G.C.E. (A/L) Examination
2009 August
Chemistry I / Two hours

Important :

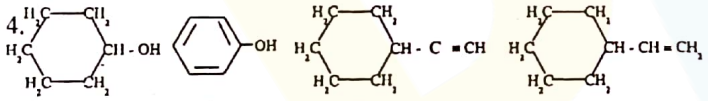
- *This paper consists of 08 pages (Periodic Table is also provided)*
- *Answer **all** the questions.*
- *Use of calculators **is not allowed.***
- ***Write your Index Number** in the space provided in the answer sheet.*
- *Instructions are given on the back of the answer sheet. Follow those carefully.*
- *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. $R = 8.314\ JK^{-1}\ mol^{-1}$
Avogadro Constant $N_A = 6.022 \times 10^{23}\ mol^{-1}$

1. The number of elements that exist as gases at room temperature is.
(1) 8 (2) 9 (3) 10 (4) 11 (5) 12

2. The electronic configuration of the element (X) that forms a diatomic molecule (X_2) with the highest bond energy is,
(1) $1s^2\ 2s^2 2p^6 3s^1$ (2) $1s^2 2s^2 2p^4$
(3) $1s^2 2s^2 2p^3$ (4) $1s^2 2s^2 2p^1$
(5) $1s^2 2s^2 2p^2$

3. Among the following, the molecules/ions having the same shape are,
(A) NH_3 (B) H_3O^+ (C) ClF_3
(D) BCl_3 (E) PCl_3
(1) A and C (2) C and D (3) A, B and E
(4) C, D and E (5) B and C

4. 
A B C D

The correct **increasing** order of the acid strength of the compounds **A,B,C** and **D** is,
(1) **A<C<B<D** (2) **D<C<A<B** (3) **B<D<C<A**
(4) **C<A<B<D** (5) **A<C<D<B**

5. A solution of Na_2SO_4 has been prepared by dissolving 142 mg of pure Na_2SO_4 in water, in a 500 cm^3 volumetric flask and by diluting up to the mark. The Na^+ ion content in mg dm^{-3} units in this solution is, (O = 16.0, Na = 23.0, S = 32.0)
(1) 2.00×10^{-3} (2) 4.00×10^{-3} (3) 46
(4) 92 (5) 184

6. The **decreasing** order of the volume percentages of the gases (A) Ar, (B) CO_2, (C) H_2, (D) N_2 and (E) O_2 in air, in general is,
(1) **D>E>B>A>C** (2) **D>E>A>B>C**
(3) **D>E>B>C>A** (4) **E>D>A>B>C**
(5) **D>A>E>B>C**

7. Which of the following reacts most rapidly when mixed with $ZnCl_2$ and conc. HCl?
(1) $CH_2 = CHC(CH_3)_2OH$ (2) $CH_3CH_2CH(CH_3)OH$
(3) $CH_3C(CH_3)_2OH$ (4) $CH_3CH_2CH_2CH_2OH$
(5) $CH_2 = CHCH_2CH_2OH$

8. The mass percentage of $Na_2S_2O_3.5H_2O$ in an aqueous solution is 20%. The density of this solution at room temperature is 1.24 g cm^{-3}. The molarity of $Na_2S_2O_3$ is this solution is,
(H = 1.0, O = 16.0, Na = 23.0, S = 32.0)
(1) 1.0 (2) 1.0×10^{-3} (3) 0.050 (4) 1.6 (5) 0.10

9. Which of the following statements is **not** true regarding transition elements in general?
(1) They all are metals.
(2) They form complex cations.
(3) They do not form oxy-anions.
(4) They show variable oxidation states.
(5) They have catalytic properties.

10. Which of the following electronic configurations corresponds to the atom with the largest atomic radius among them?
(1) $1s^2 2s^2$ (2) $1s^2 2s^2 2p^6$
(3) $1s^2 2s^2 2p^6 3s^2$ (4) $1s^2 2s^2 2p^6 3s^2 3p^2$
(5) $1s^2 2s^2 2p^6 3s^2 3p^5$

11. In which of the following groups of molecules/ions, nitrogen is in the oxidation states -3, 0 and +3 respectively?
(1) NH_4^+, N_2, NH_2^- (2) N_2O_3, N_2, NH_4^+
(3) N_2H_4, N_2, NCl_3 (4) NO_2, N_2, NO_2^+
(5) NH_4^+, N_2, N_2O_3

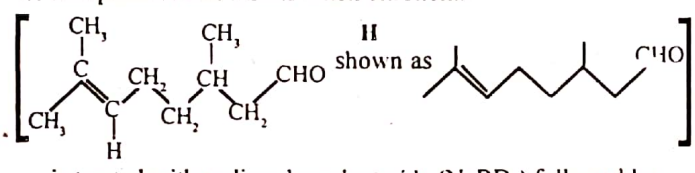
12. What is the IUPAC name of the following compound?
$CH_3\text{-}C(=O)\text{-}CH = CH\text{-}CH(CH_3)\text{-}CO_2H$
(1) 5 - Carboxyhex -3-en-2-one
(2) 5-Oxohex-3-en-2-carboxylic acid
(3) 5-Methyl-2-oxohex-3- enoic acid
(4) 2-Methylhex-5-on-3-enoic acid
(5) 2-Methyl-5-oxohex -3-enoic acid

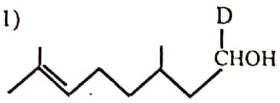
13. The correct **increasing** order of the first ionization energies of the elements from Li to F is,
(1) **Li<B<Be<C<O<N<F** (2) **Li<Be<B<C<N<O<F**
(3) **Li<Be<B<C<O<N<F** (4) **Li<Be<B<O<C<N<F**
(5) **Li<B<Be<O<C<N<F**

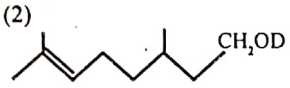
14. A sample of H-atoms excited in a flame has electrons distributed in n = 1,2, 3, 4 and 5 energy levels. How many different wavelengths of radiation are emitted by the sample according to Bohr theory?
(1) 4 (2) 5 (3) 8 (4) 10 (5) 15

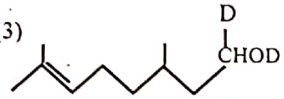
15. The relative molecular masses of **X** and **Y** are in the ratio 2:3. In a mixture of **X** and **Y** the mole fraction of **X** is 1/3. The mass percentage of **X** in the mixture is,
(1) 10% (2) 25% (3) 33.3% (4) 50% (5) 75%

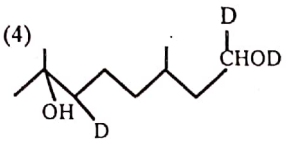
16. Which of the following statements is **not** true regarding H_2O_2?
(1) H_2O_2 disproportionates when heated.
(2) In acid medium, Fe^{2+} ions reduce H_2O_2 to H_2O.
(3) Ag_2O oxidizes H_2O_2 to O_2
(4) H_2O_2 is used as an antiseptic
(5) The dipole moment of H_2O_2 is zero.

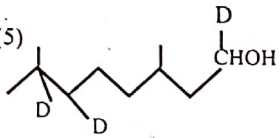
17. The product that results when citronellal

is treated with sodium borodeuteride ($NaBD_4$) followed by hydrolysis with water is

(1) 

(2) 

(3) 

(4) 

(5) 

18. When a salt **X** was heated with dil. H_2SO_4, it evolved a gas that gives a white precipitate with a lead acetate solution. When **X** was heated with dil. H_2SO_4 and Zn, it evolved a gas that gives a black precipitate with a lead acetate solution. The anion present in **X** is,
(1) S^{2-} (2) Cl^-. (3) NO_3^- (4) CO_3^{2-} (5) SO_3^{2-}

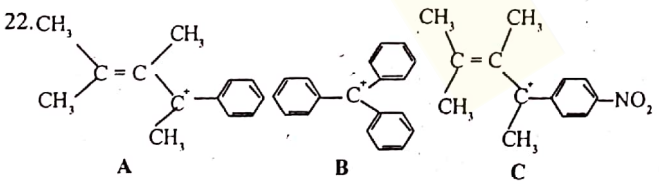
19. The correct **decreasing** order of the ionic radii of the ions Al^{3+}, F^-, Mg^{2+}, Na^+ and O^{2-} is,
(1) $Al^{3+} > F^- > Na^+ > Mg^{2+} > O^{2-}$ (2) $Al^{3+} > Mg^{2+} > O^{2-} > Na^+ > F^-$
(3) $O^{2-} > F > Na^+ > Mg^{2+} > Al^{3+}$ (4) $Al^{3+} > Mg^{2+} > Na^+ > F^- > O^{2-}$
(5) $F^- > O^{2-} > Na^+ > Al^{3+} > Mg^{2+}$

20. The amounts of heat evolved when 25.0cm³ each of the following aqueous solutions are mixed together are given below.

Solutions mixed	Heat evolved
0.1 mol dm^{-3} HCl and 0.1 mol dm^{-3} NaOH	ΔH_1
0.1 mol dm^{-3} HCl and 0.1 mol dm^{-3} NH_4OH	ΔH_2
0.1 mol dm^{-3} CH_3COOH and 0.1 mol dm^{-3} NH_4OH	ΔH_3
0.05 mol dm^{-3} H_2SO_4 and 0.05 mol dm^{-3} $Ba(OH)_2$	ΔH_4

Which of the following is correct?
(1) $\Delta H_1 > \Delta H_2 > \Delta H_3 > \Delta H_4$ (2) $\Delta H_4 = \Delta H_3 = \Delta H_2 = \Delta H_1$
(3) $\Delta H_1 = \Delta H_4 > \Delta H_3 > \Delta H_2$ (4) $\Delta H_1 = \Delta H_4 > \Delta H_2 > \Delta H_3$
(5) $\Delta H_4 > \Delta H_1 > \Delta H_2 > \Delta H_3$

21. Of the following scientists, identify who was **not** connected with the development of the atomic theory?
(1) Neils Bohr (2) J.J. Thomson (3) Chadwick
(4) Linus Pauling (5) Rutherford

22. 
A B C

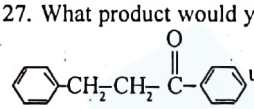
The correct **increasing** order of stability of the carbocations **A**,**B** and **C** is,
(1) **A<B<C** (2) **C<A<B** (3) **B<C<A**
(4) **A<C<B** (5) **C<B<A**

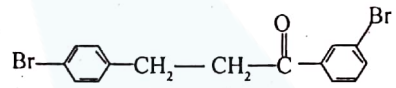
23. Which of the following is the strongest reducing agent in the gas phase?
(1) Al (2) Na (3) Zn (4) H_2 (5) F_2

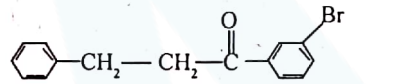
24. Which of the following gases will react with an aqueous solution of $FeBr_3$?
(A) SO_2 (B) CO_2 (C) H_2S (D) Cl_2
(1) **A** and **B** (2) **A**,**B** and **C** (3) **A**, **C** and **D**
(4) **C** and **D** (5) **A**,**B** and **D**

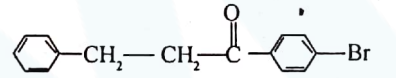
25. Which of the following statements is **not true** regarding electrolysis?
(1) Chemical energy is converted to electrical energy during electrolysis.
(2) The oxidation state of at least one element of a chemical species is changed in each electrode reaction.
(3) The pH of the solution is changed if H_2O is a reactant only in one of the electrode reactions.
(4) The amount of a substance produced during electrolysis depends on the electric current passed.
(5) Electrolysis is a convenient method to produce some metals in pure state.

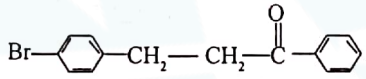
26. Which of the following will **not** evolve ammonia gas when heated with aqueous NaOH?
(1) Urea (2) $(NH_4)_2CO_3$ (3) $NaNO_3$ + Zn powder
(4) $[Cu(NH_3)_4]SO_4$ (5) $NaNO_3$+Fe powder

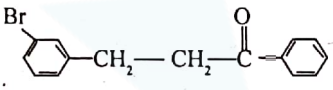
27. What product would you expect when the compound  undergoes bromination with Br_2 and $FeBr_3$?

(1) 

(2) 

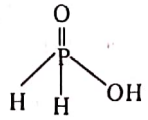
(3) 

(4) 

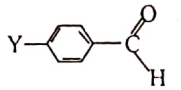
(5) 

28. Which of the followings can be used separately to distinguish between aqueous solutions of Na_2CO_3 and $NaHCO_3$?
(A) Phenolphthalein (B) Methyl orange
(C) Litmas paper (D) Lime water
(1) **A** and **B** (2) **A**, **B** and **C** (3) **B** and **C**
(4) **B** and **D** (5) **A** and **D**

29. The equilibrium constant for the reaction, $Al^{3+}(aq) + 6F^-(aq) \rightleftharpoons AlF_6^{3-}(aq)$ at 25°C is 1.0×10^{25} $mol^{-6}dm^{18}$. The concentration of $AlF_6^{3-}(aq)$ in mol dm^{-3} in the solution obtained when 25.0 cm^3 of 0.010 mol dm^{-3} $Al(NO_3)_3$ and 25.0 cm^3 of 0.10 mol dm^{-3} NaF are mixed with each other is,
(1) 0.010 (2) 0.0050 (3) 0.017
(4) 0.0084 (5) 0.060

30. Hypophosphorous acid has the structure 
Which of the following properties are consistent with the above structure?
(A) It is a reducing agent.
(B) It is a monobasic acid.
(C) Phosphorus atom is in -1 oxidation state.
(D) Phosphorus atom is in +1 oxidation state.
(1) **A** only (2) **B** only (3) **A** and **B** only
(4) **A**, **B** and **D** only (5) **A**, **B** and **C** only

31 The rates of the reaction of benzaldehyde compounds,



(where Y = NO_2, Cl, CH_3 or OH) with hydrogen cyanide, under identical conditions follow the order.

(1) O_2N-C_6H_4-CHO<Cl-C_6H_4-CHO<CH_3-C_6H_4-CHO<HO-C_6H_4-CHO

(2) HO-C_6H_4-CHO<CH_3-C_6H_4-CHO<Cl-C_6H_4-CHO <O_2N- C_6H_4-CHO

(3) Cl-C_6H_4-CHO<CH_3-C_6H_4-CHO<HO-C_6H_4-CHO<O_2N-C_6H_4-CHO

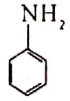
(4) CH_3-C_6H_4-CHO<Cl-C_6H_4-CHO<O_2N-C_6H_4-CHO<HO-C_6H_4-CHO

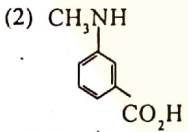
(5) O_2N-C_6H_4-CHO<HO-C_6H_4-CHO<$CH_3C_6H_4$-CHO<Cl-C_6H_4-CHO

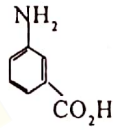
32. Which one of the following statements is **not** true about the hydrogen halides HF, HCl, HBr and HI?
(1) HF has the highest boiling point.
(2) HI has the lowest bond energy.
(3) HI is the strongest acid in aqueous solution.
(4) HF is the most covalent.
(5) HCl has the lowest boiling point.

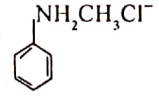
33. $Zn(s)/Zn^{2+}$ (aq, 1.0 mol dm^{-3}) and $Cu(s)/Cu^{2+}$ (aq. 1.0 mol dm^{-3}) electrodes were combined through a salt bridge to construct an electrochemical cell. The standard reduction electrode potentials of the Zn^{2+} (aq)/Zn(s) and Cu^{2+}(aq)/Cu(s) electrodes at 25°C are - 0.76 V and +0.34 V, respectively. The experimentally measured e.m.f. of the above cell at the same temperature was 1.20 V. Which of the following statements would **not** be a possible reason for the deviation of the measured e.m.f. as compared to the expected value?
(1) The concentrations of solutions were slightly different from 1.0 mol dm^{-3}.
(2) The temperature of measurement was different from 25°C.
(3) The Cu rod used to construct the Cu electrode had been corroded.
(4) The Zn rod and the Cu rod were immersed in Cu^{2+} and Zn^{2+} solutions, respectively.
(5) The potentiometer used to measure the potential was not functioning properly.

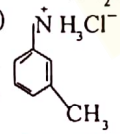
34. Compound A reacts with aqueous Na_2CO_3 releasing a gas that turns lime water milky. A is insoluble in aqueous NaOH. A gives a red dye when treated with nitrous acid followed by phenol in aqueous NaOH. What is the structure of A?

(1) 

(2) 

(3) 

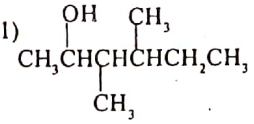
(4) 

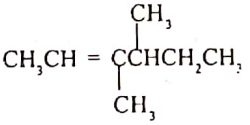
(5) 

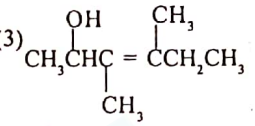
35. A 50.0 cm^3 sample of 1.00 mol dm^{-3} HCl solution was mixed with a 100.0 cm^3 sample of 0.50 mol dm^{-3} NaOH solution in an insulated flask. Then the temperature of the solution mixture rose from 25.0°C to 29.5°C. If the specific heat of the solution mixture is 4.2 J^0C^{-1} g^{-1} and the heat capacity of the flask is negligible, the enthalpy of neutralization of HCl and NaOH, in $KJmol^{-1}$ at this temperatue is.
(1) 1.1 (2) 57000 (3) 57 (4) 570 (5) 2.8

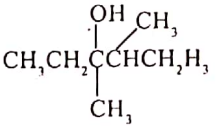
36. The structure of nylon 6,6 is,
(1) $+CO-(CH_2)_6-CONH(CH_2)_4NH+_n$
(2) $+CO-(CH_2)_4CONH(CH_2)_4NH+_n$
(3) $+CO(CH_2)_6NH+_n$
(4) $+CO-(CH_2)_6CO-NH(CH_2)_6NH+_n$
(5) $+CO(CH_2)_4CONH(CH_2)_6NH+_n$

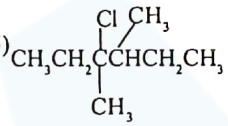
37. 2-Butanol reacts with acidified sodium dichromate to give **A**. Another sample of 2-butanol reacts with PCl_3 to give **B**. When heated with magnesium and ether, **B** gives **C**. **A** and **C** react to give a product which hydrolysis produces **D**. What is the structure on of **D**?

(1) 

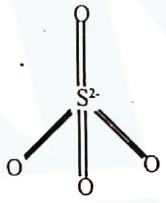
(2) 

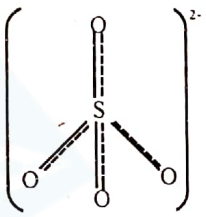
(3) 

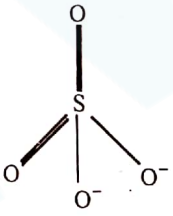
(4) 

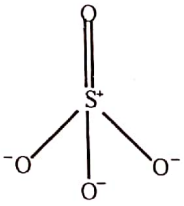
(5) 

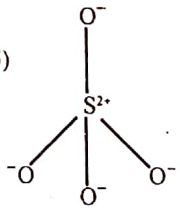
38. The structure which is closest to the true structure of the sulphate ion is

(1) 

(2) 

(3) 

(4) 

(5) 

39. In which of the following solvents would hexane have the lowest solubility?
(1) Dichloromethane
(2) Diethyl ethre
(3) Ethanol
(4) Ethyl acetate
(5) Porpanone

40. What would happen to the concentration of Fe^{3+} in a saturated solution of $Fe(OH)_3$ when the pH of the solution is increased by one unit?
(1) Decrease by 1000 times. (2) Decrease by 10 times
(3) Increase by 1000 times (4) Increase by 10 times.
(5) Remain unchanged.

- **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 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 correct.

41. Which of the following statements regarding water is/are true?
(a) Water reacts more readily with ethanoyl chloride than with chloroethane.
(b) Water reacts readily with CH_3MgBr to produce methanol.
(c) The dipole moment of a water molecule is zero.
(d) In ice, four hydrogen atoms are arranged tetrahedrally around each oxygen atom.

42. Which of the following substance(s) would produce acidic solutions when dissolved in water?
(a) NH_4Cl *(b)* NH_4ClO_3 *(c)* CH_3COONa *(d)* NaF

43. **A** and **B** are two miscible liquids. The boiling point of **A** is higher than that of **B**. An equimolar solution of **A** and **B** is placed in an evacuated vessel and allowed to reach equilibrium with its vapour. Which of the following is/are true regarding this system? (Assume ideal behaviour.)
At equilibrium,
X_A = mole fraction of A in solution phase.
X_B = mole fraction of B in solution phase.
Y_A = mole fraction of A in vapour phase.
Y_B = mole fraction of B in vapour phase.

(a) $X_A = X_B$ *(b)* $X_A + X_B = Y_A + Y_B$ *(c)* $X_A < X_B$
(d) $Y_A < Y_B$

44. Which of the following statements is/are **not** true regarding graphite?
(a) All the carbon atoms in graphite are sp^3 hybridized.
(b) It has a high melting point.
(c) It is a conductor of electricity.
(d) It is used as a fuel in industry.

45. Which of the following statements is/are true about steam distillation?
(a) Steam distillation is used to obtain ethanol after fermentation of sugar.
(b) Steam distillation of cloves gives an essential oil that contains eugenol as the major constituent.
(c) The composition of the distillate remains the same during steam distillation of cinnamon leaves.
(d) Steam distillation is used in refining petroleum.

46. Which of the following statements is/are true about metals?
(a) They conduct electricity.
(b) The density of all metals is higher than that of water.
(c) They react with dilute acids always liberating H_2 gas
(d) Majority of the elements are metals.

47. Which of the following statements is/are true regarding a homogeneous chemical reaction system at dynamic equilibrium?
(a) The rate constants of forward and reverse reactions are equal.
(b) The concentrations of all components of the reaction are constant at any time.
(c) The Le chatelier principle can be used to predict the change in the system upon addition of a reactant.
(d) Increase in temperature will increase the rates of both forward and reverse reactions only if the equilibrium is endothermic.

48. Which of the following conversions is/are neither an oxidation nor a reduction?
(a) $N_2O_3 \longrightarrow N_2O$ *(b)* $CrO_4^{2-} \longrightarrow Cr_2O_7^{2-}$
(c) $ClO^- \longrightarrow Cl^-$ *(d)* $SO_3 \longrightarrow SO_4^{2-}$

49. $CH_3CH_2\underset{\displaystyle Br}{\underset{|}{C}}HCH_2\ CH = CHCH_3$

Which of the following statements is/are true about the above compound?
(a) It has **four** stereoisomers.
(b) It reacts with aqueous HCl to give a mixture of **two** alcohols which show position isomerism.
(c) When subjected to catalytic hydrogenation, it gives a haloalkane which does not show stereoisomerism.
(d) A purple coloration is observed when aqueous $FeSO_4$ is added to a sodium fusion extract of the above compound.

50. Which of the following statements is/are true for a sample of an ideal gas?
(a) The distribution of molecular speeds depends on temperature.
(b) At constan t pressure, the rate of change in volume with respect to temperature is **independent** of the temperature scale, centigrade or Kelvin.
(c) The volume of the sample is constant as long as the temperature is kept constant.
(d) The pressure of the gas depends on the square (2nd power) of the number of collisions that occurs per unit time.

- **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

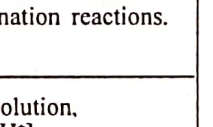
	First Statement	Second Statement
51	HF is a weaker acid than HCl in aqueous solution.	Fluorine is more electronegative than chlorine.
52	Addition of a few drops of H_2SO_4 increases the electrical conductance of water.	H_2SO_4 acid increases the dissociation of water molecules.
53	Polyvinyl chloride is an unsaturated polymer.	Polyvinyl chloride is made by the polymerization of CH_2=CH-Cl.
54	In nucleophilic addition reactions, aliphatic aldehydes are generally more reactive than aliphatic ketones.	The electron release from the alkyl groups in a ketone makes the carbonyl carbon less positively charged.
55	An oxidation reaction and a reduction reaction always occur simultaneously.	All chemical reactions are disproportionation reactions.
56	The change in $[H^+]$ when the pH of a solution is changed from 1 to 2 is the same as when the pH is changed from 3 to 4.	In aqueous solution, $pH = -\log_{10}[H^+]$
57	$C_6H_5CH_2NH_2$ and $C_6H_5NH_2$ are soluble in aqueous HCl, but $C_6H_5CONH_2$ is insoluble in aqueous HCl.	Base strength of $C_6H_5CONH_2$ is higher than that of either $C_6H_5CH_2NH_2$ or $C_6H_5NH_2$.
58	A wet litmus paper **cannot** be used to distinguish between CO_2 and SO_2.	Both CO_2 and SO_2 are acidic gases.
59	Real gases deviate more from ideal behaviour at high pressures and low temperatures.	A real gas molecule has a smaller volume than an ideal gas molecule.
60	The ionic product of water, K_w, decreases as the temperature is increased.	Dissociation of water is an exothermic process.

G.C.E. (A/L) Examination 2009 August Chemistry II / Three hours

- Periodic Table is provided on page 14.
- Use of calculators is not allowed.

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 extensive answers are not expected.
- **In answering questions 3 and 4, you may represent alkyl groups in a condensed manner.**

e.g.  may be shown as CH_3CH_2 -

PART B and PART C - Essay (pages 8-13)

* Answer **four** questions selecting not more than 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.
* Take R = 8.314 JK^{-1} mol^{-1} and N_A = 6.022 x 10^{23} mol^{-1}

PART A - STRUCTURED ESSAY

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

1. (a) Define "atomic mass unit."

.....

.....

(1.0 marks)

(b) The element A forms the anions AF_2^- and AF_4^-. AF_2^- is linear and AF_4^- is square plannar in shape.

(i) Sketch the shapes of AF_2^- and AF_4^- indicating the arrangement of lone pairs if any, on the central atom.

AF_2^- AF_4^-

(ii) State the group in the periodic table to which **A** belongs.

.....

(4.0 marks)

(c) $^{4}_{2}X + {}^{}_{4}Be \rightarrow {}^{12}_{6}C + {}^{\ldots}_{\ldots}Y$

(i) Fill in the blanks denoted by dotted lines (...) at **three** places in the above equation.

(ii) Identify X and Y.

X = ... Y = ...

(2.5 marks)

(d) The first ionization energies of five consecutive elements in the periodic table with atomic numbers Z, Z+1, Z+2, Z+3 and Z+4 are given below. Z is less than 16 and one of these elements is a metal. The ionization energy values are not given in any particular order.

Ionization Energies : 495, 1313, 1681, 2081, 1402 $kJ\ mol^{-1}$

Write in the table given below, the relevant ionization energy value for each element.

Atomic number	Z	Z+1	Z+2	Z+3	Z+4
Ionization energy /kJ mol^{-1}					

(2.5 marks)

2 (a) $X.H_2$ is a white crystalline salt. The elements present in X and their mass percentages are given below.

Element	C	H	N	O
Mass %	19.4	6.4	22.6	51. 6

(C = 12. 0, H = 1.0, N = 14.0, O = 16. 0)

(i) Deduce the empirical formula of X.

.....

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.....

(ii) On heating, one mole of **X** produces **two** moles of NH_3 as the only nitrogen containing product. Write the molecular formula of X.

.....

(iii) A warm aqueous solution of **X** decolorizes an acidified $KMnO_4$ solution. Write the chemical name of **X**.

.....

(5.0 marks)

(b) (i) What is meant by the standard enthalpy of formation of $CO_2(g)$?

.....

.....

.....

(ii) When a sample of 72.0 g graphite is burnt in oxygen under standard conditions, the product mixture is found to contain by mass 28% CO(g), 66% $CO_2(g)$ and unburnt C(s).

Standard enthalpy of formation of CO(g) = -111 $kJ\ mol^{-1}$

Standard enthalpy of formation of $CO_2(g)$ = -394 $kJ\ mol^{-1}$

(C = 12.0, O = 16. 0)

I. Calculate the following :

A The mole ratio of C(s), CO(g) and $CO_2(g)$ in the product mixture.

.....

.....

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B. The number of moles of CO(g) released.

.....

.....

.....

C. The number of moles of $CO_2(g)$ released.

.....

.....

D. The heat released on burning 1.0 mol of graphite under standard conditions.

.....

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II. Using the above thermochemical data, deduce whether the conversion of CO(g) to $CO_2(g)$, under standard conditions, is endothermic or exothermic.

.....

.....

.....

.....

.....

(5.0 marks)

3. (a) An industrially important organic compound X, contains carbon, hydrogen and oxygen only.

(i) Write a balanced chemical equation for the complete combustion of **X** taking its molecular formula as $C_xH_yO_z$.

.....

(ii) The combustion of 62 mg of **X** (relative molecular mass. M_r = 62) gives 88 mg of CO_2 and 54 mg of H_2O. Deduce values for x, y and z in the molecular formula $C_xH_yO_z$. (C = 12.0, H = 1.0, O = 16.0)

.....

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(iii) The reaction of 62 mg of X with sodium gives 2 mg of hydrogen gas. Deduce the structure of X.

.....

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.....

.....

(4.4 marks)

(b) (i) What is the **main** type of intermolecular force present in each of ethanol (M_r = 46), methanoic acid (M_r = 46) and propane (M_r = 44)?

In ethanol : .....

In methanoic acid : .....

In propane : .....

(ii) Arrange ethanol, methanoic acid and propane in the **increasing** order of their boiling points.

.....

(iii) Explain your answer in (ii) above.

.....

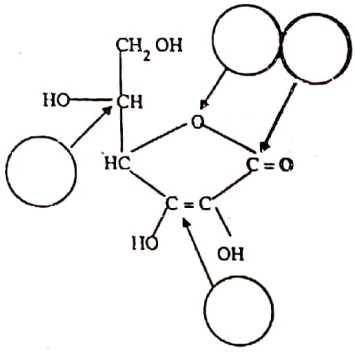
.....

.....

.....

.....

(c) The molecular structure of vitamin C is given below. Write the hybridisation of the carbon and oxygen atoms indicated by arrows as sp, sp^2 or sp^3 in the appropriate circle.

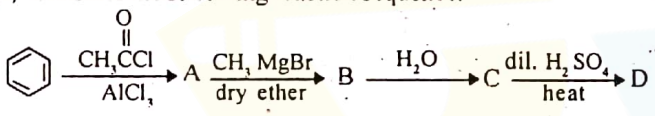


(1.6 marks)

(d) An optically active compound, $C_6H_{12}O$, gives a yellow precipitate with 2,4 - dinitrophenylhdrazine but does not react with ammoniacal silver nitrate. What is the structure of the compound?

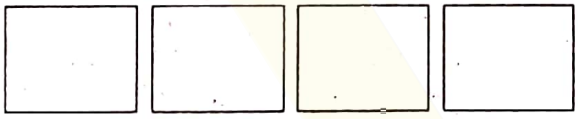
(1.6 marks)

4 (a) Consider the following reaction sequence.



Reaction 1 Reaction 2 Reaction 3 Reaction 4

(i) Write the structures of **A**,**B**,**C** and **D** in the boxes given below.



A B C D

(ii) Classify each of the reactions in the above sequence as addition (Ad), elimination (E), rearrangement (R) or substitution (S) by writing Ad, E, R or S in the appropriate cage.

Reaction	1	2	3	4
Reaction type				

(iii) Write the active species and whether it is an electrophile or a nucleophile, in each of the reactions 1 and 2 in the appropriate cages.

Reaction	Active species	Electrophile/ Nucleophile
1		
2		

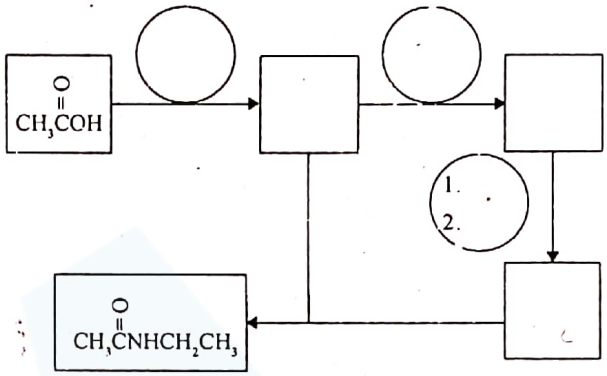
(2.4 marks)

(b) Complete the syntheses in **schemes A** and **B** selecting appropriate reactants/ reagents/ solvents **only** from those given with each scheme.

* Write the structures of appropriate compounds in the boxes and the reagents/ solvents in the circles.
* Indicate temperature where it is important.

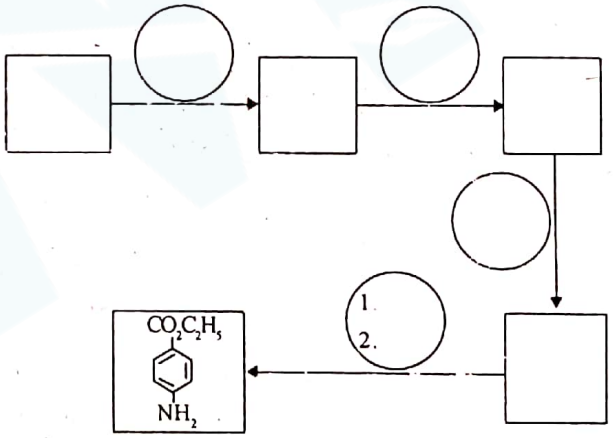
(i) **Scheme A**

Reagents/ solvents :
Mg, P_2O_5, PCl_5, $LiAlH_4$, $NaBH_4$, CH_3CHO, conc. NH_3, dil. H_2SO_4, water, dry ether



(i) **Scheme B**

Reactants/ regents / solvents :
nitrobenzene, toluene ($C_6H_5CH_3$), CH_3Cl, $AlCl_3$, Zn(Hg), Sn, $KMnO_4$, $NaNO_2$, conc. HNO_3, conc. H_2SO_4, conc. HCl, aq. NaOH, water, ethanol



(7.6 marks)

PART B - ESSAY

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

* Take R = 8.314 $JK^{-1} mol^{-1}$ and $N_A = 6.022 \times 10^{23} mol^{-1}$

5. (a) (i) 2.0 mol of X(g) was heated upto 450 K in a closed container to establish the equilibrium.

$$X(g) \rightleftharpoons 2Y(g)$$

At this equilibrium, it was found that 25% of the initial amount of **X**(g) was decomposed to produce **Y**(g) and the total pressure was 6.0×10^5 Nm^{-2}.

Calculate the following :

I. The mole fractions of **X**(g) and **Y**(g) at equilibrium

II. The equilibrium constant, K_p

(ii) When the temperature of the above system was increased to 600 K, **Y**(g) also underwent decomposition to establish the following equilibrium.

$$X(g) \rightleftharpoons 2Y(g) \rightleftharpoons Z(g)$$

When 2.0 mol of **X**(g) was initially used, it was found that 1.0 mol **X**(g) and 0.50 mol **Z**(g) were present together with **Y**(g) at equilibrium.

I. Calculate the following :

(A) The number of moles of **Y**(g) at equilibrium.

(B) The mole fractions of **X**(g), **Y**(g) and **Z**(g) at equilibrium.

(C) The total pressure of the system at equilibrium.

(D) The equilibrium constant for $X(g) \rightleftharpoons 2Y(g)$

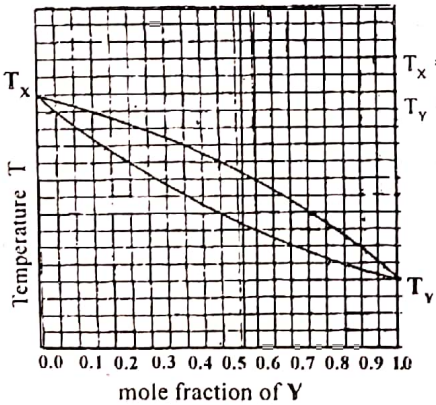
II. (A) State the assumptions, if any, you used in part C above.

(B) Is the reaction $X(g) \rightarrow 2Y(g)$ exothermic or endothermic? Briefly explain your answer.

(9.0 marks)

(b) (i) 75.0 cm^3 of an aqueous solution of solute **E** was shaken well with 50.0 cm^3 of $CHCl_3$ at room temperature, and allowed the two layers to reach equilibrium. Calculate the distribution coefficient, K_D, for the distribution of **E** between $CHCl_3$ and water if 75% of **E** (mol %) was extracted into the organic phase at equilibrium.

(ii) Two **unreactive** liquids X and Y, which are completely miscible in all proportions, are at equilibri with their vapour phase over the temperature range from T_X to T_Y. This equilibrium is shown in following phase diagram.



T_X = Boiling point of pure X

T_Y = Boiling point of pure Y

Use the above phase diagram to answer parts I & II below.

I. If an equimolar solution of X and Y is in equilibrium with the vapour phase, what is the mole ratio of X and Y (X : Y) in the vapour phase

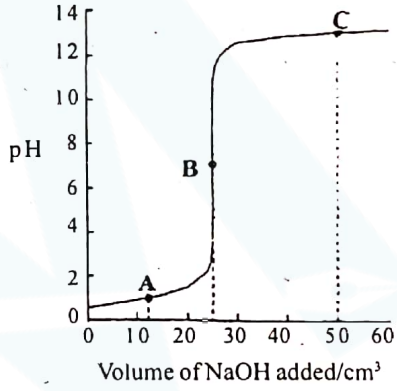
II. Briefly explain how a mixture of X and Y could be separated into pure components

(6.0 marks)

6 (a) Four titrations were conducted using different acid and base solutions as shown in the table below.

Titration	Acid solution	Volume of acid solution /cm^3	Base solution
I	0.300mol dm^{-3} HCl	25.00	0.300mol dm^{-3} NaOH
II	0.030 mol dm^{-3} HCl	25.00	0.030 mol dm^{-3} NaOH
III	0.300 mol dm^{-3} CH_3COOH	25.00	0.300 mol dm^{-3} NaOH
IV	0.150 mol dm^{-3} CH_3COOH	25.00	0.150 mol dm^{-3} NaOH

(i) The pH - titration curve of titration I is given below.



Points **A**,**B** and **C** of the curve represent the additions of 12.50 cm^3, 25.00 cm^3 and 50.00 cm^3 volumes of the NaOH solution respectively to the HCl solution. Calculate the pH values corresponding to these three points.

(ii) For each of the titrations II, III and IV, indicate whether the pH values corresponding to the add of 12.50 cm^3, 25.00 cm^3 and 50.00 cm^3 of the NaOH solution, decreased, increased or remain unchanged with respect to the points A,B and C of titration I. Use a table as shown below in your answer script to answer this part of the question.

Titrations	Volume of NaOH added/cm^3		
	12. 50	25. 00	50. 00
II			
III			
IV			

(iii) Give reasons for changes in pH values you mentioned in titration III.

(9.0 marks)

(b) Chlorine dioxide (ClO_2) undergoes the following reaction in alkaline medium

$$2ClO_2(aq) + 2OH^-(aq) \rightarrow ClO_3^-(aq) + ClO_2^-(aq) + H_2O(l)$$

The initial rates determined for the above reaction carried out at a constant temperature by changing the initial concentration of ClO_2 and initial pH are given below.

Initial concentration of ClO_2/ mol dm^{-3}	Initial pH	Initial rate mol dm^{-3} s^{-1}
0.060	12	0.022
0.020	12	0.0025
0.020	13	0.024

(i) Calculate the order of the reaction with respect to ClO_2 and with respect to OH^-

(ii) The mechanism of the above reaction does not change when the temperature is increased by 10°C Predict whether.

I. the rate of the reaction

II. the order with respect to each reactant would increase, decrease or remain unchanged when the temperature is increased by 10°C.

(6.0 marks)

7. (a) (i) At room temperature, 25.0 cm^3 of 4.00 x 10^{-3} mol dm^{-3} $AgNO_3$ solution were maixed with 75.0 cm^3 of 8.00 x 10^{-3} mol dm^{-3} NaBr solution.

I. Show that a precipitation occurs.

II. The resulting precipitate was separated and dried. Calculate the mass of the dry precipitate.

(ii) A 0.166 g sample of Ag_2CrO_4 was thoroughly shaken with 50.0 cm^3 of distilled water at room temperature. 50.0 cm^3 of 2.00 x 10^{-5} mol dm^{-3} NaCl solution were then added to the resulting Ag_2CrO_4 suspension and mixed well. The following changes were then observed.

(A) The reddish-brown precipitate dissolved and a white precipitate was formed.

(B) The colour of the supernatant solution became distinctly yellow.

Explain the above observations using suitable calculations.

Relative molar masses : AgCl = 143.5, AgBr = 188.0, Ag_2CrO_4 = 332.0

At room temperature,

K_{sp} (AgBr) = 5.0 x 10^{-13} mol^2 dm^{-6}

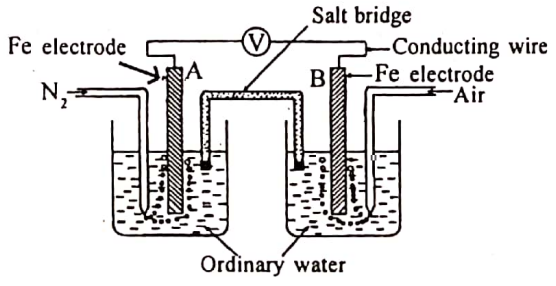
K_{sp} (AgCl) = 1.8 x 10^{-10} mol^2 dm^{-6}

K_{sp} (Ag_2CrO_4) = 2.4 x 10^{-12} mol^3 dm^{-9}

Molar solubility of Ag_2CrO_4 = 8.4 x 10^{-5} mol dm^{-3}

(10.0 marks)

(b) Consider the following electrochemical cell.



(i) Which electrode (A or B) is the cathode?

(ii) Which electrode (A or B) is negatively charged?

(iii) Write a **balanced** equation for the electrode reaction that occurs at A.

(iv) Write a **balanced** equation for the electrode reaction that occurs at B.

(v) Write a **balanced** equation for the overall cell reaction.

(vi) Give one chemical test in each case to show the forma tion of the ionic species that you have given in (iii) and (iv) above.

(vii) The overall cell reaction you have given in (v) above occurs during a common natural process. Name this process.

(5.0 marks)

PART C - ESSAY

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

8. (a) A solution Y contains dil. H_2SO_4 and oxalic acid.

(i) 25.00 cm^3 of this solution was titrated with a 0.050 mol dm^{-3} $KMnO_4$ solution. The volume of $KMnO_4$ solution required was 24.00 cm^3.

(ii) The solution obtained after completing the titration (i) was further titrated with a 0.040 mol dm^{-3} NaOH solution. The volume of NaOH solution required was 15.00 cm^3.

I. Write balanced chemical equations for the reactions.

II. Calculate the concentrations of

(A) Oxalic acid and

(B) H_2SO_4 acid

in the solution Y.

(8.0 marks)

(b) (ii) Using balanced chemical equations only, suggest one method for the synthesis of each of the following compounds starting from limestone.

I. Bleaching powder

II. A phosphorus fertilizer

III. Acetylene

(ii) During April 2009, a ship containing 6500 tonnes of conc. H_2SO_4 sank off the port of Trincomalee. Predict the possible threats/impacts that could occur due to leaking of conc. H_2SO_4 to the marine environment.

(7.0 marks)

08 (a) (i) Outline briefly how you would identify the following dilute aqueous solutions by mixing them with one another.

KI, $Fe_2(SO_4)_3$, $BaCl_2$, $K_4Fe(CN)_6$

(ii) Outline how you would identify the following aqueous solutions/finely powdered metals by reacting them with one another.

Al, Zn, NH_4Cl, NaOH

(7.0 marks)

(b) A is a coloured inorganic salt containing the metallic element M. On heating, A decomposes giving a green residue B (M_2O_3), a colourless gas C and water vapour. One mole of A gives one mole of residue B. The gas C reacts with heated magnesium forming a white solid D. D reacts with water forming a gas E which turns red litmus blue. Heating A with Na_2CO_3 solution also produces the gas E. The green residue B gives a yellow solution when warmed with an alkaline solution of H_2O_2.

(i) Identify A,B, C, D and E.

(ii) Write **balanced** chemical equations for the relevant reactions.

(8.0 marks)

10 (a) (i) In the determination of dissolved oxygen in a sample of water, 250 cm^3 of the water sample was treated with a solution of $MnSO_4$ and an excess of KI in an alkaline medium. The solution was then acidified and the liberated iodine was titrated with 0.020 mol dm^{-3} $Na_2S_2O_3$ solution. The volume of $Na_2S_2O_3$ solution required was 10.00 cm^3.

(I) Give **balanced** chemical equations for the relevant reactions.

(II) Calculate the concentration of dissolved oxygen in mg dm^{-3} of the water sample. (O = 16.0)

(ii) Hydrogen peroxide is decomposed into H_2O and O_2 on warming.

I. Write **balanced** ionic equations for the two half reactions relevant to this decomposition.

II. Outline one titrimetric method to determine the concentration of an aqueous solution of H_2O_2. (No experimental details are required)

(7.5 marks)

(b) To answer this part of the question, use the page 13 (at the end of PART A) which contains a flow chart.

Consider the production of Na_2CO_3 by Solvay process.

In the flow-chart provided, (page No. 13)

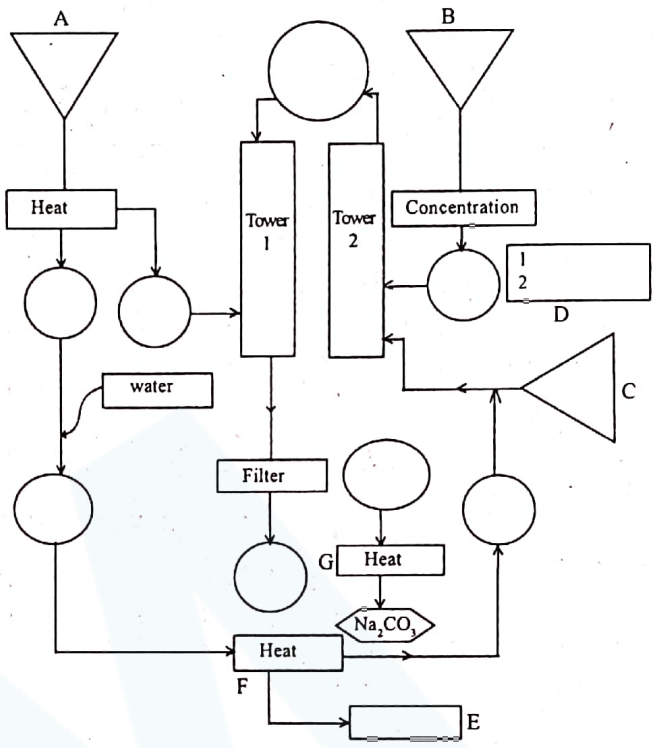
(i) write in the triangles A,B and C, the starting meterials used.

(ii) write in the box D, two by-products formed during the concentration of the starting material in B.

(iii) write in the box E the waste material produced in the process.

(iv) write in the circles the chemical formulae of the appropriate substances involved in the process.

- Only use this page to answer question numbe 10 of PART C. (Question number 10 is not compulsory)



Write in spaces provided below, the **balanced** equations for chemical reactions taking place at F,G and in tower 1.

(v) at F .....

(vi) at G .....

(vii) in tower 1

.....

.....

.....

.....

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 - 2009

M.C.Q. Answers

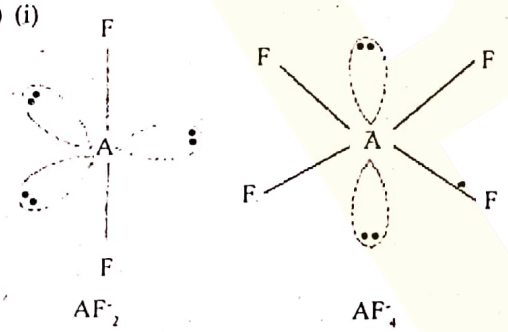
(1) - 4	(16) - 5	(31) - 2	(46) - 4
(2) - 3	(17) - 1	(32) - 4	(47) - 2
(3) - 3	(18) - 5	(33) - 4	(48) - 5
(4) - 2	(19) - 3	(34) - 5	(49) - 1
(5) - 4	(20) - 5	(35) - 3	(50) - 1
(6) - 2	(21) - 4	(36) - 5	(51) - 2
(7) - 1	(22) - 2	(37) - 4	(52) - 3
(8) - 1	(23) - 2	(38) - 2	(53) - 4
(9) - 3	(24) - 3	(39)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

PART A - STRUCTURED ESSAY

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

1. (a) $\frac{1}{12}$th the mass of on atom of ^{12}C (isotope) (10)

(b) (i)



AF_2^- AF_4^- (15) + (15)

(ii) VII A (or 17 or halogen group or group VII) (10)

(c) (i) $^{4}_{2}X + {}^{9}_{4}Be \rightarrow {}^{12}_{6}C + {}^{1}_{0}Y$

(ii) X - α particle or He

Y - n or neutron (5 x 5)

(d)

Atomic number	Z	Z+1	Z+2	Z+3	Z+4
Ionization Energy/ KJ mol^{-1}	1402	1313	1681	2081	495

(5 x 5)
100 marks

02. (a) (i)

Element	C	H	N	O
Mass %	19.4	6.4	22.6	51.6
	12.0	1.0	14.0	16.0
	1.62	6.4	1.6	3.2
	1	4	1	2

12 x (02)

CH_4NO_2 (06)

(ii) $C_2H_8N_2O_4$ (10)

(iii) Ammonium oxalate (10)

2 (a) = 50 marks

(b) (i) The enthalpy change when one mole of CO_2 (g) is formed from C (granite) and O_2 (g) at a specified temperature and at 1 atm pressure. (10)

(ii) I. A.

	C	:	CO	:	CO_2
Mass %	6	:	28	:	66
No. of moles	$\frac{6}{12.0}$		$\frac{28}{28.0}$		$\frac{66}{44.0}$ (3x2=6)
Mole ratio	= 0.5		= 1.0		= 1.5 (3)
	1	:	2		3 (3)

B. $\frac{72.0g}{12.0\ g\ mol^{-1}} \times \frac{2}{6}$ (2)

= 2 mol (2)

C. $\frac{72.0g}{12.0\ g\ mol^{-1}} \times \frac{3}{6}$ (2)

= 3 mol (2)

D. $\frac{2}{6}$ mol x 111 kJ mol^{-1} + $\frac{3}{6}$ mol x 394 kJ mol^{-1} 2(1+1)

= 234 kJ (2+2)

II. $CO\ (g) + 1/2\ O_2\ (g) \longrightarrow CO_2(g)$

Enthalpy change when 1 mol of CO_2 is formed

= -394kJ - (-111kJ) (2+2)

= -283 kJ (1+1)

Reaction is exothermic (6)

2 (b) = 50 marks

03. (a) (i) $2C_xH_yO_z + \frac{1}{2}(4x+y-2z)\ O_2 \longrightarrow 2xCO_2 + yH_2O$

(2+2) (2+2) (2+2)

(ii) $C_xH_yO_z \xrightarrow{O_2} xCO_2 + \frac{y}{2} H_2O$

62 mmol 88 mmol 54mmol

62 44 18

1 mmol 2 mmol 3 mmol (4)

$C_2H_6O_z$ $\therefore x = 2$ (4) $\therefore y = 6$ (4)

$M\gamma = 12 \times 2 + 1x\ 6 + 16\ z = 62$

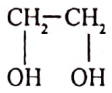
$\therefore \quad z = 2$ (4)

(iii) 62 m mol of x gives $\frac{2}{2}$ m mol of H_2

That is, 1 m mol of x gives 1 m mol of H_2 (4)

Na reacts with 1 mol of OH gp, give 1/2 mol of H_2 (4)

∴ x has 2 OH gps (4)

∴ x is  (4)

3 (a) = 44 marks

(b) (i) In ethanol : hydrogen bonding / dipole - dipole attractive forces (4)

In methanoic acid : hydrogen bonding / dipole - dipole attractive forces (4)

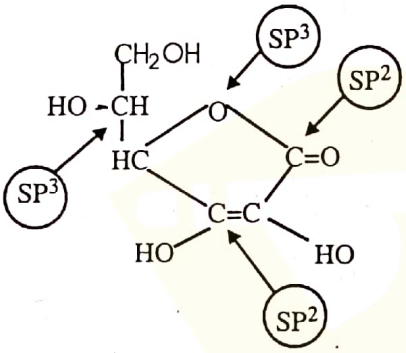
In propane : Vanderwaals attraction / London forces/ Dispersion forces/ attractive forces between non-polar molecules (4)

(ii) propane < ethanol < methanoic acid (4)

(iii) Hydrogen bonding is stronger than Vanderwaals forces. (4)
Between 2 molecules, ethanol has 1 hydrogen bond and methanoic acid has 2 hydrogen bonds (4)

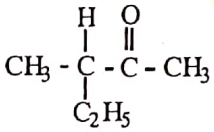
3 (b) = 24 marks

(c)



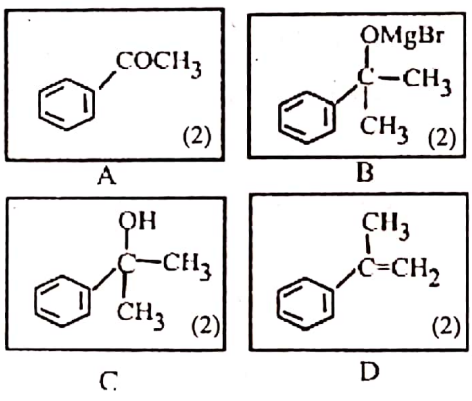
(4 x 4)

3 (c) = 16 marks

(d)  (16)

3 (d) = 16 marks

04. (a) (i)



(ii)

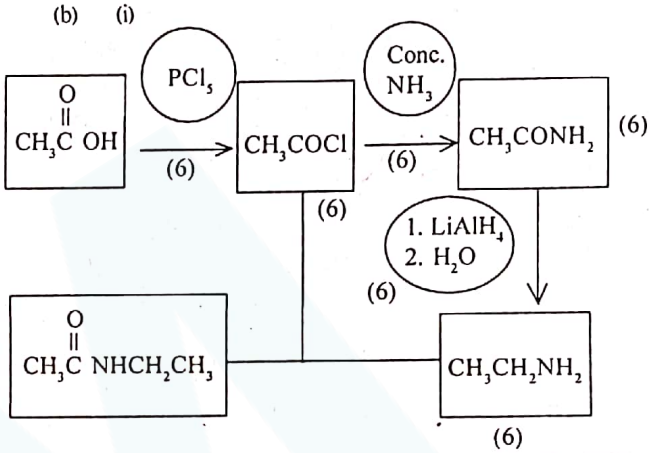
Reaction	1	2	3	4
Reaction type	S (2)	Ad (2)	S (2)	E (2)

(iii)

Reaction	Active Species	Electrophile/ Nucleophile
1	$CH_3C^+=O$ (2)	Electrophile (2)
2	CH^-_3 (2)	Nucleophile (2)

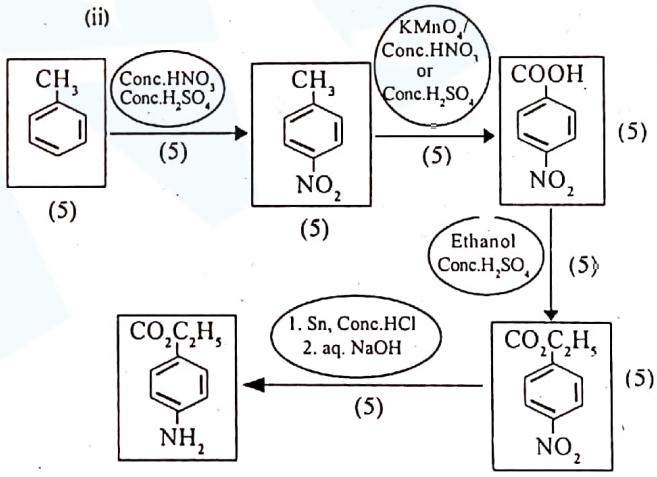
4 (a) = 24 marks

(b) (i)



(6 x 6 =36)

(ii)



5 x 8 =40

4 (b) = 76 marks

5. a) i) $X_{(g)} \rightleftharpoons 2Y_{(g)}$

Initially	2.0	..... mol
At eqm.	2.0 (1-25/100)	2 x 2.0x (25/100) mol
	= 1.5	1.0 mol (2+1)

2 x (2+1)

I. Total amount of X(g) and Y(g) at equilibrium
= 1.5 + 1.0 mol
= 2.5 mol (2+1)

Mole fraction of X(g) = 1.5 mol / 2.5 mol
= 3/5 (or 0.6) (3)

Mole fraction of Y(g) = 1.0 mol / 2.5 mol
= 2/5 (or 0.4) (3)

II. $K_p = \frac{(P_Y)^2}{P_X}$

$= \frac{(2/5P)^2}{3/5\ P}$ (P = total pressure or $6.0 \times 10^5\ Nm^{-2}$) (3)

$= 4/15\ P$

Substituting for P,

$K_p = 4/15 \times 6.0 \times 10^5\ Nm^{-2}$ (2+1)

$= 1.6 \times 10^5\ Nm^{-2}$ (2+1)

a (i) = 30 marks

ii) I(A) $X_{(g)} \rightleftharpoons 2Y_{(g)} \rightleftharpoons Z_{(g)}$

Initially	2.0	—	..... mol
At eqm.	1.0		0.5 mol OR

Amount of X dissociated = 1.0 mol (2+1)

Amount of Y initially formed = 2.0 mol (2+1)

Amount of Y then dissociated to yield 0.5 mol of Z
= 1.0 mol (2+1)

Amount of y remained at equilibrium = 2.0 - 1.0 mol (2+1)
= 1.0 mol (2+1)

(B) $X_{(g)} \rightleftharpoons 2Y_{(g)} \rightleftharpoons Z_{(g)}$

At eqm.	1.0	1.0	0.5 mol

Total amount of X(g), Y(g) and Z(g) at equilibrium
= 1.0 + 1.0 + 0.5 mol
= 2.5 mol (2+1)

Mole fraction of X(g) = 1.0 mol / 2.5 mol
= 2/5 (or 0.4) (3)

Mole fraction of Y(g) = 1.0 mol / 2.5 mol
= 2/5 (or 0.4) (3)

Mole fraction of Z(g) = 0.5 mol / 2.5 mol
= 1/5 (or 0.2) (3)

(C) Apply pV = nRT at the two temperatures (3)

Total number of moles and the volume have not changed

$\frac{6.0 \times 10^5\ Nm^{-2}}{P} = \frac{450k}{600k}$ (2 +1)

$p = 8.0 \times 10^5\ Nm^{-2}$ (2 +1)

D) $K_p = \frac{(P_Y)^2}{P_X}$

$= \frac{(2/5P)^2}{2/5\ P}$ (P = total pressure or $8.0 \times 10^5\ Nm^{-2}$) (3)

$= 2/5\ P$ (3)

Substituting for P, $K_p = 2/5 \times 8.0 \times 10^5\ Nm^{-2}$ (2+1)

$= 3.2 \times 10^5\ Nm^{-2}$ (2+1)

II (A) Assumption : 1. Ideal behavior (3)

2. The container does not expand OR volume does not change. (3)

(B) Kp has increased when the temperature is increased from 450 K to 600 K (3)

Therefore, the reaction is endothermic (3)

Total for part (a) (ii) = 60 marks

b) i) $K_D = \frac{[E]_{CHCl_3}}{[E]_{H_2O}}$ (3)

Let C = Concentration of E, in mol dm^{-3} . in the aqueous phase before partitioninge.

Amount of E initially present
= C mol dm^{-3} x 0.075 dm^3 (2+1)

After partition equilibrium,

Amount of E remaining in the equeous phase
= C mol dm^{-3} x 0.075 dm^3 x (1-75/100) (2+1)

$[E]_{H_2O} = \frac{C\ mol\ dm^{-3} \times 0.075\ dm^3 \times (1-75/100)}{0.075\ dm^3}$ (2+1)

$= C \times 25/100\ mol\ dm^{-3}$ (2+1)

Amount of E transferred to the organic phase
= C mol dm^{-3} 0.075 dm^3 x (75/100) (2+1)

$[E]_{CHCl_3} = \frac{C\ mol\ dm^{-3}\ 0.075\ dm^3 \times (75/100)}{0.050\ dm^3}$ (2+1)

$= C \times 3/2 \times 75/100\ mol\ dm^{-3}$ (2+1)

$k_D = \frac{C \times 3/2 \times 75/100\ mol\ dm^{-3}}{C \times 25/100\ mol\ dm^{-3}}$ (2+1)

$= 9/2$ (or 4.5) (3)

Note : $K_D = 2/9$ if $K_D = \frac{[E]_{H_2O}}{[E]_{CHCl_3}}$ is used

Total for part (b) (i) = 30 marks

ii) Mole fraction of Y = 0.75 (5)

Mole fraction of X = 0.25 (5)

Mole ratio of X :Y = 0.25 : 0.75 or 1:3 (5)

II. Distill the mixture and collect the distillate (3)

According to the diagram, it will have more Y compared to the initial mixture (3)

Distill it again (3)

The distillate will have even more Y compared to that of the first distillate (3)

Continue this process until the distillate contains only Y. (3)

Total for part (b) (ii) = 30 marks

Total for part (b) = 60 marks

6. a) i) Point A

Concentration of H^+ from excess acid

$= \frac{(0.300\ mol\ dm^{-3} \times 25.00\ cm^3 - 0.300\ mol\ dm^{-3} \times 12.5\ cm}{37.50\ cm^3}$ (3+2)

$= \frac{0.300\ mol\ dm^{-3} \times 12.50\ cm^3}{37.50\ cm^3}$ (3+2)

$= 0.100\ mol\ dm^{-3}$ (3+2)

Point B

Concentration of H^+ from excess acid.

$= \frac{0.300\ mol\ dm^{-3} \times 25.00\ cm^3 - 0.300\ mol\ dm^{-3} \times 25.00\ cm}{50.00\ cm^3}$

0 (3+2

OR,

The titration is between a strong acid and a strong base. (5)

H+ ions are only due to the ionization of water.

pH = 7.00 (5)

Point C

Concentration of OH^- from excess base

$$= \frac{(0.300 \text{ mol dm}^{-3} \times 50.00 \text{ cm}^3 - 0.300 \text{ mol dm}^{-3} \times 25.00 \text{cm}^3}{75.00 \text{ cm}^3} \quad (3+2)$$

$$= 0.100 \text{ mol dm}^{-3} \quad (3+2)$$

$$pOH = -\log (0.100) = 1.00$$

$$pH = 14.00 - 1.00 = 13.00 \quad (5)$$

Total for part (a) (i) = 40 marks

ii)

Titration	Volume of NaOH added, cm^3		
	12.50	25.00	50.00
II	increased	unchanged	decreased
III	increased	increased	unchanged
IV	increased	increased	decreased

9 answers x 4 marks = 36 marks

Total for part (a) (ii) = 36 marks

ii) Point A

CH_3COOH is a weak acid OR Ionization of CH_3COOH is incomplete. (2)

$[H^+]$ in titration III < $[H^+]$ in titration I at the same point (2)

pH in titration III > pH in titration I (or pH is increased)

Point B

CH_3COOH has been completely converted to CH_3COONa (2)

CH_3COONa solutions are basic (2)

pH > 7 (or pH in titration III >pH in titration I)

Point C

This point characterized by the excess NaOH (2)

Volume and the concentrations of the acids in titrations I and III are the same (2)

Concentration of the base is the same (2)

pH is unchanged

part (a) (iii) = 14 marks

Total for part (a) = 90 marks

b) i) Let m = order of the reaction with respect to ClO_2 and

n = order of the reaction with respect to OH^-

rate $[ClO_2]^m [OH^-]^n$ or

rate = $k [ClO_2]^m [OH^-]^n$ (10)

Trial I : $[OH^-] = 1.0 \times 10^{-2}$ mol dm^{-3} (3+2)

0.022 mol dm^{-3} s^{-1} $\propto$ [0.060 mol dm^{-3}]^m [1.0x10^{-2} mol dm^{-3}]^n ① (4+1)

Trial 2 :

0.0025mol dm^{-3}s^{-1} $\propto$ [0.0201mol dm^{-3}]^m[1.0x 10^{-2} mol dm^{-3}]^n ② (4+1)

Trial 3 : $[OH^-] = 1.0 \times 10^{-1}$ mol dm^{-3}

0.024 mol dm^{-3}s^{-1} $\propto$ [0.020 mol dm^{-3}]^m [1.0x10^{-1} mol dm^{-3}]^n 3 ④ (4+1)

$$\frac{①}{②} \quad \frac{0.022}{0.0025} = \left(\frac{0.060}{0.020}\right)^m \quad (5)$$

$$8.8 = 3^m$$

$$m \approx 2 \quad (5)$$

$$\frac{③}{②} \quad \frac{0.024}{0.0025} = \left(\frac{1.0 \times 10^{-1}}{1.0 \times 10^{-2}}\right)^n \quad (5)$$

$$9.6 = 10^n$$

$$n \approx 1 \quad (5)$$

Total for part (b) (i) = 50 marks

ii) (I) Rate is increased when the temperation is increased (5)

(II) Mechanism is not changed when the temperature is increased.

Order with respect to each reactant is not changed. (5)

part (b) (ii) = 10 marks

Total for part (b) = 60 marks

7. (a) (i) $AgNO_3(aq) + NaBr(aq) \rightleftharpoons AgBr(s) + NaNO_3(aq)$

or $Ag^+(aq) + Br^-(aq) \rightleftharpoons AgBr(s)$ (4)

I. $[Ag^+]_{aq} = 4.00 \times 10^{-3}$mol dm^{-3} x 25.00 dm^3 /100.00 cm^3

$= 1.00 \times 10^{-3}$mol dm^{-3} (3+1)

$[Br^-]_{aq} = 8.00 \times 10^{-3}$ mol dm^{-3} x 75.00cm^3 /100.00cm^3

$= 6.00 \times 10^{-3}$mol dm^{-3} (3+1)

$[Ag^+]_{aq}[Br^-]_{aq} = (1.00 \times 10^{-3}$mol dm$^{-3}) \times (6.00 \times 10^{-3}$mol dm$^{-3})$

$= 6.00 \times 10^{-6}$mol^2 dm^{-6} (3+1)

$> K_{sp}$ of AgBr (4)

precipitation occurs (4)

II. Limiting reagent is $AgNO_3(aq)$ or $Ag^+(aq)$

or NaBr is in excess or Br^- is in excess (4)

Mass of precipitate

$= 4.00 \times 10^{-3}$mol dm^{-3} x 0.0250 dm^{-3} x 188.0g mol^{-1}

Or $= 1.00 \times 10^{-3}$mol dm^{-3} x 0.100dm^3 x 188.0g mol^{-1} (6+2)

$= 0.0188$ g (3+1)

Total for part (a) (i) =40 marks

ii. Mass of Ag_2CrO_4 dissolved in 50.0 cm^3

$= 8.4 \times 10^{-5}$mol dm^{-3} x 332.0 g dm^{-1} x 0.050 dm^3

$= 0.00139$ g (3+1)

This is less than the mass of Ag_2CrO_4 used (4)

Initially a reddish brown precipitate of Ag_2CrO_4 obseved (4)

Concentration of Cl^- in the final solution (of 100.0 cm^3)

$= 2.00 \times 10^{-5}$ mol dm^{-3} x (50.0 cm^3 / 100.0cm^3)

$= 1.00 \times 10^{-5}$ mol dm^{-3} (3+1)

Concentration of Ag^+ needed to precipitate AgCl

$= Ksp\ [AgCl_s] / [Cl^-_{aq}]$ (3+1)

$= 1.8 \times 10^{-10}$ mol^2 dm^{-6} / 1.00×10^{-5} mol dm^{-3}

$= 1.8 \times 10^{-5}$ mol dm^{-3} (3+1)

Concentration of Ag^+ in a saturated solution of Ag_2CrO_4
$= 2x\ (8.4 \times 10^{-5})$ mol dm^{-3} (3+1)
$= 1.7 \times 10^{-4}$ mol dm^{-3} (3+1)
This is greater than the required concentration (4)
Therefore, AgCl precipitates as a white solid (4)

Alternative answer I

Concentration of Ag^+ in a saturated solution of Ag_2CrO_4
$= 2x\ (8.4 \times 10^{-5})$ mol dm^{-3}
$= 1.7 \times 10^{-4}$ mol dm^{-3} (6+2)
$[Ag^+]_{aq}[cl^-]_{aq} = (1.7 \times 10^{-4}$ mol dm$^{-3}) \times (1.00 \times 10^{-5}$ mol dm$^{-3})$
$= 1.7 \times 10^{-9}$ mol^2 dm^{-6} (6+2)
$> K_{sp}$ (AgCl) (4)
Therefore, AgCl precipites as a white solid. (4)

Alternative answer II

Concentration of Ag^+ needed to precipitate AgCl
$= K_{sp}[AgCl]_s / [Cl^-]_{aq}$ (3+1)
$= 1.8 \times 10^{-10}$ mol^2 dm^{-6} / 1.00×10^{-5} mol dm^{-3}
$= 1.8 \times 10^{-5}$ mol dm^{-3} (3+1)

Mass of Ag_2CrO_4 that would produce the above concentration
$= 1.8 \times 10^{-5}$ mol dm$^{-3} \times (1/2) \times 0.100$ dm$^3 \times 332$g mol^{-1} (3+1)
$= 0.00030$ g (3+1)
Mass of Ag_2CrO_4 (0.166g) is higher (4)
Therefore, AgCl precipitates as a white solid (4)
Molar solubility of AgCl $= (1.8 \times 10^{-10})$ mol dm^{-3}
OR
$= 1.3 \times 10^{-5}$ mol dm^{-3} (3+1)
Molar solubility of AgCl < Molar solubility of Ag_2CrO_4 (4)
More Ag_2CrO_4 will come into solution as Ag+ is precipitated as AgCl (8)
yellow coloured supernatant solution is observed

part (a) (ii) = 60 marks
Total for part (a) = 100 marks

b) i) B (5)
ii) A (5)
iii) $Fe(s) \longrightarrow Fe^{2+}(aq) + 2e$ (5)
iv) $2H_2O(l) + O_2(g) + 4e \longrightarrow 4OH^-(aq)$ (5)
v) $2Fe(s) + 2H_2O(l) + O_2(g) \longrightarrow 2Fe^{2+}(aq) + 4OH^-(aq)$ (5)
vi) To show the formation of Fe^{2+} :
Add a solution of $K_3Fe(CN)_6$ (5)
Appearence of blue colour (5)
To show the formation of OH^- :
Add a few drops of phenolphthalein (5)
Red or pink colour (5)
vii) Corrosion or rust formation (5)

Total for part (b) = 50 marks

8. (a) (i) Balanced chemical equations
$2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \longrightarrow 10\ CO_2 + 2Mn^{2+} + 8H_2O$
OR
$2KMnO_4 + 5H_2C_2O_4 + 3H_2SO_4 \longrightarrow 10\ CO_2 + 2MnSO_4 + 8H_2O + K_2SO_4$ (10)
OR
$MnO_4^- + 8H^+ + 5e \longrightarrow Mn^{2+} + 4H_2O$ (5)
$C_2O_4^{2-} \longrightarrow 2CO_2 + 2e$ (5)
$H^+ + OH^- \longrightarrow H_2O$ (5)
OR
$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

II. (A) Amount of MnO_4^- in 24.0 cm^3
$= \frac{0.05 \times 24.0}{1000}$ mol $= 1.2 \times 10^{-3}$ mol (5)
Amount of $C_2O_4^{2-}$
$= \frac{0.05 \times 24.0 \times 5}{1000 \times 2}$ mol $= 3.0 \times 10^{-3}$ mol (5)

Concenration of oxalicacid
$= 3.0 \times 10^{-3} \times \frac{1000}{25.0}$ mol dm^{-3} (5)
$= 0.12$ mol dm^{-3} (3+2)

(B)
[Amount of H^+ ions from H_2SO_4] = [Amount of H^+ ions remaining after step (i)] + [Amount of H^+ ions used in step (i)] - [Amount of H^+ ions from oxalic acid] (10)

Amount of H^+ remaining after step (i)
$= \frac{0.04 \times 15.0}{1000}$ mol $= 6.0 \times 10^{-4}$ mol (5)
Amount of H^+ ions used in step (i) $= 8 \times 1.2 \times 10^{-3}$ mol (5)
Amount of H^+ from oxalic acid $= 2 \times 3.0 \times 10^{-3}$ mol
$= 6.0 \times 10^{-3}$ mol (5)
Amount of H^+ from H_2SO_4
$= 6 \times 10^{-4}$ mol $+ 8 \times (1.2 \times 10^{-3}$ mol$) - 2 \times (3.0 \times 10^{-3}$ mol$)$
$= 4.2 \times 10^{-3}$ mol (5)
NO. of moles of H_2SO_4 in 25cm^3 of Y $= \frac{4.2}{2} \times 10^{-3}$ mol (5)
Concentration of H_2SO_4 $= 2.1 \times 10^{-3} \times \frac{1000}{25}$ mol dm^{-3} (5)
$= 0.084$ mol dm^{-3} (3+2)

Total for part (a) = 80 marks

(b) i) (I) Bleaching powder.
$CaCO_3 \longrightarrow CaO + CO_2$ (5)
$CaO + H_2O \longrightarrow Ca(OH)_2$ (5)
$2Ca(OH)_2 + Cl_2 \longrightarrow Ca(OCl)_2 + CaCl_2 + H_2O$ OR
$3Ca(OH)_2 + 2Cl_2 \longrightarrow Ca(OCl)_2.CaCl_2.Ca(OH)_2 + 2H_2O$ (10)

(II) $CaCO_3 \longrightarrow CaO + CO_2$
$3CaO + P_2O_5 \longrightarrow Ca_3(PO_4)_2$ OR
$3CaO + 2H_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3H_2O$ (10)
Balanced equations with $CaCO_3 + H_3PO_4$ are also accepted.

(III) $CaCO_3 \longrightarrow CaO + CO_2$
$CaO + 3C$ (coke) $\longrightarrow CaC_2 + CO$ (5)
$CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$ (10)

(ii) Harmful to fauna (animals, fish) Harmful to flora (plants) Harmful to corals
Lowering of pH, Evolution of heat,
Evolution of CO_2, Evolution of Cl_2 (and other halogens)
any five - 5 x 05 = (25)
part (b) = 70 marks

9. (a) i) KI, $Fe_2(SO_4)_3$, $BaCl_2$, $K_4[Fe(CN)_6]$ (solutions are dilute identification by colour not accepted)
The two solutions that give a white ppt when mixed are $Fe_2(SO_4)_3$ and $BaCl_2$. (5) Take one of these solutions (we don't know which is which) and to the other two. (5) If the added solution does not produce any observale change (5), then the solution added is $BaCl_2$ (5). The other solution is $Fe_2(SO_4)_3$ (5)

Add this $Fe_2(SO_4)_3$ solution to the two remaining solutions (KI, $K_4[Fe(CN)_6]$) (5). That which produces ablue coloration / ppt is $K_4[Fe(CN)_6]$, the other is KI. (5)
OR that which produces a brown colour (due to I_2) is KI, the other is $K_4[Fe(CN)_6]$

ii) React the two meta powders separately with the two solutions. (5)
The soloution that dissolves the metal powders is NaOH (5)
The other is NH_4Cl (5)
Now add NH_4Cl solution, to the two solutions of the metal powders in NaOH. (5)
The solution that produces a white ppt. (5) contains Al. (5)
The other contains Zn (No ppt is formed here) (5)

part (b) = 70 marks

b) i) A = $(NH_4)_2Cr_2O_7$ (15)
B = Cr_2O_3 (10)
C = N_2 (10)
D = Mg_3N_2 (10)
E = NH_3 (10)

$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4H_2o$

$3Mg + N_2 \rightarrow Mg_3N_2$

$Mg_3N_2 + 6H_2O \rightarrow 2NH_3 + 3Mg(OH)_2$

$(NH_4)_2Cr_2O_7 + 2Na_2CO_3 \rightarrow 2NH_3 + 2Na_2CrO_4 + H_2O + 2CO_2$

$Cr_2O_3 + 4NaOH + 3H_2O_2 \rightarrow 2Na_2CrO_4 + 5H_2O$
OR
$Cr_2O_3 + 4OH^- + 3H_2O_2 \rightarrow 2CrO_4^{2-} + 5H_2O$

5 x 5= 25

Total for part (b) = 80 marks

10. a) i) Reactions

$2Mn^{2+} + 4\ OH^- + O_2 \rightarrow 2MnO_2(s) + 2H_2O$
OR
$MnSO_4 + 2OH^- \rightarrow Mn(OH)_2 + SO^{2-}_4$

$2Mn(OH)_2(s) + O_2(aq) \rightarrow 2MnO(OH)_2(s)$
OR
$2Mn(OH)_2(s) + O_2(aq) \rightarrow 2MnO_2(s) + 2H_2O$
$MnO_2 + 4H^+ + 2I^- \rightarrow Mn^{2+} + 2H_2O + I_2$
$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$

(4 x 5= 20)

$1mol\ O_2 \equiv 2mol\ MnO_2 \equiv 2mol\ I_2 \equiv 4\ mol\ S_2O_3^{2-}$

The sample of water (250 cm^3) required 10.0cm^3 of 0.02 mol dm^{-3} $Na_2S_2O_3$
No. of moles of $S_2O_3^{2}$ required for titration
$= \frac{0.02 \times 10}{1000} = 2 \times 10^{-4}$ (5)
Amount of dissolved O_2 = $(2 \times 10^{-4})/4$ mol (5)
= 5.0×10^{-5} mol

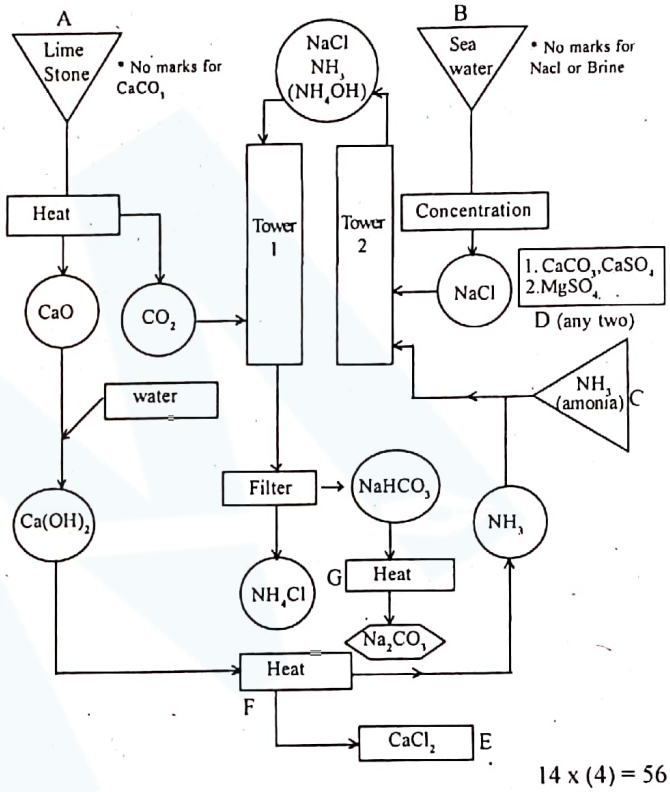
Concentration of dissolved O_2
$= \frac{5.0 \times 10^{-5} \times 1000}{250}$ mol dm^{-3} (5)
$= 2.x\ 10^{-4} \times 32$ g dm^{-3} = 0.0064 g dm^{-3}
= 6.4 mg dm^{-3} (3+2)

ii) I) $H_2O_2 + 2H^+ + 2e \rightarrow 2H_2O$ (5)
$H_2O_2 \rightarrow O_2 + 2H^+ + 2e$ (5)

II) React a known volume (5) of H_2O_2 with excess (5) of KI solution (5) tritrate the liberated I_2 with standard $S_2O_3^{2-}$
OR (5)
Titrate a known volume (5) of H_2O_2 with standard (5) acidified (5) $KMNO_4$ solution (5)

part (b) = 70 marks

10. (b)



14 x (4) = 56

(v) at F $2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O$ (5)
(vi) at G $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$ (5)
(vii) In tower 1

$NH_3(g) + H_2O \rightleftharpoons NH_4^+ + OH^-$
$CO_2(g) + H_2O \rightleftharpoons HCO_3^- + H^+$
$NH_4^+ + Na^+ + Cl^- + HCO_3^- \rightarrow NaHCO_3(s) + NH_4Cl$ OR
$NH_3 + NaCl + CO_2 + H_2O \rightarrow NaHCO_3(s) + NH_4Cl$
OR
$NH_3 + CO_2 + H_2O \rightarrow NH_4HCO_3$
$NH_4HCO_3 + NaCl \rightarrow NaHCO_3 + NH_4Cl$ (9)

part (b) = 75 marks