly basic, basic. strongly basic, amphoteric, neutral

.....

.....

.....

.....

.....

.....

(ii) State how the electronegativity, atomic radius and first ionization energy very from left to right across the third period.

electronegativity .....

atomic radius .....

first ionization energy .....

(iii) Give the general reaction to show the thermal decomposition of Group II nitrates using M as the metal.

.....

(iv) Arrange the Group II nitrates in the order of **increasing** thermal stability (use the notation<). Explain your answer based on polarization of ions.

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.....

(3.5 marks)

(b) The following questions are based on the transition metal, Mn and its compounds.

(i) Give the electronic configuration of Mn.

.....

(ii) State the common oxidation states of Mn.

.....

(iii) Give the chemical formulae of the oxides formed by Mn in these common oxidation states. Indicate whether each of these oxides is acidic, amphoteric or basic.

.....

.....

.....

(iv) Give the IUPAC name of $KMnO_4$.

.....

(v) Mn has the lowest melting point and lowest boiling point among the 3d transition elements. Explain why this is so.

.....

.....

.....

(vi) What would you expect to observe when a dilute ammonia solution is added to an aqueous solution of Mn^{2+} and then left exposed to the air?

.....

.....

(vii) An aqueous solution of $KMnO_4$ turns green upon addition of conc. KOH. On diluting the green solution with water or acid, a purple solution and a blackish brown precipitate are obtained. Write balanced chemical equations to explain these observations.

.....

.....

.....

.....

(viii) Give **one** important use of each of the following.

I. $KMnO_4$ (other than as an oxidizing agent)

.....

.....

II. Mn metal

.....

(ix) Give half reactions to show how $KMnO_4$ behaves as an oxidizing agent in acidic and basic media.

acidic medium : .....

basic medium : .....

(x) Indicate **two** problems you may expect when using $KMnO_4$ as an oxidizing agent.

.....

.....

.....

(6.5 marks)

3. (a) At pressure P and temperature T, a mixture of $O_2(g)$ and $O_3(g)$ exists at equilibrium in a closed rigid container of volume V.

(i) Express the density of the gas mixture (d), in terms of n_1, n_2, M_1, M_2 and V, where

n_1 = number of moles of O_2 n_2 = number of moles of O_3

M_1 = molar mass of O_2 M_2 = molar mass of O_3

.....

.....

.....

.....

(ii) Express the above relationship in terms of X_1, X_2, M_1, M_2, V and n, where,

X_1 = mole fraction of O_2 X_2 = mole fraction of O_3

n = total number of moles of both gases

.....

.....

.....

.....

(iii) Hence show that, $X1 = \left[3 - \frac{dRT}{16P}\right]$

Where R is the universal gas constant. (relative atomic mass of O = 16)

.....

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.....

.....

(iv) State the assumption/s you made in the above steps.

.....

.....

(5.0 marks)

(b) (i) Consider the following standard reduction potentials :

E^0 $[Br_2(l)/Br^-(aq)]$ = 1.07 V

E^0 $[I_2(s)/I^-(aq)]$ = 0.54 V

I. What reaction would you expect to take place when liquid bromine is added to an aqueous solution of 1.0 mol dm^{-3} KI?

.....

II. Write the colour changes you would expect in the above experiment.

.....

.....

(ii) Consider the following electrochemical reaction.

$Mg(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g)$

I. Write the cathodic reaction of the Galvanic cell consistent with the above reaction.

.....

II. Write the conventional notation for representing the above cell, which includes a salt bridge.

.....

III. Does the entropy increase, decrease or remain constant when the above cell reaction proceeds?

.....

Briefly explain your answer.

.....

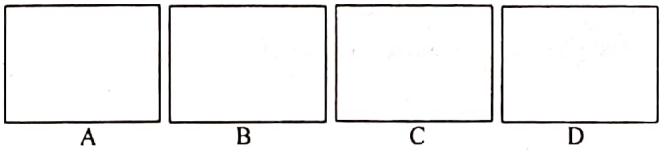
.....

IV. What should be the relationship between enthalpy change (ΔH) and entropy change (ΔS) for the above reaction to be spontaneous at temperature T?

.....

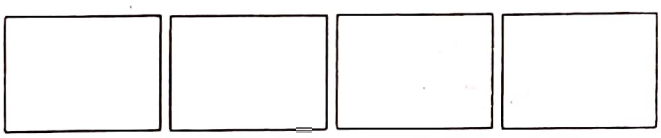
(5.0 marks)

4. (a) **A, B** and **C** are three isomeric hydrocarbons with the molecular formula C_7H_{14}. Compound **A** shows geometrical isomerism while compounds **B** and **C** do not. All three compounds exhibit optical isomerism. On catalytic hydrogenation all three compounds yield compound **D** (C_7H_{16}). Compound D also shows optical isomerism. Give the structures of **A, B, C** and **D**. (It is **not** necesary to draw the stereoisomeric forms).



A B C D

On treatment with bromine followed by dehydrobromination with alcoholic KOH. A forms two compounds **E** and **F**. while **B** forms compound **G**, and **C** forms compound **H**. All four compounds **E, F, G** and **H** have the same molecular formula of C_7H_{12}. Compound **E** shows geometrical isomerism. while **F, G** and **H** do not. Give the structures of **E, F, G** and **H**



E **F** **G** **H**

Give **one** chemical test to distinguish between **F** and **G**.

.....

.....

.....

(7.0 marks)

(b) The reactant and reagent in each of the reactions 1-5 are given in the table below.

For each reaction, write the reaction type [Nucleophilic addition (A_N), Electrophilic addition (A_E), Nucleophilic substitution (S_N), Electrophilic substitution (S_E), Elimination (E) and the major product in the relevant boxes.

	Reactant	Reagent	Reaction type	Major product
1.		conc. HNO_3/ conc. H_2SO_4		
2.	$CH_3CH = CH_2$	HBr		
3.	CH_3CHO	H^+/ KCN		
4.	$CH_3CH_2CHBrCH_3$	alcoholic KOH		
5.	CH_3CH_2I	aq KCN		

(3.0 marks)

PART B - ESSAY

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

Universal gas constant. $R = 8.314\ JK^{-1}\ mol^{-1}$
Avogadro Constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$

5. (a) Consider the following equilibria exhibited by gas **A**, contained in a closed rigid vessel.

(i) At a temperature T (in Kelvin) **A** undergoes the reaction,

$$2A(g) \rightleftharpoons B(g) \qquad (1)$$

After equilibrium is reached, it has been found that 40% of the initial amount of **A** has been converted to **B**, and that the total pressure of the system is $4 \times 10^5\ Nm^{-2}$. Calculate the equilibrium constant K_p at temperature **T** for this equilibrium.

(ii) When the temperature of the system is increased to 2T (in Kelvin), in addition to the above reaction, A under goes another reaction as shown below.

$$2A(g) \rightleftharpoons C(g) + D(g) \qquad (2)$$

After the system reaches equilibrium at 2T, it has been found that 20% of the initial amount of **A** has been converted to **C** and **D**, and that 20% of the initial amount of **A** remains.

I. Calculate separately, the number of moles of **A**,**B**,**C** and **D** at this equilibrium if the initial number of moles of **A** was a.

II. Calculate the equilibrium constant K_p for equilibrium (2) at 2T.

III. Calculate the equilibrium constant K_p for equilibrium (1) at 2T.

(8.5marks)

(b) A student used the following procedure to determine the distribution coefficient of acetic acid between water and *n*-butanol phases at a constant temperature.

Different volumes of *n*-butanol 1.0 mol dm^{-3} aqueous acetic acid and water were added to numbered reagent bottles 1 and 2 as shown in the table below.

Reagent bottle	Volume of *n*-butanol/cm^3	Volume of aqueous acetic acid/cm^3	Volume of water/cm^3
1	20.00	40.00	0.00
2	20.00	30.00	10.00

The bottles were shaken well and then, each system was allowed to reach equilibrium. After the layers were separated. 10.00 cm^3 each from the aqueous layer and the butanol layer were withdrawn and titrated with a standard NaOH solution of concentration 0.500 mol dm^{-3}. The reading obtained at the end point on titrating the aqueous layer taken from bottle (I) is given in the table below.

Reagent bottle	Volume of NaOH required for 10.00 cm^3 of aqueous layer/ cm^3	Volume of NaOH required for 10.00 cm^3 of n-butanol layer/cm^3
1	16.00	x
2	y	z

(i) Calculate the end point x that would have been obtained for the n-butanol layer of bottle (1).

(ii) Calculate the distribution coefficient of acetic acid between water and n-butanol using the system in bottle (1)

(iii) Calculate the volumes y and z that would have been obtained for the system in bottle (2)

(iv) State the assumptions you made in the above calculations.

(v) Name an indicator that could be used for these titrations.

(vi) State whether the pH of the aqueous layer would change during the period when the bottles were being shaken. Explain your answer.

(6.5 marks)

6. (a) (i) Derive an expression for the pH of an aqueous CH_3COOH solution of concentration c mol dm^{-3}, in terms of the acid dissociation constant Ka and c.

(ii) Write the assumptions you made in the above derivation.

(iii) A 100.0 cm^3 sample of the above acid solution was diluted to 1.00 dm^3 by adding distilled water. Write an expression for the pH of this acid solution with the help of the expression obtained in Part (i) above.

(iv) Using the answers obtained in Parts (i) and (iii) above, show that the difference in pH values of the two acid solutions is 0.5 pH units.

(v) Calculate the pH of the solution prepared by mixing 220.0 cm^3 of the acid solution in Part (i) above and 20.0 cm^3 of NaOH solution of concentration c mol dm^{-3}

(7.5 marks)

(b) (i) The solubility product of $BaSO_4$ is $1.0 \times 10^{-10}\ mol^2dm^{-6}$ at 25°C. Calculate the Ba^{2+} concentration in a saturated aqueous solution of $BaSO_4$ at this temperature.

(ii) Calculate the mass of pure solid Na_2SO_4 that should be added to 1.0 dm^3 of the solution in Part (i) above to halve the concentration of Ba^{2+} at 25°C.
(O = 16, Na = 23, S = 32)

State assumptions, if any, you made in this calculation.

(iii) The solubility product of $PbSO_4$ is 1.6×10^{-8} mol^2 dm^{-6} at 25°C. Calculate the concentrations of Ba^{2+} and Pb^{2+} separately in an aqueous solution saturated with both $BaSO_4$ and $PbSO_4$ at ths temperature.

(7.5 marks)

7 (a) Grignard reagents are prepared by reacting alkyl or aryl halides with Mg in dry ether. However, the Grignard reagent given below **cannot** be prepared using the following reaction. Explain why it cannot be.

$$HOCH_2CH_2CH_2Br \xrightarrow{Mg/dry\ ether} HOCH_2CH_2CH_2MgBr$$

(2.0 marks)

(b) Provide a mechanism for chlorination of benzene in the presence of $FeCl_3$. (3.0 marks)

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

$$(CH_3)_2C{=}CH_2 \longrightarrow (CH_3)_3C\text{-}\overset{\overset{O}{\|}}{C}\text{-}OC(CH_3)_3$$

List of chemicals
conc. H_2SO_4, dil. H_2SO_4, PCl_5, Mg, Ether, HCHO, $K_2Cr_2O_7$

(5.0 marks)

(d) Show how you would synthesize the following compound using propanal as the **only** organic starting material.

$$CH_3\text{-}CH_2\text{-}\overset{\overset{O}{\|}}{C}\text{-}NH\text{-}CH_2\text{-}CH_2\text{-}CH_3$$

(5.0 marks)

PART C - ESSAY

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

8. (a) (i) A solid mixture contains only **two** of the following.

$Ba(NO_3)_2$ $Zn(NO_3)_2$ $AgNO_3$ $CaCO_3$ NaOH

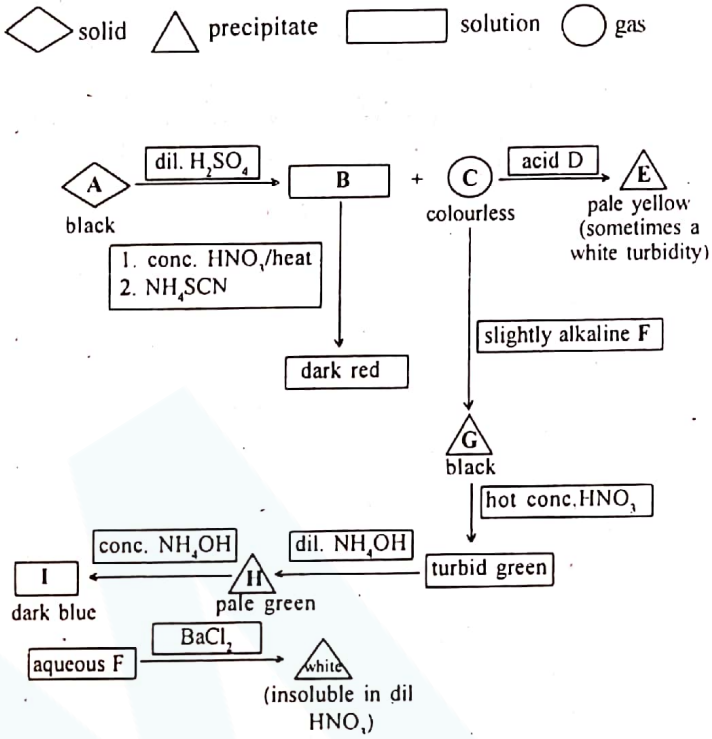
Tests carried out along with the observations to identify them are as follows :

	Test	Observation
1	Water was added to the mixture	The mixture dissolved giving a clear solution.
2.	A few drops of phenolphthalein were added to a portion of the aqueous solution obtained from 1 above.	The clear colourless solution turned pink
3.	Dilute HCl was gradually added to another portion of the aqueous solution obtained from 1 above.	A white precipitate formed. It dissolved on further addition of the acid.

Giving reasons, identify the **two** compounds present in the mixture

(ii) Write the **formulae** of the compounds **A - I** given in the diagram below. **(Balanced chemical equations and reasons are not required)**

The following symbols are used to represent solids, precipitates, solutions and gases.



(7.0 marks)

(b) (i) A 3*d* block element **M** forms an ion M^{n+}. This ion can be oxidized by MnO_4^- in a dil. H_2SO_4 medium to give the MO_2^+ ion. In an experiment, 30.0 cm^3 of 0.100 mol dm^{-3} $KMnO_4$ was required to oxidize 5.00×10^{-3} mol of M^{n+} to MO_2^+. Use this data to calculate the value of n.

(ii) The following procedures **I** and **II** were used to determine the percentage of Cu in the Cu-containing alloy Z

Procedures :

I A sample of 2.80 g of the alloy **Z** was dissolved in 500.0 cm^3 of dil. H_2SO_4. Addition of excess KI to 25.0 cm^3 of this solution produced the white precipitate CuI and I_2 as the only products. The liberated I_2 was titrated with $Na_2S_2O_3$ solution using starch as the indicator. The volume of $Na_2S_2O_3$ solution required was 30.0 cm^3.

II. To 25.0 cm^3 of $K_2Cr_2O_7$ solution, prepared by dissolving 1.18 g in 500.0 cm^3 of distilled water, 20 cm of dil. H_2SO_4 and excess KI were added. The liberated I_2 was titrated with the $Na_2S_2O_3$ solution used in procedure I with starch as the indicator. The volume of $Na_2S_2O_3$ required was 24.0 cm^3.

1 Give balanced chemical equations for the reactions taking place in procedures I and II.

2 Determine the percentage of Cu in alloy Z.

3 Indicate the colour changes you would observe at the end points of the titrations in procedures I and II

(O = 16, K = 39, Cr = 52, Cu = 63.5)

(8.0 marks)

9 (a) (i) Answer the following questions which are based on the manufacture of sodiumu using Down's cell.

I. Name the starting materials used in the manufacture of sodium.

II A substance is added to lower the melting point of the starting material before electrolysis. Identify this substance.

III State the approximate temperature at which the electrolytic cell operates.

IV Identify the anode and cathode used in the Down's cell

V Give the balanced chemical equations for the half cell reactions that take place at the anode and cathode.

VI Why is it necessary to separate the anode from the cathode by a steel gauze?

VII. Apart from separating the anode from the cathode, state an important precaution that must be taken during the manufacturing process.

VIII State whether the following statement is true or false.

" A small current and a large voltage are used in the manufacture of sodium."

IX Give the physical state in whice sodium is obtained by this method.

X Give **two** uses of sodium and **one** use of the product obtained at the anode.

(ii) **Briefly** describe the four steps involved in the manufac ture of soap.

(7.5 marks)

(b) (i) Consider the statements I to V given below:

I. Natural processes that support life on earth

II. Unfavourable processes that occur due to the inter action of solar radiation with atmospheric gases

III. Processes that may introduce harmful gases leading to environmental problems

IV. Environmental damage due to some agricultural practices

V. Environmental damage due to acid rain

Write the **three msot suitable** choices from the list given below for each of the statements from I to V.

(Write the statgement numbers I to V on your answer script and the notation **A,B,C**....etc. of the three relevants choices in front of each statement number. You may use one choice more than once.)

A - photosynthesis	B - corrosion of metal or limestone structures
C - global warming	D - absorption of UV radiation by ozone layer
E - volcanic eruptions	F - dissolution of heavy metal salts in sediments
G - greenhouse effect	H - ozone layer depletion
I - coral reef distortion	J - fossil fuel combustion
K - photochemical smog	L - pollution of ground water
M - metal refining	N - rapid growth of algae in reservoirs (Eutrophication)

(ii) Contribution to acid rain from a coal power plant can be reduced by controlling the emissions of acidic gases. Suggest a suitable method to control the acidic emissions using locally available raw materials. Write balanced chemical equations to support your answer.

(iii) The acidic gases NO and SO_2 released to the atmosphere through numerous processes result in the formation of the acids HNO_3 and H_2SO_4 respectively. in the atmosphere. Write balanced chemical equations for the formation of these acids.

(iv) Consider the following compounds

$CH_3(CH_2)_4CH_3$ $CFCl_3$ CF_2Cl_2 N_2 NO

Of these , identify the compounds that contribute to.

I. global warming

II. ozone layer depletion

(v) In the ozone layer, ozone is formed and destroyed naturally Ozone is also lost catalytically on inclusion of radical forming compounds to the ozone-layer region. Write balanced chemical equations for the following processes in the ozone layer :

I. Natural formation and diestruction of ozone

II. Formation of radicals

III. Catalytic destruction of ozone

(7.5 marks)

10. (a) Give **four** important differences between fluorine chemistry and the chemistry of the rest of the halogens.

(2.5 marks)

(b) Sodium sulphite (Na_2SO_3) is sometimes added to sausage meat as a preservative. The following procedure was used to determine the amount of the preservative. Na_2SO_3 present in a sample of meat.

Step 1 : One kilogram (1.00 kg) of meat was boiled with an excess of dil. HCl.

Step 2 : The gas released was completely absorbed in an excess of 0.050 mol dm^{-3} I_2 solution. The volume of I_2 solution used was 40.0 cm^3.

Step 3 : The resulting solution from step 2 was titrated with a 0.100 mol dm^{-3} $Na_2S_2O_3$ solution using starch as the indicator. The volume of the $Na_2S_2O_3$ solution required was 26.0 cm^3.

(O = 16, Na = 23, S = 32)

(i) Write balanced chemical equations for the **three** steps involved in the above procedure.

(ii) Calculate, in moles, the amount of Na_2SO_3 present in 1.00 kg of meat sample

(iii) The amount of preservative present in meat samples is usually expressed as parts per million (ppm)

(Hence, 1 ppm = 1 g of Na_2SO_3 in 10^6 g of meat)

Express in ppm, the amount of Na_2SO_3 determined in Part (ii) above.

(iv) Indicate the colour change at the end point of the titration

(5.0 marks)

(C) A student conducted three experiments to investigate the kinetics of the following reaction at a constant temperature.

$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$

(i) In the first experiment, 500 cm^3 of 0.160 mol dm^{-3} solution of $I^-(aq)$ and 500 cm^3 of 0.040 mol dm^{-3} solution of $S_2O_8^{2-}(aq)$ were mixed to allow the above reaction to proceed. It was found that 2.8×10^{-5} moles of I_2 have been formed at the end of the initial 5 second period.

I. Calculate the rate of production of $I_2(aq)$
II. Calculate the rate of consumption of $I^-(aq)$
III. Calculate the rate of consumption of $S_2O_8^{2-}(aq)$

(ii) In the second experiment, 500 cm^3 of 0.320 mol dm^{-3} solution of $I^-(aq)$ and 500 cm^3 of 0.040 mol dm^{-3} solution of $S_2O_8^{2-}(aq)$ were mixed. The rate of the reaction was then determined to be 1.12×10^{-5} mol $dm^{-3}s^{-1}$.

Calculate the order of the reaction with respect to $I^-(aq)$ using the information given in parts (i) and (ii).

(iii) The order of the reaction with respect to $S_2O_8^{2-}(aq)$ was determined to be 1 in the last experiment conducted by changing the concentration of $S_2O_8^{2-}(aq)$

I. Write the rate equation for this reaction.
II. Calculate the rate of the reaction when the volumes of both solutions in Part(ii) are doubled by adding distilled water and the solutions are then mixed.

(iv) I. What is meant by the half-life of a first order reaction?

II. The half-life of the above reaction when the concentration of $I^-(aq)$ is kept constant, is independent of the initial concentration of $S_2O_8^{2-}(aq)$. Explain this statement with the help of a graphical resperesentation.

(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	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

G.C.E. (A/L) Examination Chemistry - 2012

M.C.Q. Answers

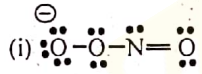
(1)	2	(14)	3	(27)	all	(40)	4
(2)	2	(15)	3	(28)	4	(41)	3
(3)	4	(16)	2	(29)	3	(42)	1
(4)	3	(17)	2	(30)	4	(43)	3
(5)	3	(18)	4	(31)	5	(44)	1
(6)	5	(19)	3	(32)	2	(45)	5
(7)	1	(20)	4	(33)	5	(46)	4
(8)	5	(21)	5	(34)	1 or 5	(47)	4
(9)	5	(22)	2	(35)	5	(48)	all
(10)	1	(23)	3	(36)	4	(49)	5
(11)	2	(24)	4	(37)	3	(50)	3
(12)	4	(25)	3	(38)	1		
(13)	4	(26)	4	(39)	4		

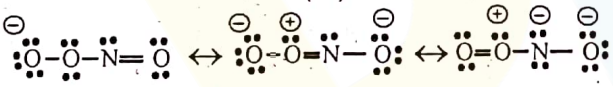
PART A - STRUCTURED ESSAY

Answer all four questions on this paper it self (Each question carries **10 marks)**

(01) (a) (i) Cr^{3+} or CO^{2+}
(ii) V
(iii) Si
(iv) Mg
(v) N^{3-}
(vi) Al^{3+} (5 x 6 = 30 marks)

(b)

(i)  (06)

(ii) 

(02) (02)

stable (01) unstable (01) unstable (01)

Reason : Negative charge on most electronegative oxygen atom. (01)

Greater charge separation or electronegative O carries a positive charge. (02)

Greater charge separation or electronegative O carries a positive charge. (02)

(12 marks)

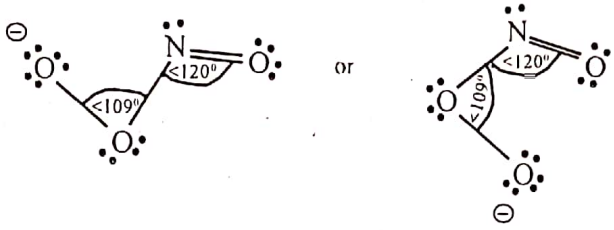
(iii) I. N valence electron pairs = 4 (01)
VSEPR pairs or sigma bonds and lone pairs = 3 (01)
Lone pairs of electrons = 1 (01)
Shape = angular or V (01)

II O attached to both N and O
valence electron pairs = 4 (01)
VSEPR pairs or sigma bonds and lone pairs = 4 (01)
Lone pairs of electrons = 2 (01)
Shape = angular or V (01)

(iv)

		N	O attached to both N and O
i	electron pair geometry	trigonal planar	tetrahedral
II	hybridization	SP^2	SP^3

(v)



sketch (03)
angles (01 x 2) = 05

(vi) I. O^1 and O^2 2p atomic orbital and SP^3 hybrid orbital (04 marks)

II O^2 and N SP^3 hybrid orbital and SP^2 hybrid orbital (04 marks)

(vii) HNO_3 (nitric acid) or [nitric acid (v)] (03 marks)

I. HBr(g) and H_2S(g) dipole - dipole + London forces.

II. Cl_2(g) and CCl_4(g) London forces

III. $CH_3OH(l)$ and $H_2O(l)$ Hydrogen bonding + London forces 02x5 = 10 marks

2. (a) (i) Na_2O - Strongly basic
MgO - weakly basic/ basic
Al_2O_3 - amphoteric
SiO_2 - very weakly acidic
P_2O_5 or P_4O_{10} - weakly acidic
SO_3 - strongly acidic/ very strongly acidic
Cl_2O_7 - very strongly acidic
(1 x 07 + 7 x 07 = 14 marks)

(ii) electronegativity - Na <Mg <Al <Si <P < S < Cl (03)
atomic radius - Na > Mg> Al> Si> P> S> Cl (03)
first ionization energy - Na< Mg >Al < Si< P > S <Cl
or
Cl>P> S> Si> Mg> Al > Na
Drawing zig-zag , variation with correct labelling elements (03)

(iii) $2M(NO_3)_2 \rightarrow 2MO + 4NO_2 + O_2$ (03)

(iv) Increasing thermal stability
$Be(NO_3)_2 < Mg(NO_3)_2 < Ca(NO_3)_2 < Sr(NO_3)_2 < Ba(NO_3)_2$ (04)
anion same (01), cation charge same (01), but size increases, down the group (01)
$\therefore$ polarizing power $Be^{2+} > Mg^{2+} > Ca^{2+} > Sr^{2+} > Ba^{2+}$ (01)
Hence polarization of nitrate by cations becomes difficult down the group (01). Thus thermal stability increases down the group. (05)

(b) (i) $1S^2\ 2S^2\ 2P^6\ 3S^2\ 3P^6\ 4S^2$ or ..... $4S^2\ 3d^5$ (06)

(ii) +2, +4, +7, +6 (any three) (2 x 3 = 06)

(iii) MnO - basic (2+1)
MnO_2 - amphoteric (2+1)
Mn_2O_7 - acidic (2+1)
MnO_3 - acidic any three

(iv) potassium manganate (vii) or
potassium permanganate or
potassium tetraoxomanganate (vii) (06)

(v) Both 3d and 4s electrons are delocalized to form metalic bonds (02).

Mn has a half filled 3d sub shell and a completely filled 4s sub shell 02, making the electrons less available for delocalization. (02)

(06 marks)

(vi) Beige / pale pink/ (white) precipitate (03)
precipitate turns brown / brownish black on exposure to air (03)

(06 marks)

(vii) $4\ MnO_4^- + 4OH^- \rightarrow 4MnO_4^{2-} + 2H_2O + O_2$ (04)

$3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

OR

$3MnO_4^{2-} + 2H_2O \rightarrow 2MnO_4^- + MnO_2 + 4OH^-$ (04)

(viii) I. $KMnO_4$: disinfectant/ germicide/ deodorant/ selfindicator/ identification of anode and cathode/ preparation of O_2 (03)

II. Mn metal
steel/ alloys (03)

(ix) acidic medium : $MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O$ (03)

basic medium : $MnO_4^- + 2H_2O + 3e \rightarrow MnO_2 + 4OH^-$

OR

$MnO_4^- + e \rightarrow MnO_4^{2-}$ (03)

(x)
- Cannot be used in the presence of Cl^- or Br^-
- Not a primary standard (aqueous) solutions not stable.
- Strongly coloured that it is impossible sometimes to see whether crystals are dissolved.
- formation of MnO_2 as a brown precipitate when kept in solution

(any two) (03 x 2 = 06 marks)

3. (a) (i) density (d) = $\frac{\text{mass}}{\text{volume}}$ (03)

$= \frac{m_{O_2} + m_{O_3}}{v}$ (03)

$= \frac{n_1M_1 + n_2M_2}{v}$ (04)

(ii) $n = n_1 + n_2$ (03)

$d = \frac{\left[\frac{n_1}{n_1+n_2}\right] M_1 + \left[\frac{n_2}{n_1+n_2}\right] M_2 \ (n_1+n_2)}{v}$ (03)

$= \frac{X_1M_1 + X_2M_2}{v} . n$ (04)

(iii) $X_2 = 1 - X_1$ or $X_1 + X_2 = 1$ (04)

$d = \frac{X_1M_1 + (1-X_1)M_2}{v} . n$ (04)

For the mixture, $pv = nRT$ or $n/v = p/RT$ (04)

$d = [X_1M_1 + (1-X_1)M_2] \frac{p}{RT}$ (04)

$X_1M_1 + (1-X_1)M_2 = \frac{dRT}{p}$

Substituting for molar mass.

$32X_1 + 48(1-X_1) = \frac{dRT}{p}$ (04)

$16X_1 = 48 - \frac{dRT}{p}$

$X_1 = 3 - \frac{dRT}{16p}$ (03 + 01)

Total (24)

(iv) Assumptions : O_2 (g) and O_3(g) do not react with each other

OR

mixture of O_2(g) and O_3(g) behave ideally (06)

(b) (i) I. $Br_2(l) + 3I^-(aq) \rightarrow 2Br^-(aq) + I_3^-(aq)$

OR

$Br_2(l) + 2I^-(aq) \rightarrow 2Br^-(aq) + I_2(s)$ (10)

II. Colourless/ pale yellow colour solution turns brown. (05)

(ii) I. $2H^+(aq) + 2e \rightarrow H_2(g)$ OR

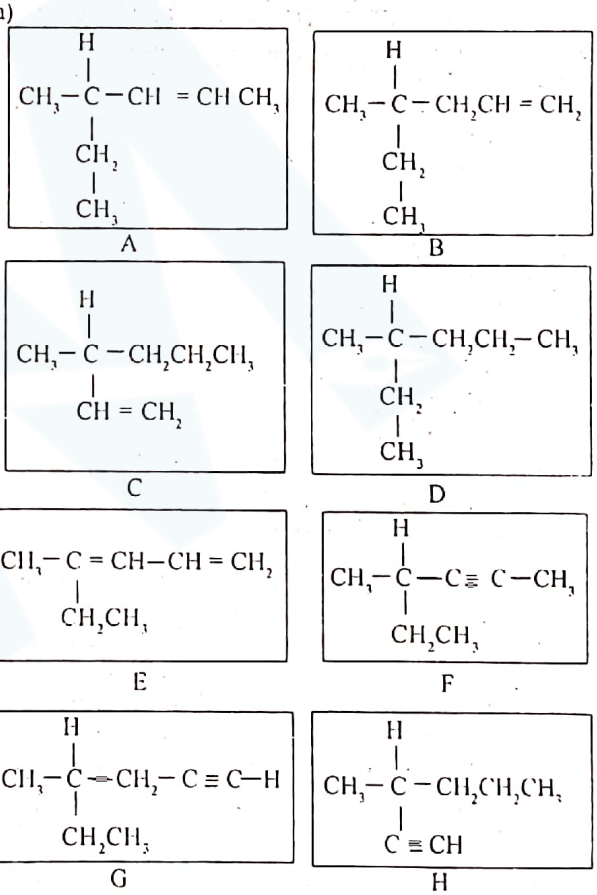
$2H_3O^+(aq) + 2e \rightarrow 2H_2O(l) + H_2(g)$ (05)

II. $Mg(s)/ Mg^{2+}(aq) // H^+(aq) / H_2(g), pt(s)$ (10)

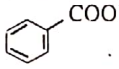
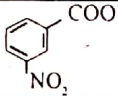
III. Entropy increases (05)

(iv) $\Delta H - T\Delta S < 0$ OR $\Delta H < T\Delta S$ OR $\Delta H / T < \Delta S$ (10)

4. (a)



(08 x 8 marks)

	Reactant	Reagent	Reaction type	Major product
1.		conc HNO_3/ conc H_2SO_4	S_E	
2.	$CH_3CH = CH_2$	HBr	A_E	CH_3-CH(Br)-CH_3
3.	CH_3CHO	H+/ KCN	A_N	CH_3-C(H)(OH)-CN
4.	$CH_3CH_2CHBrCH_3$	alcoholic KOH	E	CH_3-CH=CH-CH_3
5.	CH_3CH_2I	aq KCN	S_N	CH_3CH_2CN

(03 x 10 = 30 marks)

5. (a) (i) $2A(g) \rightleftharpoons B(g)$

initialy	a	-------	mol
at eqm	$a - \frac{40}{100}a$	$\frac{20}{100}a$	mol
	$= 0.6\,a$	$= 0.2\,a$	mol

2 x (02+01)

Mole fraction $\frac{0.6\,a}{0.8\,a} = \frac{3}{4}$ $\frac{0.2\,a}{0.8\,a} = \frac{1}{4}$ (03)

$K_p = \frac{P_B}{P_A^2}$ (03)

$= \frac{1/4 \times (4 \times 10^5\ Nm^{-2})}{[3/4 \times (4 \times 10^5\ Nm^{-2})]^2}$ 2 x (02+01)

$= \frac{1}{9} \times 10^{-5}\ N^{-1}m^2$ OR $1.1 \times 10^{-6}\ N^{-1}m^2$ (02+01)

5 a (i) 21 marks

(i) I $2A(g) \rightleftharpoons B(g)$ ①

$C(g) + D(g)$ ②

initial amount of A (g) = a

at equilibrium. Amount of C(g) = 1/10 a (3)

Amount of D (g) = 1/ 10 a (3)

Amount of A(g) = 2/10 a (3)

Amount of A that participates in Eqm. I = 6/10 a

Amount of B (g) = 3/10 a (3)

Logical approach for the above calculations (03)

5. a (ii) I (15) marks

II Total number of mol of A(g), B(g), $C_{(g)}$ and $D_{(g)}$

$\frac{2}{10}a + \frac{3}{10}a + \frac{1}{10}a + \frac{1}{10}a$

$\frac{7}{10}a$ (03)

Mole fraction of A $= \frac{2a/10}{7a/10} = \frac{2}{7}$ (03)

Mole fraction of B $= \frac{3a/10}{7a/10} = \frac{3}{7}$ (03)

Mole fraction of C $= \frac{a/10}{7a/10} = \frac{1}{7}$ (03)

Mole fraction of D $= \frac{a/10}{7a/10} = \frac{1}{7}$ (03)

$K_p = \frac{P_C P_D}{P_A^2}$ (03)

$\frac{\frac{1}{7}P \times \frac{1}{7}P}{\left(\frac{2}{7}P\right)^2}$ (03)

$\frac{1}{4}$ OR 0.25 (02 + 01)

5. a (ii) II. (24) marks

III Total mol of gases as T = 0.6 a + 0.2 a = 0.8 a

pv = nRT oR P/T $\propto$ n at constant V (03)

At T, $\frac{4 \times 10^5\ Nm^{-2}}{T} \propto 0.8\,a$ ①

At 2T, $\frac{P}{2T} \propto 0.7\,a$ ②

For both ① and ② (02 + 01)

$\frac{①}{②} = \frac{4 \times 10^5\ Nm^{-2}}{p/2} = \frac{0.8\,a}{0.7\,a}$ (03)

$P = 7 \times 10^5\ Nm^{-2}$ (02+01)

partial pressure of A $= \frac{2}{7} \times (7 \times 10^5\ Nm^{-2})$

$= 2 \times 10^5\ Nm^{-2}$ (02+01)

partial pressure of B $= \frac{3}{7} \times (7 \times 10^5\ Nm^{-2})$

$= 3 \times 10^5\ Nm^{-2}$ (02+01)

$K_p = \frac{(3 \times 10^5\ Nm^{-2})}{(2 \times 10^5\ Nm^{-2})^2}$ (02+01)

$= 7.5 \times 10^{-6}\ N^{-1}\ m^2$ (03+01)

5 a (ii) III. (25) marks

(b) (i) Initial amount of CH_3COOH = 1.0 mol $dm^{-3} \times \frac{40.00}{1000}\ dm^3$

= 0.040 mol (02+01)

$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$

After partitioning,

Amount of CH_3COOH in 10.00cm^3 of the aqueous layer

$= 0.5\ mol\ dm^{-3} \times \frac{16.00\ dm^3}{1000}$

= 0.008 mol (02+01)

Amount of CH_3COOH in the aqueous layer

$= 0.008\ mol \times \frac{40.00\ cm^3}{10.00\ cm^3}$

= 0.032 mol (02+01)

Amount of CH_3COOH in the butanol layer

= 0.040 mol - 0.032 mol

= 0.008 mol (02+01)

Amount of CH_3COOH in 10.00cm^3 of the butanol lay

$= 0.008\ mol \times \frac{10.00\ cm^3}{20.00\ cm^3}$

= 0.004 mol (02+01)

Expected end point (x) $= \frac{0.004\ mol}{0.50\ mol\ dm^{-3}}$

$= 0.008\ dm^3$ OR $8.0\ cm^3$ (02+01)

5 b (i) = 18 marks

(ii) Amount of CH_3COOH in 10.00 cm^3 of the aqueous layer = 0.008 mol

Amount of CH_3COOH in 10.00cm^3 of the butanol layer = 0.004 mol

Partition coefficient $= \frac{[CH_3COOH]_{but}}{[CH_3COOH]_{H_2O}}$ (03)

$= \frac{0.004\ mol / (10.00/1000\ cm^3)}{0.008\ mol / (10.00/1000\ cm^3)}$

= 0.5 (02+01)

Alternative answer for 5 b(ii)

Butanol layer required half volume of NaOH solution required for the aqueous layer (03)

Therefore, Partition coefficient $= \frac{[CH_3COOH]_{but}}{[CH_3COOH]_{H_2O}}$

= 0.5 (02+01)

5 b (ii) (06)

(iii) Before partitioning.

Amount of CH_3COOH = 1.0 mol dm^{-3} x $\frac{30.00}{1000}$ dm^3

= 0.030 mol

Volume of NaOH required for the total volumes of both phases (03)

$= \frac{0.030 \text{ mol}}{0.50 \text{ mol dm}^{-3}}$

= 60.0 cm^3 (02+01)

$4y + 2z = 60.0$ ① (03)

$\frac{z}{y} = \frac{1}{2}$ ② (03)

By solving ① and ②,

y = 12.00 cm^3 (02+01)

z = 6.00 cm^3 (02+01)

Alternative answer for 5b(iii)

Initial concentration of acetic acid in bottle 1 = 1.0 mol dm^{-3}.

Initial concentration of acetic acid in bottle 2 = 3/4 x 1.0 mol dm^{-3} (05+01)

Therefore, y = 3/4 x 16.00 cm^3 (03)

= 12.00 cm^3 (02+01)

z = 3/4 x 8.00 cm^3 (03)

= 6.00 cm^3 (02+01)

5 (b) (iii) 18 marks

(iv) 1. Butanol and aqueous layers do not mix with each other

2. Butanol does not vaporize OR the volume of the butanol layer does not change.

3. Extent of ionization of CH_3COOH is negligible

4. Acetic acid does not undergo dimerization in the butanol layer OR acetic acid remains in the same molecular form.

Any two correct assumptions 03 x2 = (06)

(v) Phenolphthlein or Bromothymol Blue (03)

(vi) yes (02)

During partitioning, CH_3COOH molecules are transferred to the butanol layer. (03)

$[CH_3COOH]_{aq}$ decreases (03)

$[H_3O^+]_{aq}$ decreases (03)

thus, pH increases (03)

5 b (vi) 14 marks

6. (a) (i) $CH_3COOH_{(aq)} + H_2O(\ell) \rightleftharpoons H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$ (03)

Initially, C ---- ------- mol dm^{-3}

At eqm.. C - x x x mol dm^{-3} (02+01)

$K_a = \frac{[H_3O^+(aq)]\,[CH_3COO^-(aq)]}{[CH_3COOH(aq)]}$ (03)

$= \frac{x^2}{C-x}$ mol dm^{-3} (03)

$C - x \approx C$

$Ka = \frac{x^2}{C}$ (03)

$x^2 = K_aC$ (03)

$x = [H_3O^+(aq)] = \sqrt{K_aC}$

$pH = -\log \sqrt{K_aC}$

OR

$pH = -\frac{1}{2}\log K_a - \frac{1}{2}\log C$ (03)

6 (a) (i) 21 marks

(ii) Assumption : x is negligible compared to C

OR C - x ≈ C OR Amount ionized is negligible. (03)

(iii) Concentration of the diluted solution

= C mol dm^{-3} x $\frac{100\ cm^3}{1000\ cm^3}$

$= \frac{C}{10}$ mol dm^{-3} (02+01)

$pH = -\log \sqrt{(K_aC/10)}$ OR

$pH = -\frac{1}{2}\log K_a - \frac{1}{2}\log \frac{C}{10}$ (06)

Total for 6 a (iii) 09 marks

(iv) pH of the diluted solution - pH of the initial solution

$= -\log \sqrt{K_aC/10} - [-\log \sqrt{K_aC}]$ (03)

$= -\frac{1}{2}\log K_a - \frac{1}{2}\log \frac{C}{10} - \left[-\frac{1}{2}\log K_a - \frac{1}{2}\log C\right]$ (03)

$= -\frac{1}{2}\log K_a - \frac{1}{2}\log \frac{C}{10} + \frac{1}{2}\log K_a + \frac{1}{2}\log C$

$= \frac{1}{2}\log C - \frac{1}{2}\log \frac{C}{10}$ (03)

$= \frac{1}{2}\log \frac{C}{C/10}$ (03)

$= \frac{1}{2}\log 10$ (03)

= 0.5 (03)

6 (a) (iv) 18 marks

(v) $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(\ell)$ (03)

Total volume of solution = 240.0 cm^3

Concentration of the salt formed

$= \frac{20.0 cm^3}{240.0\ cm^3}$ x C mol dm^{-3} (02+01)

Concentration of the remaining acid

$= \frac{200.0 cm^3}{240.0\ cm^3}$ x C mol dm^{-3} (02+01)

$pH = pK_a + \log \frac{[salt]}{[acid]}$ (06)

$= pK_a + \log \frac{\left[\frac{20.0\ cm^3}{240.0\ cm^3} \times C \text{ mol dm}^{-3}\right]}{\left[\frac{200.0\ cm^3}{240.0\ cm^3} \times C \text{ mol dm}^{-3}\right]}$ (03)

$= pK_a + \log (1/10)$ (03)

$= pK_a - 1$ (03)

6 (a) (v) 24 marks

(b) (i) Let S (mol dm^{-3}) = concentration of Ba^{2+} in a saturated solution of $BaSO_4$

$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$ (03)

At eqm --------- S S (03)

$K_{SP} = [Ba^{2+}(aq)]\,[SO_4^{2-}(aq)]$ (03)

$= S^2$

$S^2 = 1.0 \times 10^{-10}$ mol^2 dm^{-6} (02+01)

$S = 1.0 \times 10^{-5}$ mol dm^{-3}

Concentration of $Ba^{2+} = 1.0 \times 10^{-5}$ mol dm^{-3} (02+01)

6 (b) (i) = 15 marks

(ii) $BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$ (03)

At eqm --------- 5.0×10^{-6} mol dm^{-3} x (03)

where x = concentration of $SO_4^{2-}(aq)$ in solution at precipitation.

$K_{SP} = [Ba^{2+}(aq)]\ [SO_4^{2-}(aq)]$ (03)

$= (5.0 \times 10^{-6}$ mol dm$^{-3}) \times$

$= 1.0 \times 10^{-10}$ mol^2 dm^{-6} (02+01)

$x = 2.0 \times 10^{-5}$ mol dm^{-3} (02+01)

concentration of $SO_4^{2-}(aq)$ from Na_2SO_4

$= 2.0 \times 10^{-5}$ mol dm^{-3} - 5.0×10^{-6} mol dm^{-3} (03)

$= 1.5 \times 10^{-5}$ mol dm^{-3} (02+01)

Alternative answer for 6 b (ii)

$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$

At eqm ——— 5.0×10^{-6} mol dm^{-3} 5.0×10^{-6} mol dm^{-3} + y (06)

where y = concentration of $SO_4^{2-}(aq)$(mol dm^{-3}) due to Na_2SO_4 at precipitation

$K_{SP} = [Ba^{2-}(aq)]\ [SO_4^{2-}(aq)]$

$(5 \times 10^{-6}$ mol dm$^{-3})\ (y + 5.0 \times 10^{-6}$ mol dm$^{-3}) = 1.0 \times 10^{-10}$ mol^2 dm^{-6}) (02+01)

$y + 5.0 \times 10^{-6}$ mol dm$^{-3} = 2.0 \times 10^{-5}$ moldm^{-3} (02+01)

$y = 1.5 \times 10^{-5}$ mol dm^{-3} (02+01)

Amount of Na_2SO_4 to be added = 1.5×10^{-5} mol dm$^{-3} \times 1$ dm^3

OR

$= 1.5 \times 10^{-5}$ mol (02+01)

Mass of Na_2SO_4 to be added = 1.5×10^{-5} mol $\times$ 142 g mol^{-1} (02+01)

$= 2.13 \times 10^{-3}$ g OR 2.13 mg (02+01)

Assumption : Volume of the solution is not changed during the addition of Na_2SO_4 (03)

6 (b) (ii) = 27 marks

(iii) Let S = Solubility of $BaSO_4$ (mol dm^{-3})

and S' = Solubility of $PbSO_4$ (mol dm^{-3})

$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$

At eqm. ------ S S + S' (06)

$PbSO_4(s) \rightleftharpoons Pb^{2+}(aq) + SO_4^{2-}(aq)$ (03)

At eqm. ------ S' S + S' (03)

$K_{SP}(BaSO_4) = [Ba^{2+}(aq)] + [SO_4^{2-}(aq)]$

$S(S + S') = 1.0 \times 10^{-10}$ mol^2 dm^{-6} ① (02+01)

$K_{SP}(PbSO_4) = [Pb^{2+}(aq)] + [SO_4^{2-}(aq)]$ (03)

$S'(S + S') = 1.6 \times 10^{-8}$ mol^2 dm^{-6} ② (02+01)

$\frac{②}{①} = \frac{S'}{S} = \frac{1.6 \times 10^{-8}}{1.0 \times 10^{-10}} = 160$ (03)

①, $S(S + 160\ S) = 1.0 \times 10^{-10}$ (03)

$S = 7.9 \times 10^{-7}$ (03)

It can be assumed that $160 + 1 \approx 160$

Concentration of $Ba^{2+} = 7.9 \times 10^{-7}$ mol dm^{-3} (02+01)

Concentration of $Pb^{2+} = 160 \times 7.9 \times 10^{-7}$ mol dm^{-3}

$= 1.3 \times 10^{-4}$ mol dm^{-3} (02+01)

Alternative answer for 6 b (iii)

$BaSO_4(s) \rightleftharpoons Ba^{2+}(aq) + SO_4^{2-}(aq)$ (03)

$K_{SP}(BaSO_4) = [Ba^{2+}(aq)] + [SO_4^{2-}(aq)]$

$= 1.0 \times 10^{-10}$ mol^2 dm^{-6} ①

$K_{SP}(PbSO_4) = [Pb^{2+}(aq)] + [SO_4^{2-}(aq)]$

$= 1.6 \times 10^{-8}$ mol^2 dm^{-6} ② (02+01)

$\frac{②}{①} = \frac{[Pb^{2+}]}{[Ba^{2+}]} = \frac{1.6 \times 10^{-8}}{1.0 \times 10^{-10}} = 160$ (03)

$[Ba^{2+}(aq)] + [Pb^{2+}(aq)] = [SO_4^{2-}(aq)]$ ③ (09)

$1 + \frac{[Pb^{2+}]}{[Ba^{2+}]} = \frac{[SO_4^{2-}]}{[Ba^{2+}]}$ (03)

$1 + 160 = \frac{[SO_4^{2-}]}{[Ba^{2+}]}$

$1 + 160 = \frac{[Ba^{2+}]\ [SO_4^{2-}]}{[Ba^{2+}]^2}$ (03)

$161 = \frac{1 \times 10^{-10}\ \text{mol}^2\ \text{dm}^{-6}}{[Ba^{2+}]^2}$ (02 + 01)

$[Ba^{2+}] = 7.9 \times 10^{-7}$ mol dm^{-3} (02+01)

It can be assumed that $160 + 1 \approx 160$

Concentration of $Ba^{2+} = 7.9 \times 10^{-7}$ mol dm^{-3}

Concentration of $Pb^{2+} = 160 \times 7.9 \times 10^{-7}$ mol dm^{-3}

$= 1.3 \times 10^{-4}$ mol dm^{-3} (02+01)

6 (b) (iii) = 33 marks

7. (a) As soon as the Grignard reagent $HOCH_2CH_2CH_2MgBr$ is formed in the reaction vessel, it will react with another molecule of $HOCH_2CH_2CH_2Br$ (10) to form $HOCH_2CH_2CH_3$ (05)

OR

$HOCH_2CH_2CH_2Br \xrightarrow{Mg/\text{dry ether}} HOCH_2CH_2CH_2MgBr$ (05)

(05) $HOCH_2CH_2CH_2Br$

(05)

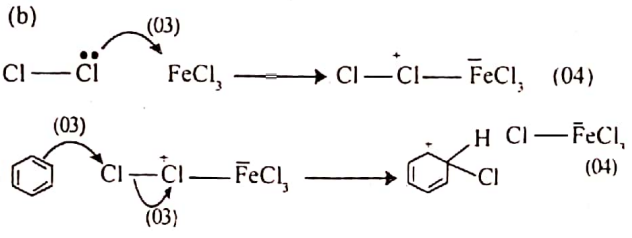
$HOCH_2CH_2CH_3 + MgBr - OCH_2CH_2CH_2Br$

Therefore Grignard reagent formed is decomposed in the presence of alchohols. (05)

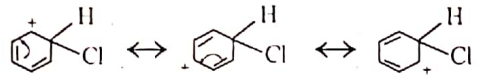
(Alternative statements indicating that RMgBr will decompose in the presence of active H compounds are acceptable)

7 a = 20 marks

(b)



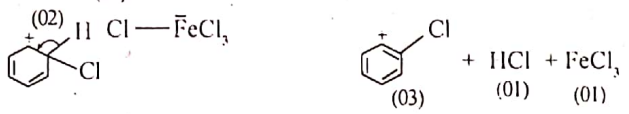
The intermediate ion is stabilized by resonance



(03)

Loss of a proton from the intermediate ion restores the stable aromatic sextet.

(03)



(02) (03) (01) (01)

7 (b) = 30 marks

(c) $(CH_3)_2C=CH_2 \xrightarrow[(04)]{dil.H_2SO_4} (CH_3)_3C-OH \xrightarrow[(04)]{PCl_5} (CH_3)C-Cl$ (04)

$\xrightarrow[(04)]{Mg/Ether} (CH_3)_3C-MgCl \xrightarrow[(04)]{HCHO} (CH_3)_3C-CH_2OMgCl \xrightarrow[(04)]{dil.\ H_2SO_4} (CH_3)_3C-CH_2OH$ (04)

$\xrightarrow[dil.H_2SO_4]{K_2Cr_2O_7/} (CH_3)_3C-COOH$ (04) (04)

$(CH_3)_3C-COOH + (CH_3)_3C-OH \xrightarrow[(02)]{Conc.\ H_2SO_4} (CH_3)_3C-C(=O)-O-C(CH_3)_3$

7 (c) = 04 x 12 + 02 x 1 = 50 marks

(d)

$CH_3CH_2CHO \xrightarrow[OR\ H^+/K_2Cr_2O_7\ OR\ H^+/KMnO_4]{CrO_3/H^+\ (06)} CH_3CH_2COOH$ (06)

$CH_3CH_2COOH \xrightarrow{PCl_5\ (06)\ [OR\ PCl_3,\ POCl_3,\ SOCl_2]} CH_3CH_2COCl$ (06)

$CH_3CH_2COCl \xrightarrow{NH_3\ (06)} CH_3CH_2CONH_2$ (06)

$CH_3CH_2CONH_2 \xrightarrow[2)\ H_2O\ or\ H^+\ (02)]{1)\ LiAlH_4\ (04)} CH_3CH_2CH_2NH_2$ (06)

$CH_3CH_2COCl + CH_3CH_2CH_2NH_2 \xrightarrow{(02)} CH_3CH_2-C(=O)-NH\ CH_2CH_2CH_3$

7 (d) = 06 x 8 + 02 x 1 = 50 marks

Alternate method :

$CH_3CH_2CHO \xrightarrow[OR\ H^+/K_2Cr_2O_7\ OR\ H^+/KMnO_4]{CrO_3/H^+\ (06)} CH_3CH_2COOH$ (06)

$CH_3CH_2CHO \xrightarrow[2)\ H_2O\ or\ H^+\ (01)]{1)\ NaBH_4\ (or\ LiAlH_4)\ (03)} CH_3CH_2CH_2OH$ (04)

$CH_3CH_2COOH \xrightarrow{PCl_5\ (06)\ (OR\ PCl_3,\ POCl_3,\ SOCl_2)} CH_3CH_2COCl$ (06)

$CH_3CH_2CH_2OH \xrightarrow[(03)]{PCl_5\ (OR\ PCl_3,\ POCl_3,\ SOCl_2)} CH_3CH_2CH_2Cl$ (04)

$CH_3CH_2CH_2Cl \xrightarrow[(03)]{excess\ NH_3} CH_3CH_2CH_2NH_2$ (06)

$CH_3CH_2COCl + CH_3CH_2CH_2NH_2 \xrightarrow{(02)} CH_3CH_2-C(=O)-NH\ CH_2CH_2CH_3$

8. (a) (i)

Test	Inference	
1	absence of $CaCO_3$	(03)
2	presence of NaOH	(03)
3	presence of $Zn(NO_3)_2$	(03)

Therefore, the two compounds present in the mixture are NaOH and $Zn(NO_3)_2$ (08+08)

8 (a) (i) = 25 marks

(ii) A = FeS, B = $FeSO_4$, C = H_2S
D = HNO_3/ H_2SO_4, E = S, F = $NiSO_4$
G = Nis, H = $Ni(OH)_2$, I = $[Ni(NH_3)_6]^{2+}$

05 x 9

8 (a) (ii) = 45 marks

(b) (i) (5-n) $(MnO_4^- + 8H^+ + 5e \rightarrow Mn^{2+} + 4H_2O)$ (04)

5 $(M^{n+} + 2H_2O \rightarrow MO_2^+ + 4H^+ + (5-n)e)$ (04)

(5-n) $MnO_4^- \equiv 5M^{n+}$ .....(relationship 1) (04)

Moles of $KMnO_4 = \frac{0.100}{1000} \times 30.0$ (04)

Therefore, Moles of $MnO_4^- = \frac{0.100}{1000} \times 30.0$

Moles of $M^{n+} = 5.00 \times 10^{-3}$

From (relationship 1) : $\frac{0.100}{1000} \times 30.0 \times \frac{5}{5-n}$

$= 5.00 \times 10^{-3}$ (04)

$3 = 5 - n$

$n = 2$ (05)

8 (b) (i) = 25 marks

(ii) 1. Procedure I

$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$ ① (03)

$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$ ② (03)

Procedure II

$Cr_2O_7^{2-} + 14H^+ + 6e \rightarrow 2Cr^{3+} + 7H_2O$

$3(2I^- \rightarrow I_2 + 2e)$

$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 3I_2 + 2Cr^{3+} + 7H_2O$ ③ (06)

$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$ ④

2. Method I

Considering Procedure II

Combining ③ +(3 x ④)

$Cr_2O_7^{2-} \equiv 6S_2O_3^{2-}$ (03)

Molar mass of $K_2Cr_2O_7$ = 294 g mol^{-1} (02)

Concentration of $K_2Cr_2O_7$ solution

$= \frac{1.18}{294} \times \frac{1000}{500.0}$

$= 0.0080$ mol dm^{-3} (03)

Moles of $K_2Cr_2O_7$ in 25.0 cm^3

$= \frac{0.0080}{1000} \times 25.0$ (03)

(03)

Therefore, Moles of $[S_2O_3^{2-}] = \frac{0.0080}{1000} \times 25.0 \times 6$

$[S_2O_3^{2-}] = \frac{0.0080}{1000} \times 25.0 \times 6 \times \frac{100}{24}$

Concentration of $Na_2S_2O_3$ solution = 0.050 mol dm^{-3}

(02+01)

Considering Procedure I

No. of moles of $S_2O_3^{2-}$ = $\frac{0.050}{1000}$ x 30.0 (03)

Combining ① + ②

$2Cu^{2+} \equiv 2S_2O_3^{2-}$

Hence $Cu^{2+} \equiv S_2O_3^{2-}$ (03)

Therefore, Moles of Cu^{2+} present in 25.0 cm^3

= $\frac{0.050}{1000}$ x 30.0 (03)

Moles of Cu^{2+} in 500.0 cm^3 = $\frac{0.050}{1000}$ x 30.0 x $\frac{500.0}{25.0}$ (03)

Therefore, weight of Cu^{2+}

= $\frac{0.050}{1000}$ x 30.0 x $\frac{500.0}{25.0}$ x 63.5

= 1.90 g (03)

% Cu in Alloy Z = $\frac{1.90}{2.80}$ x 100

= 67.9% Ω 68% (05)

Method 2

If the concentration of $S_2O_3^{2-}$ is M mol dm^{-3} (02)

Moles of I_2 evolved on reaction with $Cr_2O_7^{2-}$ = $\frac{M}{1000}$ x 24.0 x $\frac{1}{2}$ (03)

Moles of $Cr_2O_7^{2-}$ required = $\frac{M}{1000}$ x 24.0 x $\frac{1}{2}$ x $\frac{1}{3}$ (03)

Moles of $Cr_2O_7^{2-}$ in 500.0 cm^3 = $\frac{M}{1000}$ x 24.0 x $\frac{1}{2}$ x $\frac{1}{3}$ x $\frac{500.0}{25.0}$

= $\frac{1.18}{294}$ (06)

M = 0.050 mol dm^{-3} (02+01)

Moles of I_2 evolved on reaction with Cu^{2+}

= $\frac{0.050}{1000}$ x $\frac{30.0}{2}$ (05)

Moles of Cu^{2+} in 500.0 cm^3 = $\frac{0.050}{1000}$ x $\frac{30.0}{2}$ x 2 x $\frac{500.0}{25.0}$ (05)

Weight of Cu^{2+} in 500.0 cm^3

= $\frac{0.050}{1000}$ x $\frac{30.0}{2}$ x 2 x $\frac{500.0}{25.0}$ x 63.5 (05)

= 1.90 g

% Cu in alloy Z = $\frac{1.90}{2.80}$ x 100

= 67.9% Ω 68% (05)

3. End points

Procedure I blue ----→ colourless (03)

Procedure II blue ——→ (pale) green (03)

8 (b) (ii) = 55 marks

9. (a) (i) I NaCl (04)

II $CaCl_2$ (04)

III ~ 600°C (04)

IV anode - graphite (04)
cathode - steel (04)

V anode: $2Cl^-(l) \rightarrow Cl_2(g) + 2e$ (04)

cathode: $Na^+(l) + e \rightarrow Na(s)$ OR $Na(l)$ (04)

VI to prevent the reaction of Na with Cl_2 (04)

VII. to prevent Na from reacting with O_2 and moisture (02+ 02)

VIII. incorrect (04)

IX Liquid (04)

X. Na

- In sodium vapour lamps
- To dry solvents such as ether and benzene
- In organic synthesis
- In preparation of $NaNH_2$
- As a cooling fuel in nuclear reactors

(Any two of the above, 04 x 2)

Cl_2

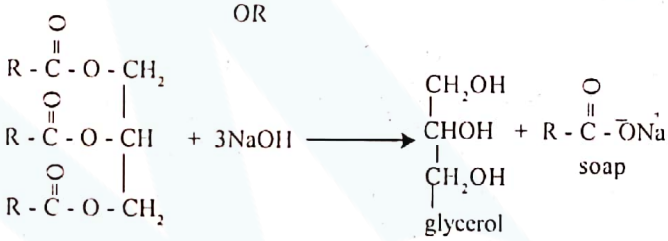
- In the preparation of HCl
- In the preparation of bleach
- In the preparation of PVC
- As a disinfectant
- To produce insecticides, drugs and dyes

(Any one of the above) (03)

9 (a) (ii) = 20 marks

(ii) 1. Saponification - involves the boiling of animal fat or vegetable oil with NaOH gives glycerol and soap.

OR



(08)

(R = long chain alkyl group)

2. Removal of glycerol (04)

3. Purification - remaining NaOH is netralized by weak acid and 2/3 removal of water to get soap. (02+02)

4 Finishing - mixing additives and shaping into bars. (02+02)

9 (a)(ii) = (20)

9 (a) = 75 marks

(b) (i) I. A, D, G

II. C, H, K

III. E, J, M

IV. C, L, N

V. B, F, I (02 x 15)

9 (b) (i) = 30 marks

(ii) Scrub the acidic gases using a base (oxides, carbonates or hydroxides of Ca and Mg or dolomite) (03)

$SO_2(g) + CaO(s) \rightarrow CaSO_3(s)$

OR $SO_2(g) + Ca(OH)_2(aq) \rightarrow CaSO_3(s) + H_2O(l)$

OR $SO_2(g) + CaCO_3(aq) \rightarrow CaSO_3(s) + CO_2(g)$ (02)

9 (b) (ii) = 05 marks

(iii) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ (02)

$2NO_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$ (02)

OR

$2NO(g) + O_2(g) + H_2O(l) \rightarrow HNO_2(aq) + HNO_3(aq)$ (04)

OR

$4NO(g) + 3O_2(g) + 2H_2O(l) \rightarrow 4HNO_3(aq)$ (04)

and

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

$SO_3\ (g) + H_2O\ (l) \rightarrow H_2SO_4\ (aq)$ (02)

OR

$2\ SO_2\ (g) + O_2\ (g) + 2H_2O(l) \rightarrow 2H_2SO_4\ (aq)$ (04)

9 (b) (iii) = 08 marks

(iv) I Global warming : $CH_3(CH_2)_4CH_3$, $CFCl_3$, CF_2Cl_2, NO

II. Ozone layer depletion : $CFCl_3$, CF_2Cl_2, NO (02 x 7)

9 (b) (iv) = 14 marks

(v) I Natural formation of ozone.

$O_2\ (g) \xrightarrow{h\nu} 2\ O\ (g)$ (02)

$O\ (g) + O_2(g) + M \longrightarrow O_3\ (g) + M$

(M is the third body to absorb excess energy)

OR

$O\ (g) + O_2(g) \xrightarrow{h\nu} O_3\ (g) + \text{energy}$ (02)

Natural destruction of ozone

$O_3\ (g) \xrightarrow{h\nu} O\ (g) + O_2\ (g)$ (02)

$O\ (g) + O_3\ (g) \longrightarrow 2O_2\ (g)$ (02)

II Formation of radicals

$CCl_3F \xrightarrow{h\nu} {}^{\bullet}Cl + {}^{\bullet}CCl_2F$ (02)

III. Catalytic destruction of ozone

${}^{\bullet}Cl + O_3 \longrightarrow {}^{\bullet}OCl + O_2$ (02)

$O_2 \longrightarrow 2O$ (02)

${}^{\bullet}OCl + O \longrightarrow {}^{\bullet}Cl + O_2$ (02)

$2\ O_3 \longrightarrow 3O_2$ (net) (02)

${}^{\bullet}Cl$ serves as a catalyst

9 (b) (v) = 18 marks

10. (a)
- Fluorine exhibits only the oxidation states - 1 and O. whereas. others exhibit positive oxidation states as well (+1, +3. +5. +7)
- F_2 has a higher oxidizing power than other halogens
- F_2 forms compounds with nobel gases kr and xe. where as others do not.
- Boiling point of HF is completely out of line with the other hydrogen halides (Hcl, HBr and HI)
- Electronegativity of F is significantly higher than that of the other halogens.
- Fluorine is restricted to covalency of one since easily accessible low energy d-orbitals are not available. where as others show covalencies of 1. 3 and 5 due to participation of d-orbitals.
- F has an ionization energy much higher than that of the other halogens.
- HF is a weak acid in water where as others are strong acids
- F forms stronger bonds with other non-metals than other halongens.
- F_2 oxidizes water where as the others do not
- AgF and PbF_2 are soluble in water where as other halides of Ag and Pb are insoluble.

Any four (06 x 4)

All four answers correct (01)

10 (a) = 25 marks

10. (b) (i)

Step 1 $Na_2SO_3 + 2\ HCl \longrightarrow 2NaCl + SO_2 + H_2O$ (06)

Step 2 $SO_2 + 2H_2O + I_2 \rightarrow 4H^+ + SO_4^{2-} + 2I^-$ (06)

Step 3 $I_2 + 2\ S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$ (06)

10 (b) (i) = 18 marks

(ii) Moles of $S_2O_3^{2-} = \frac{0.100}{1000} \times 26.0$ (03)

Moles of I_2 reacted with $S_2O_3^{2-} = \left[\frac{0.100}{1000} \times 26.0\right] \Big/ 2$ (03)

Moles of I_2 added $= \frac{0.050}{1000} \times 40.0$ (03)

Moles of I_2 reacted with $S_2O_3^{2-}$

$= \frac{0.50}{1000} \times 40.0 - \frac{0.100}{1000} \times \frac{26.0}{2}$ (03)

$= \frac{1}{1000}\left[0.050 \times 40.0 - 0.100 \times \frac{26.0}{2}\right]$

$= 7.0 \times 10^{-4}$ (03)

Therefore, Moles of $SO_2 = 7.0 \times 10^{-4}$

Therefore, Moles of $Na_2S_2O_3$ present in 1 kg of meat

$= 7.0 \times 10^{-4}$ (03)

10 (b) (ii) = 18 marks

(iii) Molar mass of $Na_2SO_3 = 126\ g\ mol^{-1}$ (02+01)

Mass of Na_2SO_3 in 1 kg of meat = $7.0 \times 10^{-4} \times 126$ g

= 0.088 g (02+01)

Amount of Na_2SO_3 in 10^6 g of meat $= \frac{0.088}{1000} \times 10^6$

= 88 (ppm) (03)

10 (b) (iii) = 09 marks

(iv) Colour change : blue to colourless

10 (b) (iv) = 05 marks

10 (c) (i) I. Rate of production of I_2 (aq)

$= \frac{2.8 \times 10^{-5}\ mol}{1.0\ dm^3} \times \frac{1}{55}$ (02+01)

$= 5.6 \times 10^{-6}\ mol\ dm^{-3}\ s^{-1}$ (02+01)

II. Rate of consumption of I^- (aq)

$= 2 \times 5.6 \times 10^{-6}\ mol\ dm^{-3}\ s^{-1}$ (02+01)

$= 1.12 \times 10^{-5}\ mol\ dm^{-3}\ s^{-1}$ (02+01)

III. Rate of consumption of $S_2O_x^{2-}$ (aq)

$= 5.6 \times 10^{-6}\ mol\ dm^{-3}\ s^{-1}$ (02+01

10 (c) (i) = 15 mark

(ii)

	Conc. of I^- (aq) (mol dm^{-3})	Conc. of $S_2O_x^{2-}$ (aq) (mol dm^{-3})
Expt 1	0.080	0.020
Expt 2	0.160	0.020

Rate α $[I^-]^x\ [S_2O_x^{2-}]^y$ (04)

Expt. 1, $5.6 \times 10^{-6}\ mol\ dm^{-3}\ s^{-1} \alpha\ (0.080\ mol\ dm^{-3})^x\ (0.020\ mol\ dm^{-3})^y$

- - - - (1) (03+01)

Expt 2. $1.12 \times 10^{-5} mol\ dm^{-3}\ s^{-1} \alpha\ (0.160\ mol\ dm^{-3})^x\ (0.020\ mol\ dm^{-3})^y$

- (2) (03+01)

②/① $2 = 2^{\alpha}$

$\alpha = 1$ OR order with respect to $I^- = 1$ (04)

10 (c) (ii) = 16 marks

(iii) I. Rate α $[I^-]$ $[S_2O_8^{2-}]$ (04)

II. After dilution, $[I^-]$ = 0.080 mol dm^{-3}

$[S_2O_8^{2-}]$ = 0.010 mol dm^{-3}

For both concentrations (03+01)

Rate α $[I^-]$ = [0.080 mol dm^{-3}] [0.010 mol dm^{-3}] .... ③ (03+01)

$$\frac{③}{②} \quad \frac{\text{Rate}}{1.12 \times 10^{-5} \text{ mol dm}^{-3}\text{s}^{-1}} = \frac{(0.080 \text{ mol dm}^{-3})(0.010 \text{ mol dm}^{-3})}{(0.160 \text{ mol dm}^{-3})(0.020 \text{ mol dm}^{-3})}$$

(03+01)

$$\text{Rate} = \frac{1.12 \times 10^{-5} \text{ mol dm}^{-3}\text{s}^{-1}}{4}$$

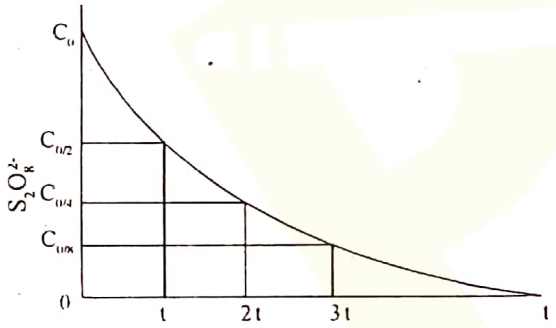
$$= 2.8 \times 10^{-6} \text{ mol dm}^{-3}\text{s}^{-1} \quad (03+01)$$

10 (c) (iii) = 20 marks

(iv) Half - Life : The time taken to decrease the concentration of the reactant to half of the initial value. (06)

The reaction appears to be first order when the concentration of I^- is kept constant. (04) Graphical representation. (08)

[Correct X-axis (01) Correct y - axis (01), Initial point (02), correct shape (04)]



Explanation :

As shown in the graph, the time taken to decrease the concentration of $S_2O_8^{2-}$ from C_0 to $C_{0/2}$ is the same as the time taken to decrease the concentration from $C_{0/2}$ to $C_{0/4}$. (06)

10 (c) (iv) = 24 marks