

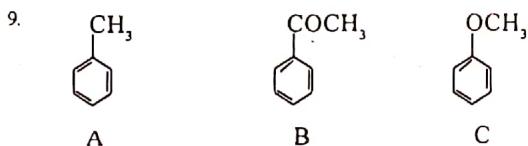
**G.C.E. (A/L) Examination**  
**2007 August**  
**Chemistry I / Two hours**

Important :

- \* This paper consists of 9 pages (Periodic Table is also provided)
- \* Answer all the questions.
- \* Use of calculators is not allowed.
- \* Write your Index Number in the space provided in the answer sheet.
- \* Instructions are given on the back of the answer sheet. Follow those carefully.
- \* In each of the questions 1 to 60, 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) on the number of the correct option 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  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

1. The highest positive oxidation state shown by a 3d transition element is  
 (1)+2      (2)+3      (3)+5      (4)+6      (5)+7
2. The oxide which is least stable to heat among the following is  
 (1) CaO    (2) Na<sub>2</sub>O    (3) CuO    (4) Ag<sub>2</sub>O    (5) ZnO
3. Which of the following is not a reducing agent?  
 (1) Cu<sup>+</sup>    (2) H<sup>+</sup>    (3) Fe<sup>2+</sup>    (4) Cl<sup>-</sup>    (5) S<sup>2-</sup>
4. The number of electrons and the number of neutrons present in  $^{12}_{12}\text{Mg}^{2+}$  ion are, respectively,  
 (1) 12 and 13                  (2) 11 and 13  
 (3) 10 and 13                  (4) 10 and 12  
 (5) 12 and 11
5. The concept of solubility product can be applied to saturated solutions of which of the following?  
 (1) Highly soluble weak electrolytes  
 (2) Sparingly soluble weak electrolytes  
 (3) Springly soluble strong electrolytes  
 (4) Highly soluble strong electrolytes  
 (5) Sparingly soluble non-electrolytes
6. Which one of the following statements is not true in relation to diluting a 0.1 mol dm<sup>-3</sup> H<sub>2</sub>SO<sub>4</sub> solution two-fold?  
 (1) The [H<sub>3</sub>O<sup>+</sup>] decreases                  (2) The [SO<sub>4</sub><sup>2-</sup>] decreases  
 (3) The [HSO<sub>4</sub><sup>-</sup>] decreases                  (4) The [OH<sup>-</sup>] decreases  
 (5) The density of the solution decreases
7. Which arrangement of the compounds given below, gives the correct increasing order of acid strength?  
 (1) Cc1ccccc1O < NO2Cc1ccccc1O < HCOOH < CH3COOH  
 (2) NO2Cc1ccccc1O < Cc1ccccc1O < CH3COOH < HCOOH  
 (3) HCOOH < Cc1ccccc1O < CH3COOH < NO2Cc1ccccc1O  
 (4) Cc1ccccc1O < NO2Cc1ccccc1O < CH3COOH < HCOOH  
 (5) CH3COOH < HCOOH < NO2Cc1ccccc1O < Cc1ccccc1O
8. A 0.744 g sample of a mixture of BaCl<sub>2</sub>·2H<sub>2</sub>O (Relative molar mass = 244) and KCl was heated to a cons. mass at 150°C. The mass of the product was 0.708 g. The mass of KCl in the sample is (H= 1.0, O= 16.0, K= 19.0, Cl= 35.5)  
 (1) 0.500g    (2) 0.425g    (3) 0.300g    (4) 0.250g    (5) 0.150g



The correct order of ease of nitration of the compounds A, B and C is

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

10. Which of the following would take place when is added to an aqueous solution of Na<sub>2</sub>CO<sub>3</sub>?  
 (a) is formed      (b) is formed

- (c) is formed      (d) CO<sub>2</sub> is evolved.  
 (1) (a) and (b)              (2) (b) and (c)              (3) (c) and (d)  
 (4) (a) and (d)              (5) (b) and (d)

11. The partition coefficient for the distribution of compound S between two immiscible liquids A and B is 49. S is more soluble in A than in B. 100cm<sup>3</sup> of B containing 1.0 x 10<sup>-4</sup> mol of S was shaken with 100 cm<sup>3</sup> of pure A. The percentage of S extracted into A from B is,  
 (1) 1%      (2) 2%      (3) 49%      (4) 98%      (5) 99%

12. The pH of a 0.01 mol dm<sup>-3</sup> solution of weak acid HA with K<sub>a</sub>=1.0 x 10<sup>-5</sup> mol dm<sup>-3</sup> is,  
 (1) 3.0      (2) 3.5      (3) 4.5      (4) 5.0      (5) 6.5

13. Salt X dissolves in conc. HCl forming a yellow-brown solution. When this solution is diluted and reacted with Zn, a light green solution is formed. The cation present in X is,  
 (1) Cu<sup>2+</sup>    (2) Ni<sup>2+</sup>    (3) Fe<sup>3+</sup>    (4) Cr<sup>3+</sup>    (5) Fe<sup>2+</sup>

14. Which of the following molecules has the lowest dipole moment?  
 (1) NO<sub>2</sub>    (2) O<sub>3</sub>    (3) CO<sub>2</sub>    (4) SO<sub>2</sub>    (5) ClO<sub>2</sub>

15. Which of the following compounds A, B, C and D evolve NH<sub>3</sub>(g) on heating?

- A. (NH<sub>4</sub>)<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>                  B. NH<sub>4</sub>Cl  
 C. (NH<sub>4</sub>)<sub>2</sub>CO<sub>3</sub>                  D. NH<sub>4</sub>NO<sub>3</sub>  
 (1) A and B                  (2) B and C                  (3) C and D  
 (4) A and D                  (5) B and D

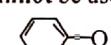
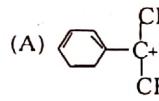
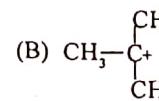
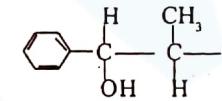
16. When H<sub>2</sub>S is passed into an aqueous solution of salt X, a yellow precipitate is formed. When an aqueous solution of X is treated with excess Na<sub>2</sub>CO<sub>3</sub>, filtered and H<sub>2</sub>S passed into the filtrate, a yellow precipitate is formed again. The cation/anion that is present definitely in the salt X is.

- (1) Sn<sup>2+</sup>    (2) Sb<sup>3+</sup>    (3) Cd<sup>2+</sup>    (4) CrO<sub>4</sub><sup>2-</sup>    (5) AsO<sub>3</sub><sup>3-</sup>

17. A. O=[N+]([O-])c1ccccc1N      B. c1ccccc1N  
 C. CH3CH2NH2      D. CH3Cc1ccccc1N

Which of the following correctly represents the increasing order of base strength of the compounds A, B, C and D given above?

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

18. Which one of the following cannot be used to distinguish between  and 
- $\text{Br}_2$  water
  - $\text{NaOH}$  solution
  - $\text{HNO}_2$  solution
  - Neutral  $\text{FeCl}_3$  solution
  - Moist blue litmus paper
19. The solubility products of three sparingly soluble salts  $\text{AB}$ ,  $\text{P}_2\text{Q}$  and  $\text{R}_2\text{S}_3$ , at a given temperature, are  $9.0 \times 10^{-44} \text{ mol}^2 \text{ dm}^{-6}$ ,  $1.08 \times 10^{-49} \text{ mol}^3 \text{ dm}^{-9}$  and  $1.08 \times 10^{-68} \text{ mol}^3 \text{ dm}^{-13}$ , respectively. The decreasing order of molar solubility of the three salts in water at that temperature is
- $\text{AB} > \text{P}_2\text{Q} > \text{R}_2\text{S}_3$
  - $\text{AB} > \text{R}_2\text{S}_3 > \text{P}_2\text{Q}$
  - $\text{P}_2\text{Q} > \text{R}_2\text{S}_3 > \text{AB}$
  - $\text{P}_2\text{Q} > \text{AB} > \text{R}_2\text{S}_3$
  - $\text{R}_2\text{S}_3 > \text{P}_2\text{Q} > \text{AB}$
20. (A)  (B) 
- (C)  $\text{CH}_2 = \text{CH}-\overset{+}{\text{CH}}-\text{CH}_2$  (D)  $\text{CH}_2 = \text{CH}-\overset{+}{\text{CH}}_2$   
(E)  $\text{CH}_2 = \text{CH}-\overset{+}{\text{CH}}-\text{CH}_3$
- The correct increasing order of stability of the carbonium ions (carbo-cations) A, B, C, D and E is,
- $\text{B} < \text{C} < \text{D} < \text{E} < \text{A}$
  - $\text{B} < \text{E} < \text{C} < \text{D} < \text{A}$
  - $\text{B} < \text{D} < \text{E} < \text{C} < \text{A}$
  - $\text{A} < \text{B} < \text{C} < \text{D} < \text{E}$
  - $\text{E} < \text{D} < \text{C} < \text{B} < \text{A}$
21. A, B and C are three cations. They react separately
- with  $\text{H}_2\text{S}$ , forming precipitates in aqueous solution.
  - with  $\text{NH}_4\text{OH}$  forming precipitates soluble in excess of are reagent.
- A, B, C are,
- $\text{Zn}^{2+}, \text{Cu}^{2+}, \text{Ba}^{2+}$
  - $\text{Zn}^{2+}, \text{Cu}^{2+}, \text{Ni}^{2+}$
  - $\text{Cu}^{2+}, \text{Al}^{3+}, \text{Ni}^{2+}$
  - $\text{Zn}^{2+}, \text{Ni}^{2+}, \text{Al}^{3+}$
  - $\text{Cr}^{3+}, \text{Ni}^{2+}, \text{Cu}^{2+}$
22. The arrangement of electron pairs around Sb atom in  $\text{SbF}_5^{2-}$  is,
- octahedral
  - square pyramidal
  - trigonal bipyramidal
  - square planar
  - pentagonal pyramidal
23. 1 mol of an organic compound X required 2 mol of  $\text{O}_2$  for complete combustion, and produced 2 mol of  $\text{CO}_2$  and 2 mol of  $\text{H}_2\text{O}$  as the only products  
The molecular formula of X is
- $\text{C}_2\text{H}_4$
  - $\text{C}_2\text{H}_6$
  - $\text{C}_2\text{H}_4\text{O}$
  - $\text{CH}_4\text{O}$
  - $\text{C}_2\text{H}_4\text{O}_2$
24. Which one of the following reactions would produce a product with an asymmetric carbon atom?
- $\text{CH}_3\text{CHO} \xrightarrow{\text{NaBH}_4, \text{H}_2\text{O}}$
  - $\text{CH}_3\text{CHO} \xrightarrow[\text{conc. HCl}]{\text{Zn(Hg)}}$
  - $\text{CH}_3\text{CHO} \xrightarrow{\text{AgNO}_3, \text{NH}_4\text{OH}}$
  - $\text{CH}_3\text{CHO} \xrightarrow{\text{HCN}}$
  - $\text{CH}_3\text{CHO} \xrightarrow[\text{H}_2\text{O}]{\text{CH}_3\text{MgBr}}$
25.  $25.0 \text{ cm}^3$  of a solution of  $0.100 \text{ mol dm}^{-3}$   $\text{BaCl}_2$  is mixed with  $50.0 \text{ cm}^3$  of a solution of  $0.050 \text{ mol dm}^{-3}$   $\text{Na}_2\text{CO}_3$  solution at  $25^\circ\text{C}$ . The  $\text{Ba}^{2+}$  ion concentration in the resulting solution is ( $K_{sp}$  of  $\text{BaCO}_3$  at  $25^\circ\text{C} = 8.1 \times 10^{-9} \text{ mol}^2 \text{ dm}^{-6}$ )
- $3.3 \times 10^{-2} \text{ mol dm}^{-3}$
  - $9.0 \times 10^{-3} \text{ mol dm}^{-3}$
  - $6.0 \times 10^{-4} \text{ mol dm}^{-3}$
  - $9.0 \times 10^{-5} \text{ mol dm}^{-3}$
  - $5.0 \times 10^{-2} \text{ mol dm}^{-3}$
26. Which one of the following statements is not true regarding ideal gases?
- There are no attractive or repulsive forces between molecules.
  - The average value of the kinetic energies of molecules depends only on temperature.
  - Molecules move randomly in straightlines at the same speed.
  - Size of gas molecules is negligibly small compared to the distance between them.
  - Molecular collisions are elastic.
27. A, B, C and D are metals
- Only A and C react with dil  $\text{HCl}$  forming  $\text{H}_2$
  - A, B and D are displaced when C is added to a solution containing ions of A, B and D.
  - B is displaced when D is added to a solution containing ions of B.
- The correct increasing order of reducing ability of these metals is,
- $\text{D} < \text{B} < \text{A} < \text{C}$
  - $\text{D} < \text{A} < \text{B} < \text{C}$
  - $\text{B} < \text{D} < \text{C} < \text{A}$
  - $\text{A} < \text{B} < \text{D} < \text{C}$
  - $\text{C} < \text{D} < \text{A} < \text{B}$
28. An iron plate with a mass of 40 g was dipped into  $250 \text{ cm}^3$  of a  $\text{CuSO}_4$  solution. After a certain time mass of the plate was 42 g. The mass of the deposited Cu is Fe = 56, Cu = 64)
- 42g
  - 16g
  - 14g
  - 8g
  - 2g
29. Which one of the following statements about the compound  is not true?
- It is soluble in dil.  $\text{HCl}$
  - It has four optical isomers.
  - It reacts with ethanoyl chloride to form an amide.
  - It reacts with hot alkaline  $\text{KMnO}_4$  to form benzoic acid.
  - It forms a diazoium salt with  $\text{HNO}_2$ .
30. Which one of the following is not used for dehydration reactions?
- $\text{H}_3\text{PO}_4$
  - $\text{H}_2\text{SO}_4$
  - $\text{Al}_2\text{O}_3$
  - $\text{P}_2\text{O}_5$
  - alcoholic KOH
31. Which one of the following compounds on heating will produce an oxide of nitrogen as one of the product?
- $(\text{NH}_4)_2\text{CO}_3$
  - $\text{NH}_4\text{NO}_2$
  - $\text{NH}_4\text{NO}_3$
  - $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$
  - $(\text{NH}_4)_2\text{SO}_4$
32. Consider the following
- liquid methane
  - a mixture of water and methanol
  - an aqueous solution of  $\text{LiCl}$
  - a solution of  $\text{I}_2$  in methanol
- The correct sequence that gives the increasing strength of intermolecular forces in the above is,
- $a < d < b < c$
  - $a < d < c < b$
  - $a < b < d < c$
  - $a < c < b < d$
  - $a < b < c < d$

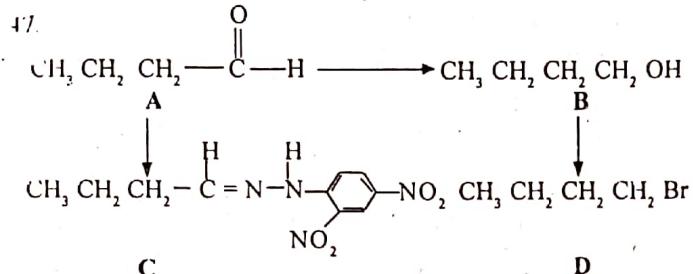
33. In which of the following do the two molecules have an unpaired electron each?  
 (1) SO<sub>2</sub> and NO                                 (2) NO and CO  
 (3) NO and NO<sub>2</sub>                                 (4) NO<sub>2</sub> and N<sub>2</sub>O  
 (5) SO<sub>2</sub> and NO<sub>2</sub>
- 34 The IUPAC name of K<sub>3</sub>[Fe(CN)<sub>5</sub>Br] is.  
 (1) Tripotassium pentacyanobromoferrate (III)  
 (2) Potassium pentacyanobromoferrate (III)  
 (3) Potassium pentacyanobromo ferrate II  
 (4) Potassium bromopentacyanoferate (III)  
 (5) Potassium bromopentacyanoferate III
- 35 Consider the reaction,  
 $A(g) + 3B(g) \rightleftharpoons 2C(g)$   
 An equimolar mixture of A(g) and B(g) is placed in a vessel at constant temperature. When 10% of A(g) reacts with B(g), the decrease in pressure is.  
 (1) 5%   (2) 8%   (3) 10%   (4) 12%   (5) 15%
36. Five energy factors and five processes are given below in pairs. In which pair, the given process does not correctly describe the relevant energy factor?
- | Energy factor                                                          | Process                                                                                    |
|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| (1) Standard enthalpy of combustion of CH <sub>3</sub> OH(l) at 298K   | 2CH <sub>3</sub> OH(l) + 3O <sub>2</sub> (g) → 2CO <sub>2</sub> (g) + 4H <sub>2</sub> O(g) |
| (2) Lattice energy of KCl(s)                                           | K <sup>+</sup> (g) + Cl <sup>-</sup> (g) → KCl(s)                                          |
| (3) Electron affinity of hydrogen                                      | H(g) + e → H <sup>-</sup> (g)                                                              |
| (4) Second ionization enthalpy of Mg                                   | Mg <sup>+</sup> (g) → Mg <sup>2+</sup> (g) + e                                             |
| (5) Standard enthalpy of formation of NH <sub>4</sub> <sup>+</sup> (g) | NH <sub>3</sub> (g) + H <sup>+</sup> (g) → NH <sub>4</sub> <sup>+</sup> (g)                |
37. The correct increasing order of the first ionization energy of the elements Na, Mg, K, N, P and F is  
 (1) K < Na < Mg < N < P < F                             (2) K < Na < Mg < P < N < F  
 (3) K < Na < P < Mg < N < F                             (4) Na < Mg < K < N < P < F  
 (5) Mg < K < Na < N < P < F
38. Which one of the following statements is not true?  
 (1) Radius of H<sup>+</sup> ion is larger than that of He atom.  
 (2) He has the highest 1<sup>st</sup> ionization energy of all elements.  
 (3) F does not show positive oxidation states.  
 (4) O<sub>2</sub>(g) + e → O<sup>2-</sup>(g) is an endothermic process.  
 (5) Na<sub>2</sub>(g) shows metallic properties.
- The following data/information applies to questions No. 39 and 40. Four monobasic acid solutions A, B, C and D are mixed together as indicated in the table given below to form solution R
- | Acid solution | Concentration/ mol dm <sup>-3</sup> | Volume mixed /cm <sup>3</sup> |
|---------------|-------------------------------------|-------------------------------|
| A             | 0.07                                | 500.0                         |
| B             | 0.06                                | 1000.0                        |
| C             | 0.12                                | 1000.0                        |
| D             | 0.05                                | 500.0                         |
- Two of the four acids are strong acids; the other two are weak acids with equal dissociation constants. A few drops of the two indicators, methyl orange and phenolphthalein, were added separately to two 30.0 cm<sup>3</sup> portions of solution R which when titrated with Z mol dm<sup>-3</sup> NaOH solution, gave end points at 10.0 cm<sup>3</sup> and 40.0 cm<sup>3</sup> respectively.
39. The two strong acid are,  
 (1) A and B                                             (2) B and C                                             (3) C and D  
 (4) B and D                                             (5) A and D
40. The value of Z is  
 (1) 0.02   (2) 0.04   (3) 0.06   (4) 0.08   (5) 0.10
- Instructions for questions No. 41 to 50 :  
 For each of the questions 41 to 50, four responses (a), (b), (c) and (d) are given; out of which, one or more 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/are correct.
- | Summary of above Instructions |                           |                           |                           |                                                          |
|-------------------------------|---------------------------|---------------------------|---------------------------|----------------------------------------------------------|
| (1)                           | (2)                       | (3)                       | (4)                       | (5)                                                      |
| Only (a) and (b) correct.     | Only (b) and (c) correct. | Only (c) and (d) correct. | Only (d) and (a) correct. | Any other number or combination of responses is correct. |
41. Which of the following will give a precipitate when added to a saturated aqueous solution of CsCl?  
 (a) Pb(NO<sub>3</sub>)<sub>2</sub> solution                                     (b) Ethanol  
 (c) Na<sub>2</sub>CO<sub>3</sub> solution                                             (d) KI solution
42. An aqueous solution of MgSO<sub>4</sub> has a concentration of 0.001 mol dm<sup>-3</sup>. Which of the following statements is/are true regarding this solution?  
 (a) The MgSO<sub>4</sub> concentration of this solution is 24.0 ppm.  
 (b) The SO<sub>4</sub><sup>2-</sup> concentration of this solution is 96.0 ppm.  
 (c) The MgSO<sub>4</sub> concentration of this solution is 120.0 ppm.  
 (d) The Mg<sup>2+</sup> concentration of this solution is 2.4 ppm.  
 (1 ppm = 1 mg dm<sup>-3</sup>; Mg = 24.0, S = 32.0, O = 16.0)
- 43
- 
- $\text{Cu}^2+(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s}) E^\ominus = +0.34\text{V}$   
 $\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s}) E^\ominus = +0.80\text{V}$
- Consider the above cell at 25°C. Which of the following statements is/are true when a current is drawn from the cell?  
 (a) The cell potential remains constant at 0.46 V.  
 (b) The cell cathode is Cu and the anode is Ag.  
 (c) Positive ions move to the cathode compartment and negative ions move to the anode compartment.  
 (d) Electrons move from Cu electrode to the Ag electrode, in the external circuit.
44. A solution X has been prepared by mixing 50.0 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> solution of NH<sub>4</sub>OH and 50.0 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> solution of NH<sub>4</sub>Cl. Which of the following statements is/are true about this solution X?  
 (a) It has a NH<sub>4</sub><sup>+</sup> concentration of 0.10 mol dm<sup>-3</sup>  
 (b) It has a OH<sup>-</sup> concentration of 0.10 mol dm<sup>-3</sup>  
 (c) Its pH is greater than 7?  
 (d) It has buffer properties

- 45 Which of the following can be used to distinguish between  $\text{AsO}_3^{3-}$  and  $\text{SO}_3^{2-}$ ?

(a)  $\text{H}_2\text{S}$  gas                                          (b) dil  $\text{H}_2\text{SO}_4$   
 (c) acidified  $\text{KMnO}_4$                                       (d) litmus paper

46. Which of the following statements is/are true?

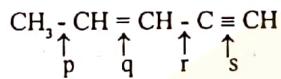
(a) Positive rays are formed when an electron is removed from an atom or molecule in a cathode ray tube.  
 (b) Cathode rays originate from the cathode.  
 (c) Positive rays originate from the anode.  
 (d) Cathode rays are a type of electromagnetic radiation.



Which of the following statements is/are true about the reaction scheme given above?

- (a) A reacts with 2,4 - dinitrophenylhydrazine to give C.  
 (b) Both  $\text{LiAlH}_4$  and  $\text{NaBH}_4$  can be used to convert A to B.  
 (c) Reaction of B with KBr gives D.  
 (d) C and D are water soluble.

18. Which of the following statements regarding the molecule

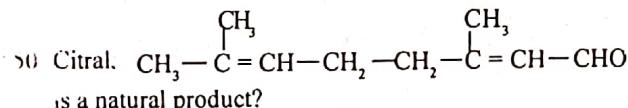


is/are true?

- (a) All carbon atoms of this molecule lie in the same plane.  
 (b) All C-H bonds of the molecule are equal in length.  
 (c) The carbon - carbon bond lengths increase in the order  $s < q < p < r$   
 (d) Three carbon atoms of this molecule are linearly arranged.

49. Which of the following statements is/are correct regarding the s and p block elements in the periodic table?

- (a) The acidic character of oxides in a given period increases from left to right/  
 (b) The covalent character of oxides in a given period increases from left to right.  
 (c) The basic character of oxides decreases down a group.  
 (d) The ionic character of oxides decrease down a group.



Which of the following statements about citral is/are true?

- (a) It shows optical activity.  
 (b) It reacts with ammoniacal silver nitrate to give a silver mirror.  
 (c) It shows geometric isomerism.  
 (d) It is completely miscible with water.

• Instructions for questions No. 51 to 60

In questions No. 51 to 60, 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 given for each of the questions 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
51. In steam distillation of an essential oil, the mixture always boils at a temperature below the boiling point of pure water.	The vapour pressure of the essential oil is proportional to its mole fraction in the mixture.
52. An aqueous solution of $\text{Ag}^+$ and an aqueous solution of $\text{Zn}^{2+}$ can be distinguished by using an $\text{NH}_4\text{OH}$ solution.	Both $\text{Ag}^+$ and $\text{Zn}^{2+}$ form precipitates with $\text{NH}_4\text{OH}$ which dissolve in excess of the reagent.
53. The solubility of a non-polar substance in a polar solvent is zero.	Intermolecular forces between a non-polar molecule and a polar molecule are weaker compared to dipole-dipole interactions.
54. The solubility of any sulphide decreases when the medium is acidified.	Sulphide ion concentration in aqueous medium decreases on acidification.
55. $\text{CsCl(s)}$ does not conduct electricity but an aqueous solution of $\text{CsCl}$ does.	$\text{Cs}$ and $\text{Cl}$ atoms in $\text{CsCl(s)}$ form $\text{Cs}^+$ and $\text{Cl}^-$ ions when dissolved in water.
56. Alkali metals react with water forming basic solutions.	Alkali metals replace hydrogen from water.
57. Calcium carbide evolves acetylene when reacted with water.	Calcium carbide contains the acetylidy ion. $(\text{C} \equiv \text{C})^2-$
58. A solution containing an $\alpha$ amino acid cannot function as a buffer solution.	In an $\alpha$ amino acid a -COOH group and an -NH <sub>2</sub> group are attached to the same carbon atom.
59. Each bond angle in the molecule. $\begin{array}{c} \text{H} \\   \\ \text{C} \\ / \quad \backslash \\ \text{Cl} \quad \text{Br} \\   \\ \text{I} \end{array}$ is equal to $109.6^\circ$	The carbon atom in this molecule is $\text{sp}^3$ hybridised.
60. Phenolphthalein is not used as an indicator for weak acid - strong base titrations as the observed end point is lower than the equivalence point.	Any indicator can be used in an acid - base titration as long as there is a rapid change of pH near the equivalence point.

**G.C.E. (A/L) Examination  
2007 August  
Chemistry II / Three hours**

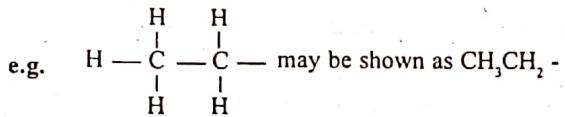
- Periodic Table is provided.
- Use of calculators is not allowed.

**PART A - Structured Essay (Pages 2-8)**

- Answer all the questions.
- Write your answer in the space provided for each question. Please note that the space provided is sufficient for the answer and that extensive answers are not expected.

**N.B. INSTRUCTION BOX**

In answering questions 3 and 4, you may represent alkyl groups in a condensed manner.



**PART B and PART C - Essay (pages 9-12)**

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.

Universal gas constant, R	=	8.314 JK <sup>-1</sup> mol <sup>-1</sup>
Avogadro constant N <sub>A</sub>	=	6.022 × 10 <sup>23</sup> mol <sup>-1</sup>

**PART A - STRUCTURED ESSAY**

Answer all four questions. Each question carries 10 marks.

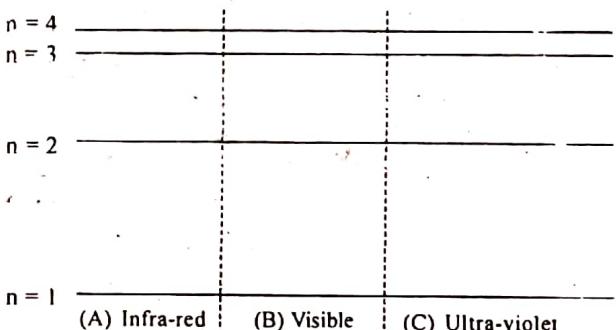
- i (a) (i) Write the complete electronic configuration of the element X with the atomic number 33.

.....  
(ii) What are the most common oxidation states of the element X?

.....  
(iii) Give the chemical formulae of the stable oxides of X.

(2 5 marks)

- (b) The first four electronic energy levels of the hydrogen atom are represented in the diagram given below.



Names of series .....

Indicate with arrows all electronic transitions that could occur between the above energy levels and which are responsible for emission lines in (A) the infra-red region (B) the visible region and (C) the ultra-violet region.

Write the names of the series to which each set of lines belongs, in the space provided in the diagram.

(2.7 marks)

- (c) Y and Z are two non-transition elements belonging to the same group of the periodic table. They form the compounds YZ<sub>2</sub> and YZ<sub>3</sub>.

- (i) identify the elements Y and Z

Y = ..... Z = .....

- (ii) Name the shapes of the molecules YZ<sub>2</sub> and YZ<sub>3</sub>. (Diagrams are not acceptable)

YZ<sub>2</sub> ..... YZ<sub>3</sub> .....

(3.0 marks)

- (d) A, B, C and D are consecutive non-transition elements in the periodic table with atomic number increasing from A to D. Atomic number of D is less than 30.

The first ionization energies of these elements are in the order D << A < B < C.

Arrange these elements in the increasing order of electronegativity

..... < ..... < ..... < .....

(1.8 marks)

2. (a) (i) Magnetite, Fe<sub>3</sub>O<sub>4</sub> is a mixed oxide of iron. Write the formulae of the constituent oxides of this mineral.

- (ii) A mixture contains Fe<sub>2</sub>O<sub>3</sub> and Fe<sub>3</sub>O<sub>4</sub>. A 5.52 g sample of this mixture when dissolved in dil. H<sub>2</sub>SO<sub>4</sub> required 20.0 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> KMnO<sub>4</sub> for complete reaction. Calculate the molar ratio Fe<sub>2</sub>O<sub>3</sub> : Fe<sub>3</sub>O<sub>4</sub> in the mixture (Fe = 56.0 : O = 16.9)

.....

.....

.....

.....

.....

- (iii) Calculate the maximum mass of iron that can be extracted from 1.0 kg of the mixture in (ii)

.....

.....

.....

(5.0 marks)

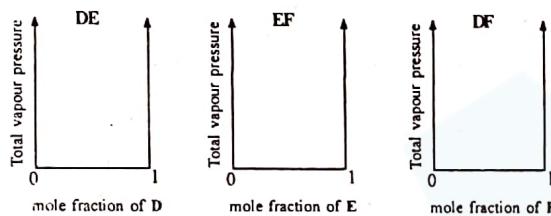
- (b) (i) The pure liquids D, E and F form binary homogeneous solutions DE, EF and DF with each other at temperature T. The intermolecular forces between any two molecules of D, E and F are as indicated in the table below.

Molecule	D	E	F
D	d	b	c
E	b	e	a
F	c	a	f

The following information is given :

- $d = c = f$
- b is slightly smaller than d and e.
- a is slightly greater than e and f.
- The vapour pressures of the three liquids D, E and F are  $P_D$ ,  $P_E$  and  $P_F$  respectively, at the given temperature with  $P_D > P_E$  and  $P_C > P_D$ .

- I. Mark  $P_D$ ,  $P_E$  and  $P_F$  as may be appropriate on each of the six vertical axes in the diagrams below.



- II. Indicate in the relevant diagrams the likely variations of the total vapour pressure of each of the solutions DE, EF and DF.

- (iii)  $\alpha$  mol of D and  $\gamma$  mol of F are mixed to give a solution DF. The total equilibrium vapour pressure above DF at temperature T is P. Intermolecular forces in the vapour phase can be assumed to be absent.

Using the symbols given above in 2(b) (i) and (ii), but no other, write down mathematical expressions for the following.

- I. The partial pressure of D in the vapour phase.

.....

- II. The partial pressure of F in the vapour phase.

.....

- III. The number of moles of D in the vapour phase.

.....

(5.0 marks)

- (a) The elements present in an organic compound A and their mass percentages are given below.

C	H	N	Cl
mass %	55.6	6.2	10.8

- (i) Deduce the empirical formula of A.

(C = 12.0, H = 1.0, N = 14.0, Cl = 35.5)

.....  
.....  
.....  
.....

- (ii) A is soluble in water and the solution is acidic. An aqueous solution containing 1.30 g A required 25.0 cm<sup>3</sup> of 0.40 mol dm<sup>-3</sup> NaOH solution when titrated using phenolphthalein as the indicator.

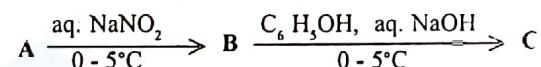
Determine the relative molar mass of A. (1 mol of A reacts with 1 mol of NaOH)

.....  
.....  
.....  
.....  
.....

- (iii) Write the molecular formula of A.

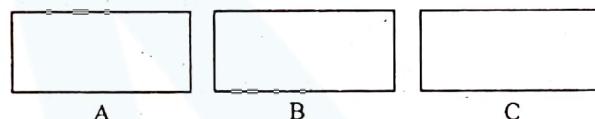
.....

- (iv) A undergoes the following reaction.



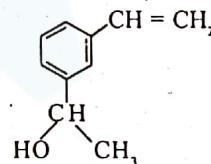
Further, an aqueous solution of A gives a white precipitate with AgNO<sub>3</sub> solution.

Write the structures of A, B and C in the relevant cages.



(5.1 marks)

- (b) Starting from benzene and selecting appropriate reagents and solvents only from those given below, show how you would synthesize the compound,



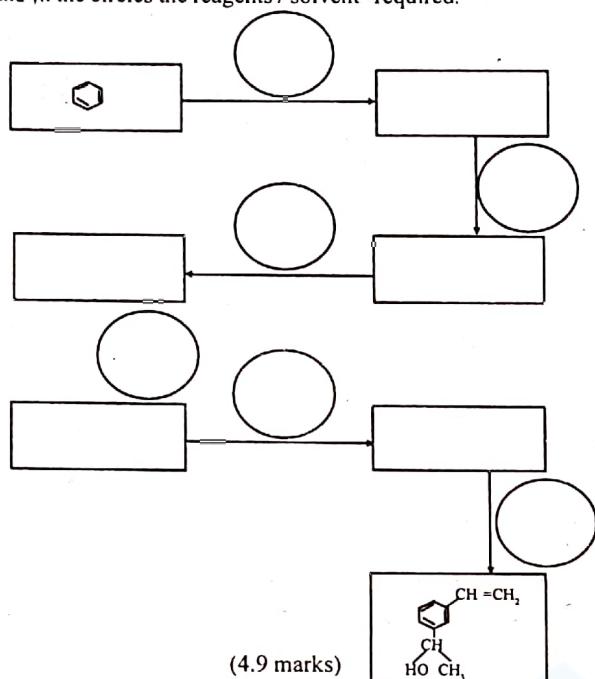
Reagents and solvents

AlCl<sub>3</sub>, PCl<sub>5</sub>, Br<sub>2</sub>, I<sub>2</sub>, LiAlH<sub>4</sub>, Zn(Hg), Mg, Fe, K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, CH<sub>3</sub>COCH<sub>3</sub>, CH<sub>3</sub>COCl, CH<sub>3</sub>CHO, dil. H<sub>2</sub>SO<sub>4</sub>, water, aq. NaOH, dry ether, ethanol

- In the following scheme, each arrow indicates a single reaction. However, consider

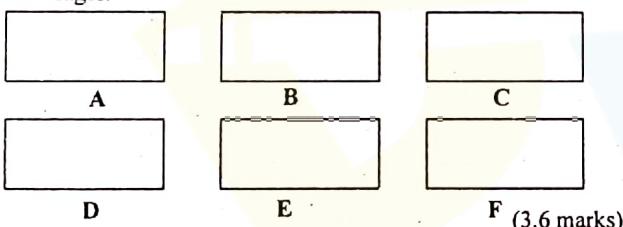
- (A) Reaction with LiAlH<sub>4</sub> followed by hydrolysis  
and (B) Reaction with RMgX followed by hydrolysis as a single reaction.

- Write in the boxes the structures of the appropriate compounds and in the circles the reagents / solvent required.



- 4 (a) A, B and C are three isomeric hydrocarbons each having two  $sp^3$  hybridized carbon atoms and two  $sp^2$  hybridized carbon atoms only. A shows stereoisomerism. On bromination followed by dehydrobromination, A, B and C form D, E and F respectively. D and E are isomers but F is not an isomer of either D or E.

Give the structures of A, B, C, D, E and F in the appropriate cages.



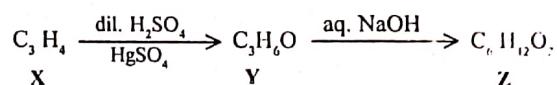
- 4 (b) (i) Reactants and reagents for reactions I-V are given in the table below.

Write active species relevant to each reaction in column R of the table.

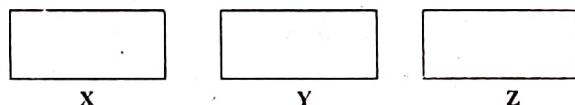
Write the major organic product/products in column S of the table, for each of the reactions.

P Reactant	Q Reagents	R Active species	S Major product/s
COOH 	conc. $HNO_3$ , conc. $H_2SO_4$		
OH 	$CH_3Cl$ , $AlCl_3$		
$CH_3$ 	$Br_2$ , $FeBr_3$		
$CH_3COCH_2CH_2COOH$	$NaBH_4$		
$CH_3$ (excess)	$Cl_2$ , sunlight		

- (ii) Consider the scheme of reactions given below



Give the structures of X, Y and Z in the relevant boxes



Write the IUPAC name of Z

(6.4 marks)

### PART B - ESSAY

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

5. (a) (i)  $NH_3(g)$  and  $O_2(g)$  react with each other forming  $NO(g)$  and  $H_2O(g)$ . Write the balanced chemical equation for this reaction.

- (ii) Calculate the standard enthalpy change,  $\Delta H^\theta$ , for the reaction you wrote in (i) above using the following data

Standard enthalpy of formation of  $NH_3(g)$ .

$$\Delta H_f^\theta(NH_3, g) = -46 \text{ kJ mol}^{-1}$$

Standard enthalpy of formation of  $NO(g)$ ,

$$\Delta H_f^\theta(NO, g) = 90 \text{ kJ mol}^{-1}$$

Standard enthalpy of formation of  $H_2O(g)$ .

$$\Delta H_f^\theta(H_2O, g) = -242 \text{ kJ mol}^{-1}$$

- (iii) Using the data given and the value calculated, briefly explain which one of the two reactions I and II is likely to be more suitable to produce  $NO(g)$

- I. Reaction between  $N_2(g)$  and  $O_2(g)$   
II. Reaction between  $NH_3(g)$  and  $O_2(g)$

(4.0 marks)

- (b) A(g) dissociates reversibly to form B(g) and C(g) at temperatures above 350 K.

An evacuated vessel of volume  $4.157 \text{ dm}^3$  was filled with 2.0 mol of A(g), 1.0 mol of B(g) and 1.0 mol of C(g), and heated to 500 K. When the system attained equilibrium at this temperature, the vessel contained 1.6 mol of A(g), 1.2 mol of B(g) and 1.6 mol of C(g).

- (i) Deduce the balanced chemical equation for the dissociation of A(g) forming B(g) and C(g).

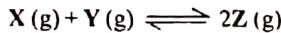
- (ii) Write an expression for the equilibrium constant,  $K_p$ , for the reaction in (i) above.

- (iii) Calculate the value of  $K_p$  at 500 K.

- (iv) If the numerical value of  $K_p$  of this reaction at 700 K in SI units is  $5.1 \times 10^{12}$ , deduce whether the dissociation of A(g) is exothermic.

(5.0 marks)

- (c) (i) The following chemical equilibrium exists among X(g), Y(g) and Z(g) at temperatures above 400 K



An evacuated vessel of volume  $16.628 \text{ dm}^3$  contains 2 mol of  $\text{X(g)}$  and 2 mol of  $\text{Y(g)}$ . This vessel is heated to 500 K to reach the above equilibrium. The equilibrium constant,  $K_p = 4$  at this temperature

- I Calculate the number of moles of  $\text{X(g)}$ ,  $\text{Y(g)}$  and  $\text{Z(g)}$  inside the vessel.
- II. Calculate the total pressure inside the vessel.
- (ii) After equilibrium is reached in (i) above, 1 mol of  $\text{Z(g)}$  is added to the vessel maintaining the temperature at 500 K. Calculate the number of moles of  $\text{X}$ ,  $\text{Y}$  and  $\text{Z}$  inside the vessel, when the new equilibrium is reached.
- (iii) After equilibrium is reached in (i) above, suppose, 1 mol of  $\text{Y(g)}$  and 1 mol of  $\text{Z(g)}$  are added to the vessel maintaining the temperature at 500 K. Deduce logically, without calculations, to which direction the equilibrium of the system shifts.

(6.0 marks)

6. (a) (i) The following procedure was used by a student to determine the solubility product of  $\text{Ca(OH)}_2$  at room temperature.

**Procedure :**

2.50 g of pure  $\text{Ca(OH)}_2$  was added to  $250.0 \text{ cm}^3$  of distilled water and shaken well. There after, half of the solution was filtered. Three  $25.00 \text{ cm}^3$  portions of the filtrate were transferred to three titration flasks and titrated with a  $0.050 \text{ mol dm}^{-3}$  HCl solution using phenolphthalein as the indicator

The following readings were then obtained.

$12.50 \text{ cm}^3$ ,  $12.05 \text{ cm}^3$ ,  $11.95 \text{ cm}^3$

- I Calculate the solubility product of  $\text{Ca(OH)}_2$  at room temperature using the above data.
- II. Indicate the colour change at the end point of this titration.
- III Name another indicator which can be used for this titration.
- IV. What is the importance of taking three measurements in the above titration?
- V. Briefly explain how you assure that the solution used in this experiment was saturated with  $\text{Ca(OH)}_2$ .
- VI. Is it possible to determine the solubility product of  $\text{CaCO}_3$  using the above method? Explain your answer in brief.

(5.0 marks)

- (ii) A 2.50 g sample of  $\text{Mg(OH)}_2$  containing 10% (w/w) NaOH was titrated using the procedure given in (a) (i) above. Calculate

- I. the concentration of  $\text{Mg}^{2+}$  ions in the filtrate.
- II. the expected end point

State the assumptions you used in the calculations I and II above. Justify your assumptions using suitable calculations.  $K_{sp}$  of  $\text{Mg(OH)}_2$  at room temperature =  $1.2 \times 10^{-11} \text{ mol}^3 \text{ dm}^{-9}$  ( $\text{H} = 1$ ,  $\text{O} = 16$ ,  $\text{Na} = 23$ )

(4.0 marks)

- (b)  $50.00 \text{ cm}^3$  of  $0.10 \text{ mol dm}^{-3}$  NaOH solution was mixed with  $25.00 \text{ cm}^3$  of a monobasic weak acid solution.

The pH of the mixture was found to be 11.0. Calculate the concentration of the weak acid solution.

When  $20.00 \text{ cm}^3$  of  $0.10 \text{ mol dm}^{-3}$  NaOH solution was mixed with  $25.00 \text{ cm}^3$  of the above weak acid solution, the pH of the mixture was 4.0. Calculate the dissociation constant of the weak acid.

State assumptions, if any, you used in the above calculations. (6.0 marks)

7. (a) In an experiment to determine the kinetic parameters of the reaction between acidified  $\text{KMnO}_4$  and oxalic acid,  $(\text{H}_2\text{C}_2\text{O}_4)$  the reagents were mixed in closed containers as shown in the table below. The experiment was carried out at  $50^\circ\text{C}$  and the volume of  $\text{CO}_2$  evolved during the first 2 minutes after mixing the reagents was measured at  $25^\circ\text{C}$  and a pressure of 1 atm. Note that the reactions in containers 1-3 were conducted at the same pH value (1.0) and the reaction in container 4 was conducted at a different pH value (1.3). The measurements obtained are given in the table below.

Con-tainer No.	Solution mixed		pH	Volume of $\text{CO}_2/\text{cm}^3$
	$\text{KMnO}_4$	$\text{H}_2\text{C}_2\text{O}_4$		
1.	$0.01 \text{ mol dm}^{-3}; 50.0 \text{ cm}^3$	$0.01 \text{ mol dm}^{-3}; 50.0 \text{ cm}^3$	1.0	9.5
2.	$0.02 \text{ mol dm}^{-3}; 75.0 \text{ cm}^3$	$0.02 \text{ mol dm}^{-3}; 25.0 \text{ cm}^3$	1.0	29.0
3.	$0.01 \text{ mol dm}^{-3}; 50.0 \text{ cm}^3$	$0.02 \text{ mol dm}^{-3}; 50.0 \text{ cm}^3$	1.0	19.5
4.	$0.01 \text{ mol dm}^{-3}; 50.0 \text{ cm}^3$	$0.01 \text{ mol dm}^{-3}; 50.0 \text{ cm}^3$	1.3	10.0

- (i) Write the balanced ionic equation for this reaction between  $\text{KMnO}_4$  and  $\text{H}_2\text{C}_2\text{O}_4$ .
- (ii) Using the data given in the above table, derive an expression for the rate of the reaction you wrote in (i) in terms of the concentrations of  $\text{MnO}_4^-$ ,  $\text{C}_2\text{O}_4^{2-}$  and  $\text{H}^+$  ions.
- (iii) Deduce by what factor the reaction rate would be increased if  $50.0 \text{ cm}^3$  of  $0.02 \text{ mol dm}^{-3}$   $\text{KMnO}_4$  were used in container 4.
- (iv) Is it possible to use your expression in (ii) above to predict the changes in reaction rate when the reactions are carried out at (I) pH = 2.0 and (II) pH = 10.0? Give reasons for your answers.

(9.0 marks)

- (b) (i) Details of two electrochemical cells A and B constructed using three standard electrodes are given below. P and Q are metals. (e.m.f. = electromotive force)

	Electrode 1 (Positive)	Electrode 2	e.m.f./ V
A	$\text{H}^+(\text{aq})/\text{H}_2(\text{g})$	$\text{P}^{2+}(\text{aq})/\text{P(s)}$	1.25
B	$\text{P}^{2+}(\text{aq})/\text{P(s)}$	$\text{Q}^{2+}(\text{aq})/\text{Q(s)}$	0.95

- I. Calculate the standard electrode potential,  $E^\circ$  of metal Q.
- II. Write the cell reaction of the electrochemical cell B
- III. Predict qualitatively the expected change in cell e.m.f if the  $\text{P}^{2+}$  (aq) concentration in cell B is increased to  $2.0 \text{ mol dm}^{-3}$
- (ii) Using your knowledge of the electrolysis of salts, outline an electrochemical method to obtain a pure sample of  $\text{Mg(OH)}_2$  starting with an aqueous solution of  $\text{MgCl}_2$ . Write the electrode reaction involved in the method you have outlined.

(6.0 marks)

### PART C - ESSAY

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

8. (a) (i) How would you identify the aqueous solutions in each of the following groups, by using **only** the method/materials given against each group.

Group	Method / Materials
I. $\text{Na}_2\text{S}_2\text{O}_3$ solution dil. $\text{H}_2\text{SO}_4$ solution $\text{Na}_2\text{CO}_3$ solution	By mixing solution pairwise
II. $\text{NaNO}_3$ solution $\text{NH}_4\text{NO}_3$ solution $\text{NH}_4\text{Cl}$ solution	Al powder By heating with NaOH and/or

- (ii) A mixture X contains salts of two metallic elements **only**. Tests performed with this mixture and the observations made are given below.

Test	Observations
I. Dissolved the mixture in distilled water.	A coloured solution was obtained.
II. Added dil. HCl to an aqueous solution of the mixture	No precipitate.
III. Passed $\text{H}_2\text{S}$ through solution from II and filtered.	A black precipitate was obtained.
IV. The precipitate from III was treated with dil. $\text{HNO}_3$ .	The precipitate dissolved forming a turbid light-blue solution.
V. $\text{NH}_4\text{OH}$ was added dropwise to filtrate from III.	A white precipitate was formed.

State the inferences that you can make from each of the tests I - V.  
Identify the cations in X.

Give **one** test to confirm the identity of the cation revealed in test V.

(8.0 marks)

- (b) An aqueous solution of an inorganic covalent compound Y (relative molar mass < 40) undergoes the following reactions.

- (A) It decolorizes an acidified  $\text{KMnO}_4$  solution with the evolution of  $\text{O}_2$  gas.  
(B) It gives a brown precipitate with alkaline  $\text{KMnO}_4$  with evolution of  $\text{O}_2$  gas.  
(C) It turns a colourless acidic solution of  $\text{NaBr}$ , yellow.  
(D) It slowly decomposes at room temperature but the decomposition can be accelerated by exposing it to sunlight.  
(E) When oil paintings are exposed to polluted air containing  $\text{H}_2\text{S}$ , white  $\text{PbCO}_3$  pigments become black due to formation of  $\text{PbS}$ . Y, can be used to restore the original white colour.

- (i) Identify Y.  
(ii) Give the Lewis (dot and cross) structure of Y.  
(iii) Draw the shape of Y.  
(iv) Give balanced chemical equations for the reactions of Y in (A) to (E) above.  
(v) Name the type of reaction in (D).

- (vi) Give **one** common use of a dilute aqueous solution of Y.  
(vii) Pure Y is a syrupy liquid with the boiling point around  $150^\circ\text{C}$ . Give a reason for this high boiling point

(7.0 marks)

9. (a) (i) Write balanced chemical equations for reactions of aqueous  $\text{NaOH}$  with (I) urea and (II) ammonium sulphate.

- (ii) A fertilizer solution contains urea and ammonium sulphate and the following procedure was used to determine their concentrations.

Two,  $50.0 \text{ cm}^3$  portions of the fertilizer solution were boiled separately with  $35.0 \text{ cm}^3$  of  $2.0 \text{ mol dm}^{-3}$   $\text{NaOH}$  solution (excess) until the evolution of  $\text{NH}_3$  ceased. One portion of the solution required  $30.0 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$   $\text{HCl}$  when titrated using phenolphthalein as the indicator. The other portion required  $50.0 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$   $\text{HCl}$  when titrated using methyl orange as the indicator.

Calculate the concentrations of urea and ammonium sulphate in the fertilizer solution.

(9.0 marks)

- (b) (i) A green salt dissolves in water and the solution turns purple with time, when dil.  $\text{HCl}$  is added, this solution turns green forming a unipositive complex ion. Identify the complex ions responsible for (i) the purple colour and (ii) the green colour in solution.

- (ii) Consider the 'hydroxides',  $\text{XOH}$  of the elements X = Na, K, Cl and Br. Explain the variation of acidic/basic character of these compounds on the basis of electronegativity.

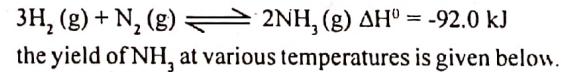
Element	H	O	Na	K	Cl	Br
Electronegativity	2.1	3.5	0.9	0.8	3.0	2.8

(6.0 marks)

10. (a)  $\text{N}_2$  is reduced to  $\text{NH}_3$  in the Haber process. This is carried out at a temperature of about  $550^\circ\text{C}$  and under a pressure of 250 atm.

- (i) Give **one** reason as to why the reduction of  $\text{N}_2(\text{g})$  is difficult.

- (ii) For the reaction,



Temperature/ $^\circ\text{C}$	Yield of $\text{NH}_3$ at 250 atm
200	88%
550	15%
1000	negligible

Briefly explain why a temperature of  $550^\circ\text{C}$  is chosen when the yield is only 15%.

- (iii) Name the catalyst used in Haber process.

- (iv) Why the catalyst is used in a finely divided state? Explain your answer.

- (v) Give a balanced chemical reaction (along with conditions) to convert  $\text{NH}_3(\text{g})$  to  $\text{N}_2(\text{g})$

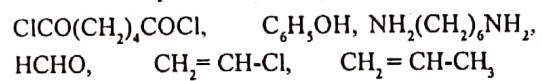
- (vi) Give **two** industrial uses of  $\text{NH}_3$ .

(7.5 marks)

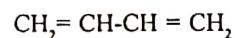
- (b) (i) Selecting compounds **only** from those given below, write one chemical equation in each case to illustrate the formation of a thermoplastic polymer by (I) Addition polymerization (II) condensation polymerization (type

of polymerization must be stated clearly with each reaction.)

Indicate the repeat units clearly.



- (ii) Using your knowledge on the structure of natural rubber, draw the structure of the more elastic polymer formed by the polymerization of butadiene,



Indicate the repeat unit clearly.

- (iii) State one common problem associated with using powdered (I) dolomite and (II) apatite, in their natural form as fertilizers.

Outline two methods by which apatite can be converted to a useful fertilizer.

(7.5 marks)

	1	H													2	He			
1			3	4															
2		Li	Be																
3		Na	Mg																
4		K	Ca	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
5		Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
6		Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
7		Fr	Ra	Ac-	104	105	106	107	108	109	110	111	112	113	....				

**The Periodic Table**

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

## G.C.E. (A/L) Examination Chemistry - 2007

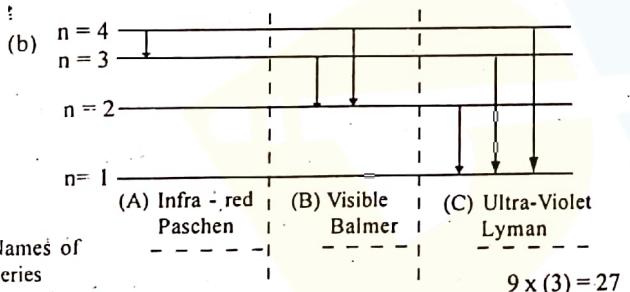
### M.C.Q. Answers

(1) 5	(16) 5	(31) 3	(46) 1
(2) 4	(17) 4	(32) 1	(47) 1
(3) 2	(18) 1	(33) 3	(48) 4
(4) 3	(19) 5	(34) 4	(49) 1
(5) 3	(20) 3	(35) 3	(50) 2
(6) 4	(21) 2	(36) 1 / 5	(51) 3
(7) 4	(22) 1	(37) 2	(52) 2
(8) 1	(23) 5	(38) 5	(53) 4
(9) 4	(24) 4	(39) 5	(54) 4
(10) 5	(25) 4	(40) 3	(55) 3
(11) 4	(26) 3	(41) 1	(56) 1
(12) 2	(27) 1	(42) 2	(57) 1
(13) 3	(28) 2	(43) 3	(58) 4
(14) 3	(29) 4 / 5	(44) 3	(59) 4
(15) 2	(30) 5	(45) 1	(60) 5

### PART A - STRUCTURED ESSAY

Answer all four questions. Each question carries 10 marks

- (01) (a) (i)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3$  (5)  
 (ii) + 3 + 5 (5) + (5)  
 (iii)  $As_2 O_3$  and  $As_2 O_5$  (5) + (5)  
 or  $As_4 O_6$  and  $As_4 O_{10}$  (a) = 25 marks



- (c) (i) Y = S (sulphur) Z = O (Oxygen) (10) + (10)  
 (ii)  $YZ_2$  = Angular/ V-shaped  $YZ_3$  = Trigonal planar (5 + 5)  
 (d) C < D < A < B (18) (d) = 18 marks

- (02) (a) (i)  $FeO$ ,  $Fe_2O_3$  (4) + (4)  
 (ii)  $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$   
 OR  $MnO_4^- \equiv 5Fe^{2+}$  (2)  
 Amount of  $MnO_4^-$  reacted =  $\frac{20.0 \times 0.1}{1000} = 2.0 \times 10^{-3}$  mol (4)

$$\begin{aligned} \text{The Amount of } FeO (Fe^{2+}) &= 5 \times 2.0 \times 10^{-3} \text{ mol} \\ &= 1.0 \times 10^{-2} \text{ mol} \\ &= 0.01 \text{ mol} \end{aligned} \quad (4)$$

$$\text{mass of } Fe_3O_4 \text{ (232)} = 0.01 \times 232 \text{ g} = 2.32 \text{ g} \quad (4)$$

$$\therefore \text{mass of } Fe_2O_3 = 5.52 \text{ g} - 2.32 \text{ g} = 3.20 \text{ g} \quad (4)$$

$$\therefore \text{Amount of } Fe_2O_3 (160) = \frac{3.20}{160} = 0.02 \text{ mol} \quad (4)$$

$$\text{Molar ratio } Fe_2O_3 : Fe_3O_4 = 0.02 : 0.01 = 2 : 1 \quad (4)$$

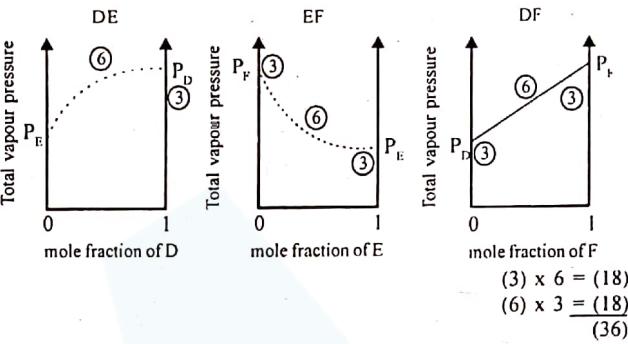
$$\begin{aligned} \text{(iii) Iron from } Fe_2O_3 &= 0.02 \text{ mol} \times 112 \text{ g mol}^{-1} \\ &= 2.24 \text{ g} \quad (4) \end{aligned}$$

$$\begin{aligned} \text{Iron from } Fe_3O_4 &= 0.01 \text{ mol} \times 168 \text{ g mol}^{-1} \\ &= 1.68 \text{ g} \quad (4) \end{aligned}$$

$$\begin{aligned} \text{Total from } 5.52 \text{ g of mixture of } Fe_2O_3 + Fe_3O_4 &= 3.92 \text{ g} \\ &= 3.92 \text{ g} \end{aligned}$$

$$\begin{aligned} \text{Iron from } 1.0 \text{ kg of mixture} &= \frac{3.92 \text{ g}}{5.52 \text{ g}} \times 1000 \text{ g} \\ &= 710 \text{ g} \quad (4) \end{aligned}$$

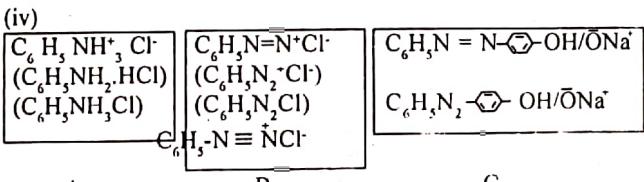
(a) = 50 marks



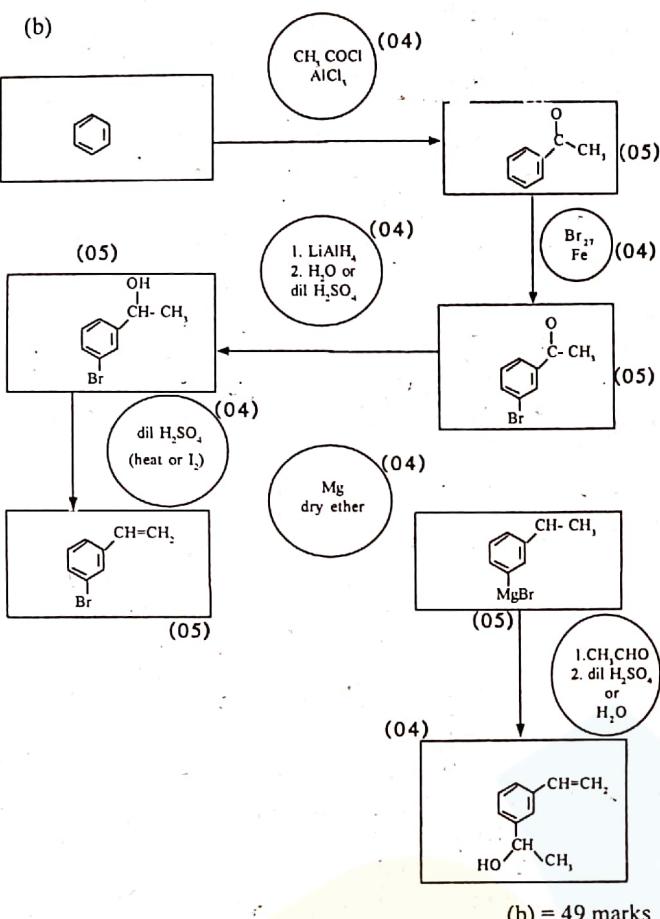
(ii) (i), (II), (III) - Award 14 marks for all candidates. (b) = 50 marks

(03) (a) (i)	C 55.6 12.0 4.6 4.6 / 0.77 6	H 6.2 1.0 6.2 / 0.77 8	N 10.8 14.0 0.77 / 0.77 1	Cl 27.4 (4x01) 35.5 0.77 (4x01) 1 (4x01)
	$C_6 H_5 N Cl$			

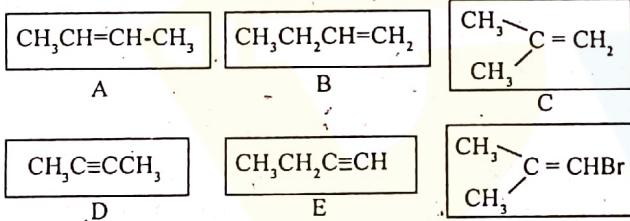
- (ii) No. of mol of NaOH mol =  $\frac{0.4 \times 25}{1000} = 0.01$  (4)  
 0.01 mol of NaOH = 0.01 mol of A (4)  
 0.01 mol of A = 1.30 g  
 ∴ 1 mol of A =  $\frac{1.30}{0.01} \text{ g} = 130 \text{ g}$  (4)  
 ∴ Relative molar mass = 130 (4)  
 (iii) M ( $C_6 H_5 N Cl$ ) = 129.5 (4)  
 ∴ molecular formula of A =  $C_6 H_5 N Cl$  (4)



A (05)                                                  B (05)                                          C (05)



4 (a).

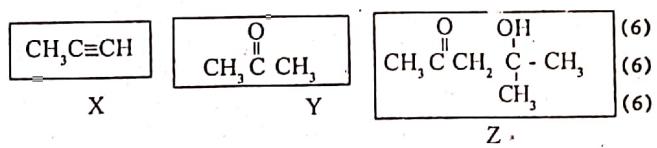


(b) (i)

6 x 06 (a) = 36 marks

P Reactant	Q Reagents	R Active species	S Major product/s	
I $\text{COOH}$ (D-deuterium)	Conc. $\text{HNO}_3$ , Conc. $\text{H}_2\text{SO}_4$	$\text{NO}_2^+$ OR $\text{NO}_2^+ \text{HSO}_4^-$		(3) (3) (3)
II $\text{OH}$	$\text{CH}_3\text{Cl}$ $\text{AlCl}_3$	$\text{CH}_3^+$ OR $\text{CH}_3^+ \text{AlCl}_4^-$		(3) (3) (3)
III $\text{CH}_3$	$\text{Br}_2$ , $\text{FeBr}_3$	$\text{Br}^+$ OR $\text{Br}^+ \text{FeBr}_4^-$		(3) (3) (3)
IV $\text{CH}_3\text{COCH}_2\text{CH}_2\text{COOH}$	$\text{NaBH}_4$	$\text{BF}_3^- \text{OR}^-$		(3) (3) (3) (3)
V $\text{CH}_4$ excess	$\text{Cl}_2$ sunlight	$\text{Cl}^-$	$\text{CH}_3\text{Cl}$	(3) (3)

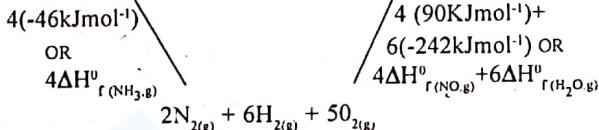
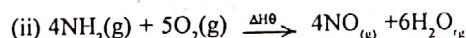
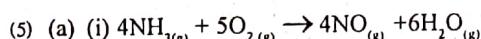
(b)(i) = 39 marks



4- Hydroxy -4- methylpentan - 2 - one

OR

(4 - Hydroxy -4- methyl - 2 - pentanone)

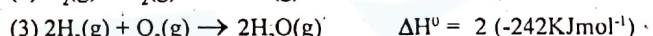
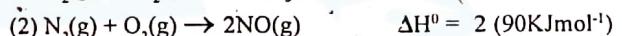
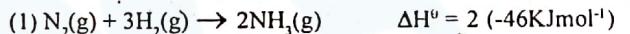


3 equations x 03 marks = 09 (in the cycle or in the following  
3 values (1 + 1) marks = 06 relationship)

15 marks

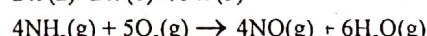
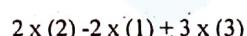
$$\begin{aligned}\Delta\text{H}^\circ &= -4\text{mol} (-46\text{ KJmol}^{-1}) + 4\text{mol} (90\text{ KJmol}^{-1}) \\ &\quad + 6\text{mol} (-242\text{ KJmol}^{-1}) \\ &= (+184 + 360 - 1452)\text{ KJ} \\ &= -908\text{ KJ}\end{aligned}$$

A Alternative approach I



3 equations x 03 marks (9)

3 values x (1 + 1) marks (6)



$$\begin{aligned}\Delta\text{H}^\circ &= 2 \times 2 \text{ mol} (90\text{KJmol}^{-1}) - 2 \times 2 \text{ mol} (-46\text{KJmol}^{-1}) + \\ &\quad 3 \times 2 \text{ mol} (-242\text{KJmol}^{-1})\end{aligned}$$

= -908 KJ

(2+2)

Alternative approach II



4 terms x 3 marks

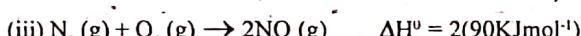
$$= 4 \text{ mol} (90\text{KJmol}^{-1}) + 6 \text{ mol} (-242\text{KJmol}^{-1}) - 4 \text{ mol} (-46\text{KJmol}^{-1}) - 0$$

First 3 terms x (2 + 1) marks =

= -908 KJ

(2 + 2)

Total for part (ii) = 25 marks



This reaction (Reaction I) is endothermic, and the Reaction (II) is exothermic

Reaction (II) is more likely to produce NO(g)

(5)

Total for part (iii) = 10 marks

Total for 5 (a) = 40 marks

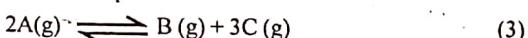
(b) (i)	$A(g) \rightleftharpoons B(g) + C(g)$		
Initially	2.0	1.0	1.0 mol (3)
At equilibrium	1.6	1.2	1.6 mol (3)
Amount reacted/ formed	0.4	0.2	0.6 mol (3)

Note : Direct deduction of amounts reacted or formed is also acceptable and (09) marks should be awarded.

The whole number ratio or



Balanced equation



Total for part (i) = 15 marks

$$(ii) K_c = \frac{[B(g)][C(g)]^3}{[A(g)]^2} \quad (3)$$

Total for part (ii) = 3 marks

$$(iii) K_p = K_c (RT)^n \quad \text{OR} \quad K_p = K_c (RT)^2$$

$$\text{OR} \quad K_p = \frac{[B(g)][C(g)]^3}{[A(g)]^2} \quad (3)$$

$$= \frac{(1.2 \text{ mol} / 4.157 \text{ dm}^3)(1.6 \text{ mol} / 4.157 \text{ dm}^3)^3(8.314 \text{ J mol}^{-1} \text{ K}^{-1} \times 500\text{K})^2}{(1.6 \text{ mol} / 4.157 \text{ dm}^3)^2}$$

5 terms x (02 + 01) marks (15)  
 $= 1.92 \times 10^6 \text{ J}^2 \text{ dm}^{-6}$  (2+1)  
 $= 1.92 \times 10^6 \times 10^6 \text{ J}^2 \text{ m}^{-6}$   
 $= 1.92 \times 10^{12} \text{ Pa}^2 \text{ or N}^2 \text{ m}^{-4}$  (2+1)

Alternative approach

$$PV = nRT \quad \text{or} \quad P = nRT/V \quad (3)$$

$$P = \frac{(4.4 \text{ mol})(8.314 \text{ mol}^{-1} \text{ K}^{-1})(500\text{K})}{4.157 \times 10^{-3} \text{ m}^3}$$

4 terms x (1 + 1) marks (8)

$$P = 4.4 \times 10^6 \text{ Pa} \quad (1+1)$$

$$K_p = \frac{P_B \times P_C^3}{P_A^2} \quad (3)$$

$$K_p = \frac{[1.2 \text{ mol} / 4.4 \times 10^6 \text{ Pa}][1.6 \text{ mol} / 4.4 \times 10^6 \text{ Pa}]^3}{[4.4 \text{ mol}]^2}$$

3 terms x (1 + 1) marks (8)

$$K_p = 1.92 \times 10^{12} \text{ Pa}^2 \quad (1+1)$$

Total for part (iii) = 24 marks

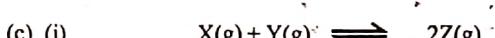
$$(iv) K_p \text{ at } 700\text{K} = 5.1 \times 10^{13} \text{ Pa}^2$$

$K_p$  has increased with increasing temperature (4)

Reaction is not exothermic (OR endothermic) (4)

Total for part (iv) = 8 marks

Total for part 5 (b) = 50 marks



$$\text{Initially} \quad 2 \quad 2 \quad \text{-- mol} \quad (2)$$

$$\text{At equilibrium} \quad 2-x \quad 2-x \quad 2x \quad \text{mol} \quad (2)$$

where  $x$  = amount of  $X(g)$  reacted = amount of  $Y(g)$  reacted

Total no. of mol at equilibrium =  $(2-x) + (2-x) + 2x = 4$

Partial pressures at equilibrium

$$P_x(g) = \frac{2-x}{4} p \quad \text{atm} \quad (p = \text{total pressure of the system}) \quad (1+1)$$

$$P_y(g) = \frac{2-x}{4} p \quad \text{atm} \quad (1+1)$$

$$P_z(g) = \frac{2x}{4} p \quad \text{atm} \quad (1+1)$$

$$K_p = \frac{P_z^2(g)}{P_x(g) P_y(g)} \quad (2)$$

$$K_p = \frac{\left(\frac{2x}{4} p \text{ atm}\right)^2}{\left[\frac{2-x}{4} p \text{ atm}\right] \left[\frac{2-x}{4} p \text{ atm}\right]} \quad (2)$$

$$= \left(\frac{2x}{2-x}\right)^2 \quad (2)$$

$$\therefore \left(\frac{2x}{2-x}\right)^2 = 4 \quad (2)$$

$$\frac{2x}{2-x} = 2 \quad (2)$$

$$2x = 4 - 2x \quad (4)$$

$$x = 1 \quad (4)$$

$$\text{mol of } x \text{ at equilibrium} = 2 - x = 1 \quad (2)$$

$$\text{mol of } y \text{ at equilibrium} = 2 - x = 1 \quad (2)$$

$$\text{mol of } z \text{ at equilibrium} = 2x = 2 \quad (2)$$

Total for part (I) = 30 marks

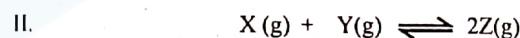
$$\text{II. } PV = nRT \quad \text{OR} \quad P = \frac{nRT}{V} \quad (2)$$

$$P = \frac{4 \text{ mol} \times 8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 500\text{K}}{16.628 \times 10^{-3} \text{ m}^3} \quad (2)$$

No marks if the value or the unit of any quantity is wrong.

$$= 1 \times 10^6 \text{ N m}^{-2} \quad (1+1)$$

Total for part (II) = 06 marks



$$\text{Initially} \quad 2 \quad 2 \quad \text{-- mol} \quad (2)$$

$$\text{Equilibrium} \quad 1 \quad 1 \quad 2 \quad \text{mol} \quad (2)$$

$$\text{added} \quad \text{--} \quad \text{--} \quad 1 \quad \text{mol} \quad (2)$$

$$\text{New Initial} \quad 1 \quad 1 \quad 3 \quad \text{mol} \quad (2)$$

$$\text{New Equilibrium} \quad 1+x/2 \quad 1+x/2 \quad 3-x \quad \text{mol} \quad (2)$$

$$K_p = \frac{P_z^2(g)}{P_x(g) P_y(g)} \quad (2)$$

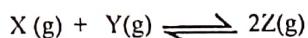
$$= \frac{\left[\frac{3-x}{5} p \text{ atm}\right]^2}{\left[\frac{1+x}{5} p \text{ atm}\right] \left[\frac{1+x}{5} p \text{ atm}\right]} \quad (2)$$

$$= \left[\frac{3-x}{1+x}\right]^2 \quad (2)$$

$$\therefore \left[\frac{3-x}{1+x}\right]^2 = 4 \quad (2)$$

$$x = \frac{1}{2} \quad (4)$$

Alternative approach



Approach I       $1+x \quad 1+x \quad 3-2x \text{ mol}$   
 $x = 1/4$

OR

Approach II       $1-x/2 \quad 1-x/2 \quad 3+x \text{ mol}$   
 $x = -1/2$

OR

Approach III       $1-x \quad 1-x \quad 3+2x \text{ mol}$   
 $x = -1/4$

Maximum marks (10)

$\therefore$  mol of x at equilibrium = 5/4      (2)

mol of y at equilibrium = 5/4      (2)

mol of Z at equilibrium = 5/2      (2)

Total for part (ii) = 18 marks

(iii) No. of mol of both Y and Z is increased by one

But the equilibrium constant expression has a square term for Z      (2)

Increase in the no. of mol of Z has a stronger effect on equilibrium constant expression      (2)

According to the he Chatlier Principle, the equilibrium will shift to the left      (2)

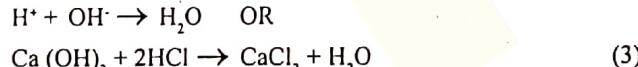
Total for part (iii) = 06 marks

Total for 5(C) = 60 marks

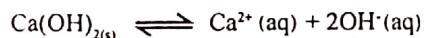
a (a) (i) I. Drop the first end point as it is too large (or much different) compared to the other two measurements. (5)

Average of the remaining (or other two) measurements       $= \frac{12.5 + 11.95}{2} \text{ cm}^3$   
 $= 12.00 \text{ cm}^3$       (3 + 2)

Stoichiometry of the reaction between  $H^+$  and  $OH^-$  is 1 : 1  
 OR



Average concentration of  $OH^-$  in the filterate  
 $= \frac{(12.00 \text{ cm}^3)(0.050 \text{ mol dm}^{-3})}{25.00 \text{ cm}^3}$       (2+1)  
 $= 2.4 \times 10^{-2} \text{ mol dm}^{-3}$       (1 + 1)



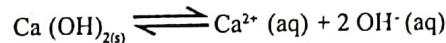
Solubility product =  $[Ca^{2+}]_{\text{aq}} [OH^-]_{\text{aq}}^2$       (3)  
 $= \left[ \frac{(OH^-)_{\text{aq}}}{2} \right] \left[ OH^-_{\text{aq}} \right]^2$       (3)  
 $= \frac{1}{2} [OH^-]_{\text{aq}}^3$   
 $= \frac{1}{2} (2.4 \times 10^{-2} \text{ mol dm}^{-3})^3$       (2+1)  
 $= 6.9 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$       (1+1)

Alternative approach

Average concentration of  $Ca(OH)_2$  in the filterate

$$= \frac{(12.00 \text{ cm}^3)(0.050 \text{ mol dm}^{-3})}{2(25.00 \text{ cm}^3)}$$

$$= 1.2 \times 10^{-2} \text{ mol dm}^{-3}$$



Solubility product =  $[Ca^{2+}]_{\text{aq}} [OH^-]_{\text{aq}}^2$       (3)  
 $= (1.2 \times 10^{-2} \text{ mol dm}^{-3})(2.4 \times 10^{-2} \text{ mol dm}^{-3})^2$       (5+1)  
 $= 6.9 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$       (1+1)

Total for (I) = 29 marks

(ii) pink (OR red) to colorless      (3)

(iii) methyl orange OR methyl red or any other acceptable acid-base indicator      (3)

(iv) Any one of the following.

- to reject outlying readings
- to obtain a reproducible result
- to obtain a reliable result
- to minimize errors
- to get consistent values

(v) Shake vigorously the initial suspension for a longer time      (3)

Repeat experiment

If the same readings (or readings within the experimental error) are obtained, the solution had been saturated with  $Ca(OH)_2$       (3)

(vi) No      (3)

Solubility product of  $CaCO_3$  is very small [or much smaller than that of  $Ca(OH)_2$ ]  
 $CO_3^{2-}$  concentration in a saturated solution of  $CaCO_3$  is very low. very low Concentrations cannot be detected using a titration      (3)

Total for a (i) = 50 marks

06. a. (ii). Consider 25.00 cm<sup>3</sup> portion of the clear filtered solution  
 Concentration of  $OH^-$  due to NaOH,

$$OH^- = 2.50g \left[ \frac{10}{100} \right] \left[ \frac{1}{40g \text{ mol}^{-1}} \right] \left[ \frac{1}{0.250 \text{ dm}^{-3}} \right]$$

$$= 2.5 \times 10^{-2} \text{ mol dm}^{-3}$$

Let S = concentration of  $Mg^{2+}$  ions in the filtrate

Solubility product,  $K_{sp} = [Mg^{2+}]_{\text{aq}} [OH^-]_{\text{aq}}^2$       (4)  
 $1.2 \times 10^{-11} \text{ mol}^3 \text{ dm}^{-9} = S (2.5 \times 10^{-2} \text{ mol dm}^{-3})^2$       (2+2)

$$\therefore S = \frac{1.2 \times 10^{-11} \text{ mol}^3 \text{ dm}^{-9}}{(2.5 \times 10^{-2} \text{ mol dm}^{-3})^2}$$

$$= 1.9 \times 10^{-8} \text{ mol dm}^{-3}$$

Total for I = 20 marks

(II) Expected end point =  $\left[ \frac{(2.5 \times 10^{-2} \text{ mol dm}^{-3})(\frac{25.00}{1000} \text{ dm}^{-3})}{0.050 \text{ mol dm}^{-3}} \right]$

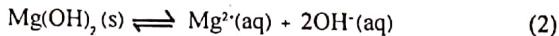
$$= \frac{12.50 \text{ dm}^{-3}}{1000} \text{ or } 12.50 \text{ cm}^{-3}$$

Total for II = 8 marks

Assumption - Amount of OH<sup>-</sup> in solution due to dissolution of Mg(OH)<sub>2</sub> is negligible compared that devied dissolving NaOH (4)

Justification :

### Approach I



$$\text{From I, } [\text{Mg}^{2+}] = 1.9 \times 10^{-8} \text{ mol dm}^{-3} \quad (2)$$

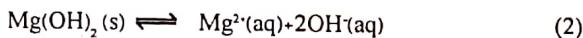
Concentration of OH<sup>-</sup> (OR amount of OH<sup>-</sup> in 1 dm<sup>3</sup> of solution) due to dissolution of Mg(OH)<sub>2</sub>,

$$\begin{aligned} &= 2 \times 1.9 \times 10^{-8} \text{ mol dm}^{-3} \\ &= 3.8 \times 10^{-8} \text{ mol dm}^{-3} \end{aligned} \quad (2)$$

This is much less than  $2.5 \times 10^{-2}$  mol dm<sup>-3</sup> (2)

Concentration (OR amount) of OH<sup>-</sup> due to dissolution of Mg(OH)<sub>2</sub> is negligible

### Approach II



$$k_{sp} \text{ of Mg(OH)}_2 = 1.2 \times 10^{-11} \text{ mol}^3 \text{ dm}^{-9}$$

Solubility of Mg(OH)<sub>2</sub> in the absence of any common ion

$$= (1.2 \times 10^{-11}/4)^{1/3} \text{ mol dm}^{-3} < 1.5 \times 10^{-4} \text{ mol dm}^{-3} \quad (2)$$

In the presence of a common ion (OH<sup>-</sup>), solubility of Mg(OH)<sub>2</sub> will be less (2)

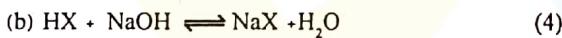
Concentration of OH<sup>-</sup> in solution due to dissolution of Mg(OH)<sub>2</sub> << [OH<sup>-</sup>] coming from NaOH.

The latter is  $2.5 \times 10^{-2}$  mol dm<sup>-3</sup> (2)

Amount of OH<sup>-</sup> in solution due to dissolution of Mg(OH)<sub>2</sub> can be neglected when compared to

$$2.5 \times 10^{-2} \text{ mol dm}^{-3}$$

Total for a (ii) = 40 marks



End point has passed to observe a pH of 11.0 (4)

Let C be the concentration of the acid in mol dm<sup>-3</sup>.

$$\text{Amount of HX mixed} = C \times \frac{25.00}{1000} \text{ mol} \quad (2+2)$$

$$\text{Amount of NaOH mixed} = 0.10 \left[ \frac{50}{1000} \right] \text{ mol} \quad (2+2)$$

Concentration of OH<sup>-</sup> in the mixture

$$= \frac{0.10 \left[ \frac{50}{1000} \right] \text{ mol} - C \left[ \frac{25}{1000} \right] \text{ mol}}{\frac{75.00}{1000} \text{ dm}^3} \quad (4)$$

$$= \frac{5.00 - 25.00 C}{75.00} \text{ mol dm}^{-3} \quad (2+2)$$

$$\text{POH} = 14.00 - \text{pH} = 3.00 \quad (4)$$

$$-\log_{10} \frac{5.00 - 25.00 C}{75.00} = 3.00$$

$$\frac{5.00 - 25.00 C}{75.00} = 10^{-3} \quad (4)$$

$$C = 0.197 \text{ mol dm}^{-3} \quad (2+2)$$

End point has not been reached to observe a pH of 4.0.

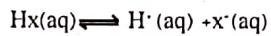
All NaOH added is reacted with HX(aq) in 1:1 stoichiometric ratio to produce Na<sup>+</sup>(aq), X<sup>-</sup>(aq) and H<sub>2</sub>O (l)

$$\text{Concentration of X}^- \text{ in the mixture} = \frac{0.10 \times 20.00}{45.00} \text{ mol dm}^{-3} \quad (4)$$

Concentration of HX in the mixture

$$= \frac{0.197 \times 25.00 - 0.10 \times 20.00}{45.00} \text{ mol dm}^{-3} \quad (4)$$

Concentration of H<sup>+</sup> in the mixture =  $1 \times 10^{-4}$  mol dm<sup>-3</sup> (4)



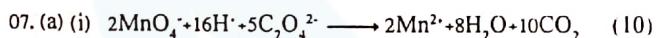
$$\text{Dissociation Constant} = \frac{[\text{H}^+(\text{aq})][\text{X}^-(\text{aq})]}{[\text{Hx(aq)}]} \quad (2)$$

$$= \frac{1.0 \times 10^{-4} \text{ mol dm}^{-3} \left[ \frac{0.10 \times 20.00}{45.00} \right] \text{ mol dm}^{-3}}{0.197 \times 25.00 - 0.10 \times 20.00 \text{ mol dm}^{-3}} \quad (2+2)$$

$$= 6.84 \times 10^{-5} \text{ mol dm}^{-3} \quad (2+2)$$

Assumption - Hydrolysis of the anion X<sup>-</sup>(aq) derived from the weak acid HX is negligible. Temperature is 25°C. (4)

Total for (b) = 60 marks



Total for i) = 10 marks

$$(ii) \text{Rate} \propto [\text{MnO}_4^-]^\alpha [\text{C}_2\text{O}_4^{2-}]^\beta [\text{H}^+]^\gamma \quad (4)$$

where  $\alpha$ ,  $\beta$  and  $\gamma$  are orders with respect to MnO<sub>4</sub><sup>-</sup>, C<sub>2</sub>O<sub>4</sub><sup>2-</sup>, H<sup>+</sup> respectively.

Container	[MnO <sub>4</sub> <sup>-</sup> ]/ mol dm <sup>-3</sup>	[C <sub>2</sub> O <sub>4</sub> <sup>2-</sup> ]/ mol dm <sup>-3</sup>	[H <sup>+</sup> ]/ mol dm <sup>-3</sup>
1.	0.005	0.005	0.10
2.	0.015	0.005	0.10
3.	0.005	0.010	0.010
4.	0.005	0.005	0.050

Calculation of 07 different concentrations (underlined) x 4 marks (28)

Rate  $\propto$  volume of CO<sub>2</sub> evolved (4)

$$9.5 \propto (0.005)^a (0.005)^b (0.10)^y \dots \quad (1)$$

$$29.0 \propto (0.015)^a (0.005)^b (0.10)^y \dots \quad (2)$$

$$19.5 \propto (0.005)^a (0.010)^b (0.10)^y \dots \quad (3)$$

$$10 \propto (0.005)^a (0.005)^b (0.05)^y \dots \quad (4)$$

04 relationships x 04 marks = (16)

$$(2)/(1) \quad 29.0 / 9.5 = (0.015 / 0.005)^a \text{ OR } 3 = 3^a \quad (02)$$

$$\alpha = 1 \quad (02)$$

$$(3)/(1) \quad 19.5 / 9.5 = (0.010 / 0.005)^b \text{ OR } 2 = 2^b \quad (02)$$

$$\beta = 1 \quad (02)$$

$$(4)/(1) \quad 9.5 / 10.0 = (0.10 / 0.05)^y \text{ OR } 1 = 2^y \quad (02)$$

$$\gamma = 0 \quad (02)$$

OR valid qualitative arguments to show that  $\alpha = 1$ ,  $\beta = 1$  and  $\gamma = 0$  (12)

$$\text{Rate} \propto [\text{MnO}_4^-][\text{C}_2\text{O}_4^{2-}] \quad (4)$$

Total for (ii) = 68 marks

(iii)  $[MnO_4^-] = 0.010 \text{ mol dm}^{-3}$

OR

$[MnO_4^-]$  is doubled OR order with respect to

$MnO_4^-$  is one

Rate is increased by a factor of two

Total for (iii) = 4 marks

(iv) (I) pH = 2.0

Rate does not change

Reason:

Rate does not depend on pH OR

Rate expression has no  $H^+$  term OR

The reaction is zeroth order w.r.t.

$[H^+]$

(ii) pH = 10.0

Rate cannot be predicted

$MnO_2$  is formed in basic medium and therefore the reaction does not proceed as written.

Total for (iii) = 8 marks

Total for 7 (a) = 90 marks

(b) (I) I.  $1.25V = E^\theta_{H^+/H_2} - E^\theta_{P^{2+/P}}$  OR

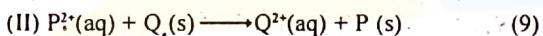
$$E^\theta_{\text{cell}} = E^\theta_{\text{cathode}} - E^\theta_{\text{anode}}$$

$$E^\theta_{P^{2+/P}} = -1.25 \text{ V}$$

$$0.95 = E^\theta_{P^{2+/P}} - E^\theta_{Q^{2+/Q}}$$

$$0.95 = -1.25 \text{ V} - E^\theta_{Q^{2+/Q}}$$

$$E^\theta_{Q^{2+/Q}} = -1.25 \text{ V} - 0.95 \text{ V} = -2.20 \text{ V}$$



III. Concentration of  $P^{2+}(\text{aq})$  is increased  $\Rightarrow$

Reaction goes forward.

e.m.f is increased

Total for (i) = 30 marks

(ii) Use two inert electrodes as the cathode and the anode (4)

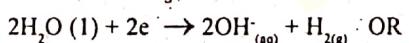
E.g., Carbon, platinum, stainless steel, graphite, etc (2)

Electrolyze the solution to produce  $H_2(\text{g})$  and  $Cl_2(\text{g})$  (4)

$Mg(OH)_2$  will precipitate and deposit at the bottom (4)

Separate and collect the deposit (4)

Electrode reactions -



OR

Evaporate  $MgCl_2$  solution to dryness, fuse  $MgCl_2$  and electrolyze. (4)

Use inert electrodes e.g. Graphite, platinum or stainless steel (2)

Heat Mg in oxygen or air to produce  $MgO$  (2)

React  $MgO$  with water to get  $Mg(OH)_2$ . Filter and collect  $Mg(OH)_2$  (2)

Electrode reactions



Total for (ii) = 30 marks

Total for 7 (b) = 60 marks

(08) (a) (i) (I)  $Na_2S_2O_3$  Solution

Dil  $H_2SO_4$  Solution

$Na_2CO_3$  Solution

The two solutions that do not show any reaction when mixed are  $Na_2S_2O_3$  and  $Na_2CO_3$  (5)

The other solution is dil  $H_2SO_4$  (5)

The solution that gives a pale yellow ppt. with dil  $H_2SO_4$  is  $Na_2S_2O_3$  OR The solution that gives effervescence ( $CO_2$ ) with dil  $H_2SO_4$  is  $Na_2CO_3$  (5)

The remaining solution is  $Na_2CO_3 / Na_2S_2O_3$  (5)

II  $NaNO_3$  Solution

$NH_4NO_3$  Solution

$NH_4Cl$  Solution

Heat each solution with NaOH. The solution that does not evolve  $NH_3$  is  $NaNO_3$  (5)

Heat the other two solutions (with NaOH) until evolution of  $NH_3$  ceases.

Then add Al powder and heat further (5)

The solution that evolves  $NH_3$  again is  $NH_4NO_3$  (5)

The other solution is  $NH_4Cl$  (5)

(ii) (1) Presence of a transition metal ion (4)

(II) Absence of group I (or  $Ag^+$ ,  $Pb^{2+}$ ,  $Hg_2^{2+}$ ) (4)

(III) Presence of  $Cu^{2+}$ ,  $Hg^{2+}$ ,  $Bi^{3+}$ ,  $Pb^{2+}$  (4)

(IV) Presence of  $Cu^{2+}$  (4)

(V) Presence of  $Zn^{2+}$  or  $Al^{3+}$  (2 + 2)

The cations present are  $Cu^{2+}$  (04) and  $Zn^{2+}$  (02) or  $Al^{3+}$  (02) continue addition of  $NH_4OH$  in test V. (04)

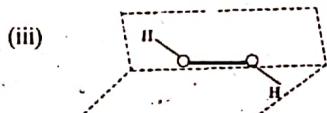
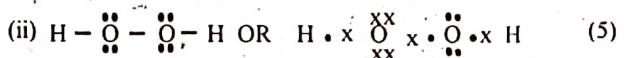
If the white ppt. persists the cation present is  $Al^{3+}$  (04)

If the ppt. dissolves, it is  $Zn^{2+}$  (04) [Charcoal block test with cobalt nitrate is also acceptable. Test (04)]

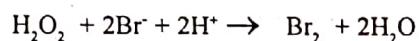
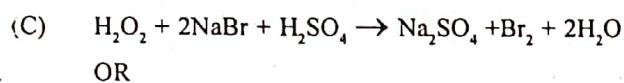
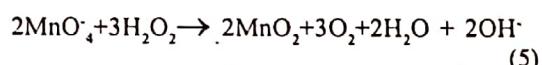
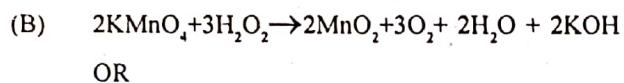
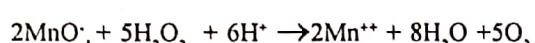
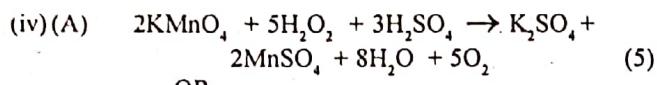
Observations 04 + 04]

Total for 8 (a) = 80 marks

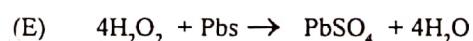
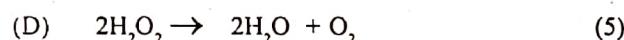
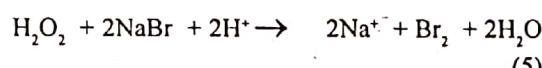
b. (i) Y is  $H_2O_2$  (or Hydrogen peroxide) (20)



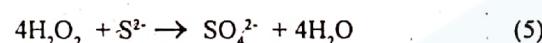
(5)



OR



OR

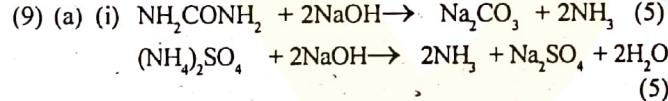


(v) Disproportionation (5)

(vi) Antiseptic / bleaching agent (5)

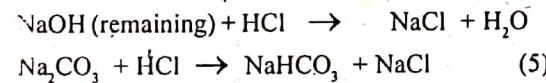
(v) Hydrogen bonding (5)

Total for 8 (b) = 70 marks

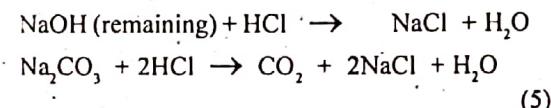


When the solution containing the mixture of urea and  $(\text{NH}_4)_2\text{SO}_4$  boiled with excess NaOH, what remains is a mixture of  $\text{Na}_2\text{CO}_3$  equivalent to the amount of urea and the unreacted (excess) NaOH. (10)

With phenolphthalein, the end point is obtained when the following reactions are complete :



With, methyl orange, the end point is obtained when the following reactions are complete :



Therefore the difference in readings is equivalent to the amount of  $\text{NaHCO}_3$ . This is equivalent to the amount of  $\text{Na}_2\text{CO}_3$  formed and hence to the amount of urea. (5)

The difference in burette readings =  $50.0 - 30.0 \text{ cm}^3$   
 $= 20.0 \text{ cm}^3$

The no. of moles of HCl in  $20.0 \text{ cm}^3$

$$= \frac{1.0}{1000} \times (20.0) = 0.02 \text{ mol}$$
  
 $= 0.02 \text{ mol}$  (5)

The amount of urea in  $50.0 \text{ cm}^3$  of fertilizer solution

$$= 0.02 \text{ mol}$$
 (5)

The concentration of urea in the fertilizer solution

$$= \frac{0.02}{50.0} [\times 1000] \text{ mol dm}^{-3}$$
 (5)  
 $= 0.40 \text{ mol dm}^{-3}$  (5)

The volume of  $1.0 \text{ mol dm}^{-3}$  HCl required to react with  $35.0 \text{ cm}^3$  of  $2.0 \text{ mol dm}^{-3}$  NaOH solution =  $70.0 \text{ cm}^3$  (5)

The volume of HCl equivalent to the amount of NaOH that has reacted with  $(\text{NH}_4)_2\text{SO}_4$  =  $70 \text{ cm}^3 - 50 \text{ cm}^3$   
 $= 20 \text{ cm}^3$  (5)

The volume of NaOH that reacted with  $(\text{NH}_4)_2\text{SO}_4$  =  $10.00 \text{ cm}^3$  (5)

Amount of NaOH reacted with  $(\text{NH}_4)_2\text{SO}_4$

$$= \frac{2.0}{1000} \times 10.00$$
  
 $= 0.02 \text{ mol}$  (5)

Amount of  $(\text{NH}_4)_2\text{SO}_4$  in  $50.0 \text{ cm}^3$  of fertilizer soln

$$= \frac{0.02}{2}$$
  
 $= 0.01 \text{ mol}$  (5)

Concentration of  $(\text{NH}_4)_2\text{SO}_4$  in fertilizer soln

$$= \frac{0.01}{50.0} \times 1000 \text{ mol dm}^{-3}$$
 (5)

$$= 0.20 \text{ mol dm}^{-3}$$
 (5)

Total for 9 (a) = 90 marks

9(b) Purple coloured ion :  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$  (10)

Green coloured ion :  $[\text{Cr}(\text{H}_2\text{O})_4 \text{Cl}_2]^+$  (10)

(ii)  $\text{Na}-\text{O}-\text{H}$        $\text{K}-\text{O}-\text{H}$        $\text{Cl}-\text{O}-\text{H}$        $\text{Br}-\text{O}-\text{H}$

Difference    0.9    3.5    2.1    -0.8    3.5    2.1    3.0    3.5    2.1    2.8    3.5    2.1

Difference    2.6    1.4    2.7    1.4    0.5    1.4    0.7    1.4

Large difference in E.N. between Na and O (2.6) in NaOH and between K and O (2.7) in KOH (5)

They ionize as  $\text{Na}^+ \text{OH}^-$  and  $\text{K}^+ \text{OH}^-$  (5)

Therefore NaOH and KOH are basic (5)

KOH is more basic than NaOH (5)

In HOBr and HOCl the E.N. difference between the halogen and oxygen is quite small (0.7 and 0.5) (5)

The X - O bond is covalent (5)

Ionization occurs forming  $\text{H}^+$  and  $\text{ClO}^-$  in HOCl and  $\text{H}^+$  and  $\text{BrO}^-$  in HOBr (5)

They are therefore acidic (5)

HOCl is more acidic than HOBr (5)

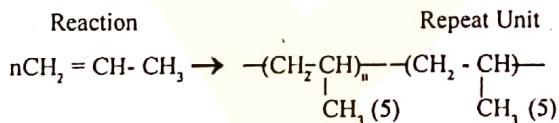
Total for 9 (b) = 60 marks

- (10) (a) (i) High bond energy of N<sub>2</sub> (g) OR N<sub>2</sub> is a very stable molecule (10)
- (ii) The reaction 3H<sub>2</sub> + N<sub>2</sub> = 2NH<sub>3</sub> is exothermic (5)  
Therefore equilibrium yield of NH<sub>3</sub> decreases with increasing temperature (5)  
The yield is high at low temperatures (88% at 200°C) but the time taken to reach equilibrium is long as the reaction rate is low (5)  
Temp. of 550°C is used as a compromise where the yield is reasonable and the reaction rate is not too small (5)
- (iii) Finely divided iron (Fe) or oxides of iron (5)
- (iv) This is gas phase reaction and takes place on the surface of Fe particles (5)  
Catalyst is used in a finely divided state to increase the surface area. (10)
- (v) 2NH<sub>3</sub> + 3CuO → N<sub>2</sub> + 3H<sub>2</sub>O + 3Cu (10)  
Ammonia is passed over heated CuO (5)
- OR  

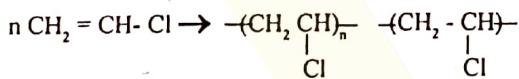
$$\left[ \begin{array}{l} 4\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O} \\ \text{Burning ammonia in O}_2 \end{array} \right] \quad (10) \quad (5)$$
- (vi) Production of fertilizer (Ammonium sulphate, ammonium nitrate)  
Production of Na<sub>2</sub>CO<sub>3</sub> (solvay process)  
As a disinfectant / cleaning agent / refrigerant cany two uses (5+5)

Total for 10 (a) = 75 marks

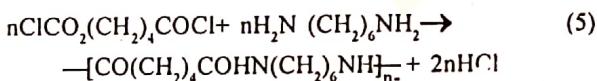
(b) (i) Addition polymerization :



OR



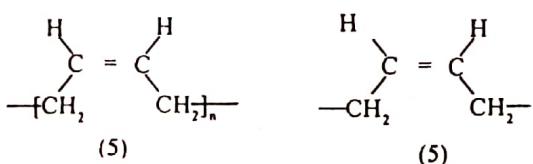
Condensation polymerization :



Repeat unit :

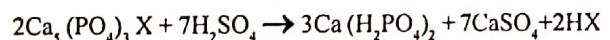


(ii) Polymer Repeat unit

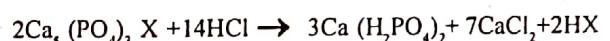


- (iii) Low water solubility of apatite and dolomite  
Therefore not suitable for short - term crops (5+5)  
Conversion to a more soluble form :  
• Formula of apatite Ca<sub>5</sub>(PO<sub>4</sub>)<sub>3</sub>X or 3Ca<sub>5</sub>(PO<sub>4</sub>)<sub>2</sub>CaX<sub>2</sub> (X = Cl, F, OH) (5)  
Any two methods ; Descriptions (10) + (10)  
Equations (5) + (5)

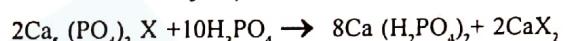
**Acidulation with H<sub>2</sub>SO<sub>4</sub>**



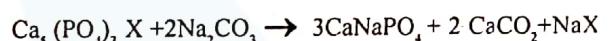
**Acidulation with HCl**



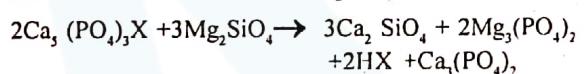
**Treating with H<sub>3</sub>PO<sub>4</sub>**



**Heating with sodium carbonate and silica sand at 900°C**



**Heating with serpentine (Mg<sub>2</sub>SiO<sub>4</sub>)**



\* using apatite mixed with peat (5)

\* Peat is acidic (5)

∴ Reacts slowly with apatite forming more soluble products (5)

Total for 10 (b) = 75 marks