G.C.E. Advanced Level

Grade 13

Chemistry I

Three hours

Channel NIE

Instructions:

- Answer **all** the questions.
- Select the correct or the most appropriate answer.

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

01. The existence of positive charges in matter was experimentally confirmed by

(1) J. J. Thomson.
(2) Eugene Glodstein.
(3) Ernest Rutherford.
(4) James Chadwick.
(5) William Crookes.

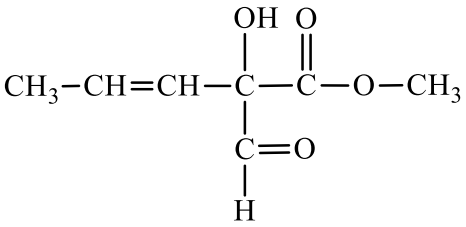
02. Of the following statements given about ionisation energies, which statement is true?

(1) First ionisation energy of B is greater than the first ionisation energy of Be.
(2) First ionisation energy of O is greater than the first ionisation energy of N.
(3) Fourth ionisation energy of B is greater than the fourth ionisation energy of Al.
(4) Second ionisation energy of Be is greater than the second ionisation energy of Li.
(5) First ionisation energy of Ne is greater than the first ionisation energy of He.

03. Which of the following statements is true about the compounds of sulphur?

(1) SO_2 behaves as a reductant in the reaction between SO_2 and H_2S.
(2) Sulphur is oxidised to SO_2 by hot, concentrated HNO_3.
(3) When reacts with hot, concentrated H_2SO_4, sulphur is oxidised to SO_3.
(4) A $Na_2S_2O_3$ solution can discharge the colour of an aqueous I_2 solution.
(5) Hot concentrated H_2SO_4 dehydrates CH_3COOH molecules giving an alkene.

04. What is the correct IUPAC name of the compound,



(1) 4-hydroxy-4-formy1-5-methoxy-1-pentenone

(2) 4-formy1-4-hydroxy-5-methoxy pent-2-en-lone

(3) methyl -2-formy1-2-hydroxy-3-pentenoate

(4) methyl 2-formy1-2-hydroxy-3-pentenoate

(5) methyl 2-hydroxy-2-formyl-3-pentenoate

05. What is the **false** statement about addition polymers?

(1) The monomer has unsaturated bonds.

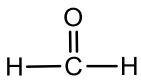
(2) Hybridisations of the monomer and the repeating unit are not identical.

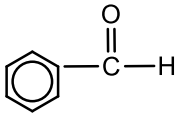
(3) Molar masses of the monomer and the repeating unit are equal.

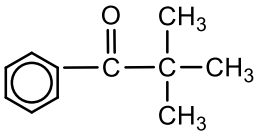
(4) The repeating unit is not unsaturated in any instance.

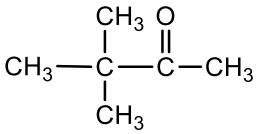
(5) The relative molecular mass of the polymer assumes a high value.

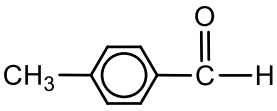
06. Of the following compounds, which can undergo self-condensation under basic conditions to double its number of carbon atoms?

(1) 

(2) 

(3) 

(4) 

(5) 

07. In the organic compound X, the enthalpy change and entropy change for fusion are 9.95 kJ mol^{-1} and 35.7 J K^{-1} mol^{-1} respectively. The melting point of X is

(1) 278.7 K (2) 279.2 K (3) 298 K (4) 298.3 K (5) 300 K

08. Which of the following statement is true about halogens?

(1) Bond dissociation energy increases in the order $I_2 < Br_2 < C1_2 < F_2$.

(2) The heat liberated in electron gain increases in the order I < Br < C1 < F.

(3) Hydrides of all elements in the halogen group are thermally unstable.

(4) The acidic strength of hydrides increases in the order HI < HBr < HC1 < HF.

(5) Cl_2 shows a disproportionation reaction with water.

09. The coloured solid X when heated, thermally dissociates leaving a black residue. When that residue is dissolved in a dilute acid and aqueous ammonia is added in excess, a green precipitate is obtained which gradually turns brown. Which of the following could be X?

(1) $Fe(NO_3)_3$ (2) $Fe(NO_3)_2$ (3) $Cr(NO_3)_3$

(4) $Cu(NO_3)_2$ (5) $Ni(NO_3)_2$

10. Which of the following is true about ionic compounds?

(1) Conduct electricity in both solid state and fused state.

(2) In all the ionic compounds, the cation is derived from a metal.

(3) All ionic compounds readily dissolve in water.

(4) Aqueous solutions of ionic compounds contain mobile ions.

(5) The rows which constitute the ionic lattice liberate energy.

11. Consider the following.

a) NO b) CO_2 c) volatile hydrocarbons d) sunlight

Of the above, the factors necessary for the formation of the photochemical smog are,

(1) only a and b. (2) only b and c. (3) only c and d.

(4) only a, b and d. (5) only a, c and d.

12. Select the correct statement about iron extraction.

(1) Coke acts as the main reducing agent.

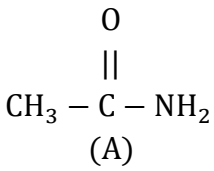
(2) The temperature of the hot air supplied to the blast furnace is higher than that at its bottom.

(3) As the molten iron floats on the slag, its separation is easy.

(4) The main reason for maintaining the temperature of the blast furnace at a higher value is the burning reaction of coke.

(5) The waste gas freed from the blast furnace contains only carbon dioxide gas.

13. Which is the correct statement about A?



(A)

(1) A is more basic than aniline.

(2) The C-N bond length in A is greater than the normal C-N bond length.

(3) The reaction of A with $NaBH_4$ gives a primary amine.

(4) The reaction of A with alkyl halides can be speeded up by bases.

(5) A primary alcohol can be obtained from A using $NaNO_2$/Dil.HCl.

14. A 1.0×10^{-3} mol dm^{-3} $MgSO_4$ solution and a 2.0×10^{-5} mol dm^{-3} $Ba(OH)_2$ solution were mixed together. The volume of $Ba(OH)_2$ solution mixed was twice as much as the volume of $MgSO_4$ solution. when mixing the above solutions,

[$K_{sp}(BaSO_4) = 1.0 \times 10^{-10}$ $mol^2 dm^{-6}$, $K_{sp}(Mg(OH)_2) = 1.0 \times 10^{-11}$ mol^3 dm^{-9}]

(1) no precipitate is formed.

(2) both $BaSO_4$ and $Mg(OH)_2$ precipitate.

(3) only $Mg(OH)_2$ precipitates.

(4) only $BaSO_4$ precipitates.

(5) the order of precipitation cannot be predicted.

15. An aqueous solution contains 0.03 mol of FeC_2O_4 and 0.02 mol of $Na_2C_2O_4$. If this solution is acidified and titrated with a 1.3 mol dm^{-3} $KMnO_4$ solution, what will be the burette reading?

(1) 4.6 cm^3 (2) 15.4 cm^3 (3) 20.0 cm^3

(4) 46.0 cm^3 (5) 200.0 cm^3

16. At 25 ^{0}C, 250.00 cm^3 of a 0.05 mol dm^{-3} solution of a weak acid HX were mixed with 250.00 cm^3 of an organic solvent, shaken well and allowed to reach the equilibrium. At equilibrium, the pH of the aqueous layer was 3.57. What is the distribution coefficient, K_D for the distribution of HX between the organic and aqueous layers?

(1) 8.2 (2) 7.5 (3) 2.8 (4) 5.6 (5) 9.2

17. Both the nitrate and carbonate of the element M when thermally decomposed by Bunsen flame give the same residue. This residue, when dissolved in water gives a strongly basic solution. This solution imparts a colour to the Bunsen flame. If the iodide of M is covalent, which of the following can be M?

(1) Li (2) Na (3) Mg (4) Ba (5) Cu

18. Which of the following statements can be true about 'S' block elements?

(1) All elements in Group 1 form superoxides.
(2) The peroxides of elements in Group 1 are not thermally decomposed.
(3) All elements in Group 2 form nitrides.
(4) The bicarbonates of Group 1 are not thermally decomposed.
(5) The water-solubility of Group 2 hydroxides decreases down the group.

19. Of the follwing organic compounds, which gives an optically active compound in its reaction with HBr in a polar medium?

(1) 2-bromobut-2-ene (2) 2-bromopropene
(3) 1-bromobut-1-ene (4) 2-methylbut-2-ene
(5) 2-butene

20. What is the equilibrium constant for the following reaction? (K_a values of NH_4^+ and HCN are 5.76 x 10^{-10} mol dm^{-3} and 4.8 x 10^{-10} mol dm^{-3} respectively.)

$$NH_4^+(aq) + CN^-(aq) \rightleftharpoons NH_3(aq) + HCN(aq)$$

(1) 0.83 (2) 1.2 (3) 8.0x10^{-11} (4) 27.6 x10^{-10} (5) 8.1 x10^{-10}

21. Which of the following will happen when an aluminium nitrate solution is is stirred with a copper spoon?

(1) Aluminium gets deposited on the spoon.
(2) Aluminium-copper alloy forms on the spoon.
(3) A reaction doesn't occur.
(4) The solution turns blue.
(5) Gas bubbles are liberated from the solution.

22. A sodium hydroxide solution of pH=9 is prepared by diluting its initial solution 1000 times. The pH value of the initial solution is

(1) 6 (2) 8 (3) 9 (4) 10 (5) 12

23. Which of the following is the correct statement about the reaction of the organic compound CH_3-CH_2-Br with OH^- ions?

(1) Ethene is obtained as the major product of the elimination reaction taking place with aqueous OH^-.

(2) Ethonol is obtained as the major product of the reaction taking place with OH^- in alcoholic medium.

(3) Ethonal is the major product of the nucleophilic substitution reaction taking place with aqueous OH^-.

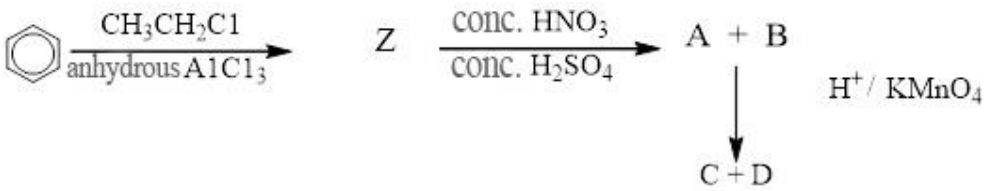
(4) Ethane is the major product of the nucleophilic addition reaction taking place with OH^- in alcoholic medium.

(5) Ethene is the major product of the nucleophilic substitution reaction taking place with OH^- in alcoholic medium.

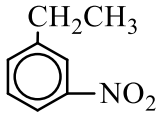
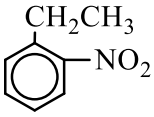
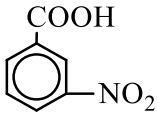
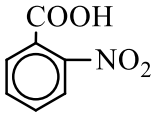
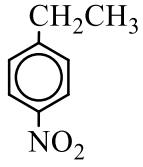
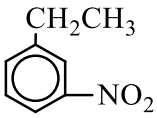
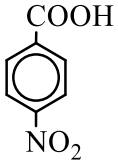
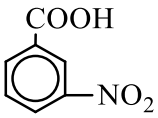
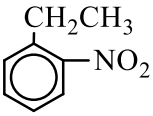
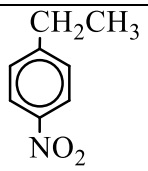
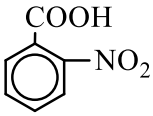
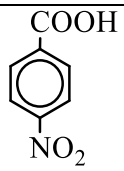
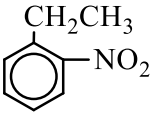
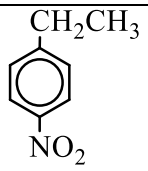
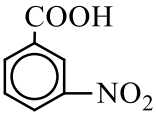
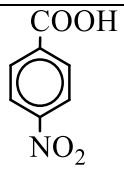
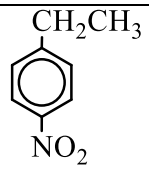
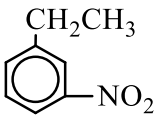
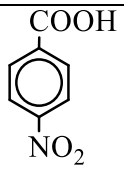
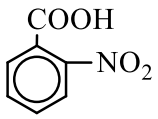
24. When a certain amount of pure Mg was burnt in a gaseous mixture containing N_2 and O_2, two products were formed in the molar ratio 4:1 where the greater product was the oxide. The mixture of the products obtained was reacted with water and the gas released was absorbed in 20.00 cm^3 of a 1.0 mol dm^{-3} HCl solution. When the resulting solution was back titrated with a 0.5 mol dm^{-3} NaOH solution, the volume of the NaOH solution used was 12.00 cm^3. What is the mass of Mg used? (Mg = 24)

(1) 0.782 g (2) 0.84 g (3) 1.092 g (4) 1.176 g (5) 2.814 g

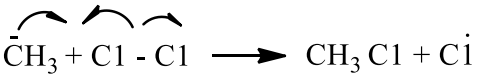
25. Consider the following reaction scheme.

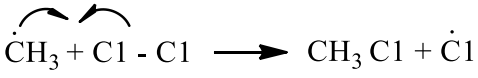


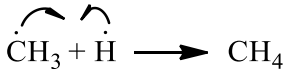
Which answer indicates the most suitable structures for A, B, C and D?

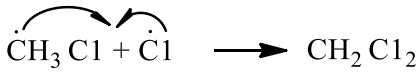
Answer	A	B	C	D
(1)				
(2)				
(3)				
(4)				
(5)				

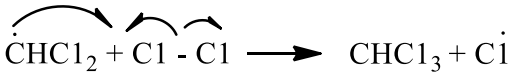
26. Which of the following steps is a correct indication about the mechanism of chlorination of methane?

(1) 

(2) 

(3) 

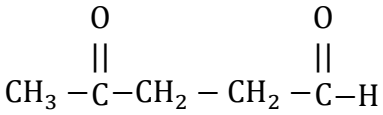
(4) 

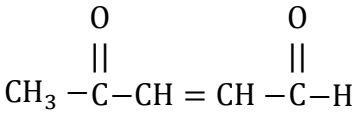
(5) 

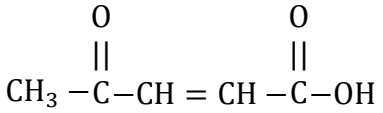
27. Given below are some pieces of experimental information relevant to the compound R.

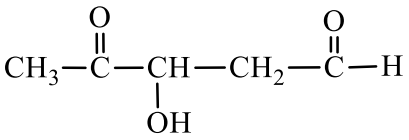
1. Doesn't answer Fehling's reagent but gives an orange precipitate with 2,4-DNP.
2. Evolves CO_2 gas bubbles when reacted with Na_2CO_3.
3. On addition of $OH^-/KMnO_4$, a brown precipitate is formed.

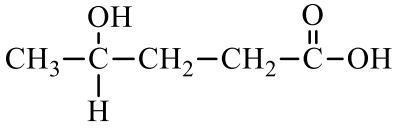
Which of the following is R as regards the above observations?

(1) 

(2) 

(3) 

(4) 

(5) 

28. To 100 cm^3 of a 0.1 mol dm^{-3} NaCl solution, 100 cm^3 of a $MgCl_2$ solution of unknown concentration were added. By an analysis, the Cl^- concentration of the new solution of volume 200 cm^3 was found to be 2.875 g dm^{-3}. Which of the following is the concentration of the $MgCl_2$ solution? (Na=23, C1=35.5, Mg=24)

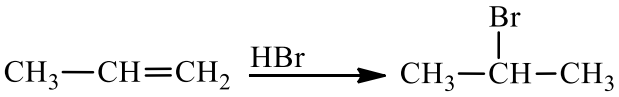
(1) 0.008 mol dm^{-3} (2) 0.011 mol dm^{-3} (3) 0.02 mol dm^{-3}

(4) 0.04 mol dm^{-3} (5) 0.2 mol dm^{-3}

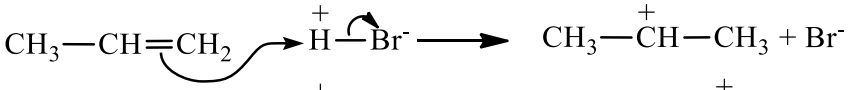
29. Of two rigid bulbs, one bulb is filled with an ideal gas while the other bulb is filled with another ideal gas Q. The density of gas P is thrice the density of A. The molar mass of gas Q is twice the molar mass of P. When these bulbs are kept under the temperature of 127 ^0C, the ratio of the partial pressures of the gases P and Q is,

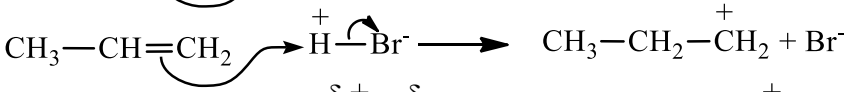
(1) 1 : 3 (2) 1 : 6 (3) 2 : 3 (4) 3 : 2 (5) 6 : 1

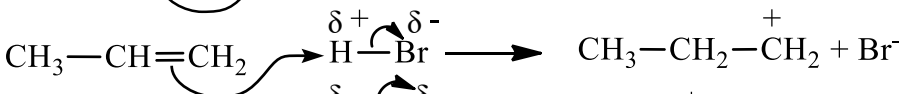
30. Consider the following reaction.

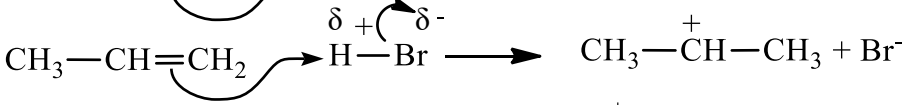


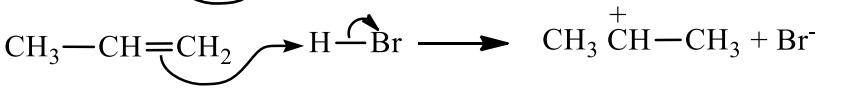
Which of the following correctly indicates a steps in the mechanism of this reaction?

(1) 

(2) 

(3) 

(4) 

(5) 

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

(1) if only (a) and (b) are correct.

(2) if only (b) and (c) are correct.

(3) if only (c) and (d) are correct.

(4) if only (d) and (a) are correct.

(5) if any other number of combination of responses is correct.

Summary of above instructions				
(1)	(2)	(3)	(4)	(5)
only (a) and (b) are correct	only (b) and (c) are correct	only (c) and (d) are correct	only (d) and (a) are correct	any other number of combination of responses is correct

31. What is/are the correct statement (s) about the atomic spectrum of hydrogen?

(a) Each line in the spectrum corresponds to each energy level in the hydrogen atom.

(b) When the frequency of lines in each series of the spectrum increases, the gap between the lines gradually decreases.

(c) $H_{\propto}$ line in the Balmer series corresponds to the transition between n=3 and n=2.

(d) Lyman series, the first series of lines in the spectrum is located in the infrared region.

32. Which reagent/reagents can be used to distinguish aqueous Fe^{2+} ions and aqueous Fe^{3+} ions from each other?

(a) acidified $KMnO_4$ (b) aqueous NH_3

(c) concentrated HCl (d) $K_3[Fe(CN)_6]$

33. Correct statement/statements for the following reaction is/are,

$$H_2O(g) + CO(g) \rightarrow H_2(g) + CO_2(g)$$

At 400 K	CO(g)	$CO_2(g)$	$H_2O(g)$	$H_2(g)$
$\triangle H^0_f$ /kJ mol^{-1}	-111	-393.5	-243	0
S^0/J K^{-1} mol^{-1}	198	214	189	131

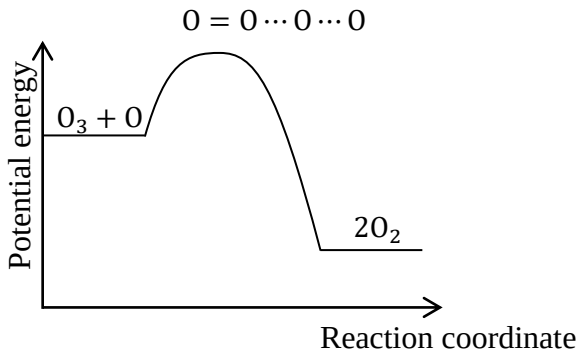
(a) At 400 K this reaction is spontaneous.

(b) This reaction has a negative entropy change.

(c) This reaction has a positive entropy change.

(d) At 400 K this reaction is not spontaneous.

34. The energy profile of the reaction $O_3 + O \longrightarrow 2O_2$ is given below.



$O_3 + O \rightarrow 2O_2$

The numerical value of the enthalpy change of the above reaction is 392 kJ mol^{-1}. The numerical value of the activation energy of the forward reaction is 19 kJ. The correct statement/statements about the reaction is/are,

(a) The activation energy of the reverse reaction is + 411 kJ.

(b) The activation energy of the reverse reaction is + 373 kJ

(c) This is an endothermic reaction.

(d) There is only one transition state for this reaction.

35. Which of the following statements given about the chemical industries is/are true?

(a) Brine is directly used in the extraction of Mg by Dow method.

(b) Brine used in the production of NaOH by the membrane cell method should be very pure.

(c) The final by-product obtained in the production of Na_2CO_3 by Solvay method is $CaCl_2$.

(d) Though NaOH is used as a raw material in the production of soap, KOH cannot be used.

36. When a catalyst is introduced to a reaction at equilibrium at a constant temperature,

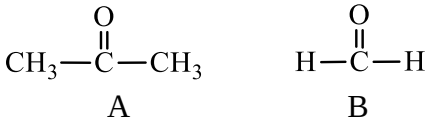
(a) the equilibrium constant remains unchanged.

(b) the enthalpy change of the reaction remains unchanged.

(c) the rate constants of the forward and backward reactions change in equal amounts.

(d) the equilibrium point changes.

37. Which of the following statement/statements is/are true about the following two compounds?



A B

(a) A reacts faster than B with Grignard's reagent.

(b) Brady's reagent cannot be used to distinguish A from B.

(c) Fehling's reagent can be used to distinguish A from B.

(d) A and B undergo nucleophilic substitution reactions with $H_2N\text{-}NH_2$.

38. The binary solution formed by the liquids A and B shows a positive deviation from Raoult's law. Which statement/statements is/are true about this system?

(a) $P_A > P^0_A \, .x_A$ and $P_B > P^0_B.x_B$

(b) Attractive forces between A and B are stronger than the attractive forces among A-A molecules and B-B molecules.

(c) Heat is absorbed (endothermic) when these two liquids are mixed.

(d) The total volume decreases when these two liquids are mixed.

39. Which of the following statement/statements is/are correct?

(a) A solution of $CH_3N^+H_3Cl^-$ shows buffer action.

(b) A buffer solution shows buffer action within any pH range.

(c) The pH value of a buffer solution remains unchanged also during dilution.

(d) A solution of $CH_3COO^-NH_4^+$ shows buffering action.

40. Which of the following species does/do not react with aqueous NaOH.

(a) $NH_4C1(S)$ (b) Na metal (c) $A1(OH)_3(s)$ (d) Fe metal

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

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

	First statement	Second statement
41.	For an ideal gas, the graph between pressure and 1/volume $(1/v)$ is a straight line passing through the origin.	At any temperature and pressure, the pressure of an ideal gas ins directly proportional to the volume.
42.	Al powder and NaOH can be used to distinguish NH_4NO_3 and NH_4C1 from each other.	NO^-_3 ions react with A1 powder and aqueous NaOH and liberate NH_3 gas.
43.	Phenol gives 2, 4, 6 substituted white precipitates with bromine water as well as with chlorine water.	Lewis acids are required for chlorination and bromiuation of phenol.
44,	When a dilute H_2SO_4 solution is electrolysed using Pt electrodes, oxygen is liberated at the anode.	Formation of O_2 and H_2 during the electrolysis of dilute H_2SO_4 is a spontaneous reaction.
45.	AgI has more ionic properties than AgF.	As the size of the anion becomes larger, polarizability increases.
46.	Hydrolysis of $SC1_2$ gives rise to a cloudy solution.	Hydrolysis of $SC1_2$ forms sulphur.
47.	Increase in the greenhouse gas concentration in the atmosphere above optimum levels in the atmosphere leads to global warming.	Greenhouse effect is an unfavourable process for the existence of living organisms on the Earth.
48.	Water cannot act as an acid or a base.	Pure water is neutral to litmus.
49.	At an instance where $Q_p < K_p$ in a reaction, reverse reaction is faster.	Reaction quotient is calculated only for non-equilibrium states of a reaction.
50.	The molecularity of a reaction doesn't become zero at any instance.	Molecularity is relevant for a fundamental reaction proposed to be one step of a mechanism.

G.C.E. Advanced Level

Grade 13

Chemistry II

Three hours

Channel NIE

PART A - STRUCTURED ESSAY

Answer **all four questions** on this paper itself.

01. (a) Q,P,T,X and Y are five non-transition, successive elements in the Periodic Table. Q,P,T,X and Y are not their standard symbols. Of these elements, only Q shows amphoteric properties and only Y exists as a diatomic gas at room temperature.

(i) Identify elements Q and Y and write their chemical symbols.

Q = ... Y = ... (4)

(ii) The values of the first ionisation energy of the above elements (in kJ mol^{-1}) are given below. Their values are not presented in order.

577, 786, 999, 1251, 1011

Of the above values, select and state the first ionisation energy of T and X.

T = ... X = ... (4)

(iii) Write the chemical formula of the hydride formed by element T in terms of symbols and state its IUPAC name.

Chemical formula : .....

IUPAC name : ..... (6)

(iv) State the type of secondary interactions existing among the molecules of the hydride formed by elements X. (6)

(v) Of the above elements, identify the elements which do not form anions or cations and name them. (3)

(vi) Write the set of quantum numbers of the electron lying in the last energy level of elements Y.

(b) Chlorosulphuric acid (HSO_3Cl) is a chemical compound causing flow of tears from eyes.

(i) Draw the most stable Lewis dot-dash structure that can be drawn for HSO_3Cl.

(4)

(ii) In addition to the stable structure you have drawn in (i) above, draw two Lewis structures that can be drawn for HSO_3Cl. (4)

(iii) Fill in the following table based on the stable Lewis structure of HSO_3Cl.

	S	O connected to H
VSEPR pairs around the atom		
Electron pair geometry around the atom		
Shape around the atom		
Hybridization of the atom		
Oxidation number of the aom		

(2x10=20)

(iv) Name the atomic orbitals/hybrid orbitals contributing to from the sigma, (σ) bonds given below in the stable Lewis structure of HSO_3Cl. (6)

I. between O connected H and S

O ..... S .....

II. between O connected H and H

O ..... H .....

III. between S connected H and Cl

S ..... Cl .....

(2x6=12)

(c) Arrange the following in the increasing order of the property stated within brackets (Reasons are not needed).

(i) $H_2CO, CO, H_2CO_3, COCl_2$ (oxidation number of carbon)

(ii) $BF_4-, H_3O^+, CH_3^+, NH_2^-$ (bond angle)

(iii) $CO_2, CF_4, NO_2^-, CO_3^{2-}$ (number of lone pair electrons in a species)

(iv) SiH_4, PH_3, H_2S, HCl (boling point)

(v) X rays, radio waves, ultraviolet rays, visible rays (wave length)

02. (a) M is an element belonging to the 'S' block of the Periodic Table. M reacts vigourously with cold water. In the flame test, salts of M give a colour to the flame. Though the sulphate of M is insoluble in water, the hydroxide of M is readily soluble in water.

(i) Identify M.

(ii) What is the colour imparted by M in the flame test? .....

(iii) Write balanced chemical equations for the reactions of the hydroxide of M with

I. Zn II. NH_4C1

(Use chemical symbols)

.....

.....

(iv) Write balanced chemical equations for the reactions occurring when M is heated in the air. (Use chemical symbols)

.....

.....

(b) KIO_3 is a compound used as a primary standard in redox titrations.

(i) Write three reasons for the selection of KIO_3 as a primary standard.

(ii) A solution of an anion can be standardised using a known amount of KIO_3 and excess KI.

I. Write the redox reaction taking place between KIO_3 and KI.

II. If 1.07g of KIO_3 were used for this, find the amount of I_2 liberated.
(I = 127, O = 16, K = 39)

III. 24.00 cm^3 of the above anion solution of unknown concentration were used to react with the amount of I_2 liberated above. I_2 and the anion react in the molar ratio of 1:2. Work out the concentration of the anion solution.

IV. Starch was used as the indicator to find the end point of the titration. Identify the above anion.

V. What observations can be made when dilute HCl is added to the anion solution?

(c) Four unlabelled beakers contain solutions of $(NH_4)_2SO_4, Na_2CrO_4, BaCl_2$ and $NaOH$ (not in order). Observations made when portions of the above solutions were mixed together were as follows.

A - Gives a precipitate with two of the other three solutions and one precipitate is coloured.

B - Gives a coloured precipitate with one of the other three solutions and a colour change with another.

C - Gives a white precipitate with one of the other three solutions and ammonia smell with another.

D - Gives ammonia smell with only one of the other three solutions.

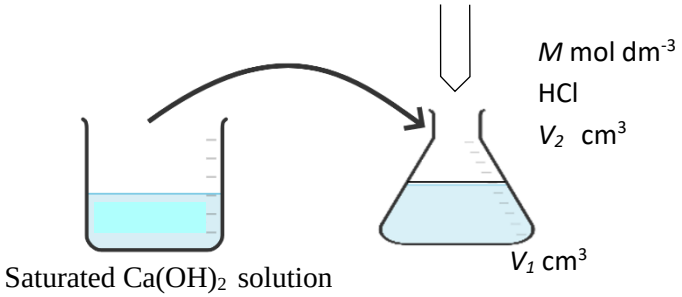
Identify the compounds A,B,C and D.

A ..... B .....

C ..... D .....

03. (a) (i) At a certain temperature, the solubility of the sparingly soluble salt A_xB_y is 'S' mol dm^{-3}. In terms of the given symbols, derive the expression for the solubility product of this salt.

(ii) Consider the experiment you have conducted to determine the solubility product of $Ca(OH)_2$ in the laboratory.



During this experiment, a volume of V_1 cm^3 of a saturated $Ca(OH)_2$ solution was titrated with a HCl solution of concentration M mol dm^{-3}. The burette reading was V_2 cm^3.

(I) Derive expressions for the following.

(A) Amount of moles of H^+ reacted.

(B) OH^- ion concentration in the solution.

(C) Ca^{2+} ion concentration in the solution.

(II) Using the above terms, derive the following equation for the solubility product of K_{sp}.

$$K_{sp} = \frac{1}{2}\left(\frac{MV_2}{V_1}\right)^3$$

(III) When 25.00 cm^3 of a saturated $Ca(OH)_2$ solution was titrated with a 0.1 mol dm^{-3} HCl solution, the burette reading obtained was 11.00 cm^3. Calculate the solubility product of $Ca(OH)_2$.

(iii) Calculate the molar solubility of Ag_2CO_3 in a 0.1 mol dm^{-3} Na_2CO_3 solution, at 25^0C.

At 25 ^{0}C $K_{sp}\ (Ag_2CO_3) = 4.0 \times 10^{-13}\ mol^3dm^{-9}$

(iv) When a NaOH solution was added little by little to a 0.01 mol dm^{-3} $MgCl_2$ solution, calculate the pH of the solution when $Mg(OH)_2$ begins to precipitate.

(at 25 ^{0}C) $K_{sp}\ (Mg(OH)_2) = 1.0 \times 10^{-12}\ mol^3dm^{-9}$

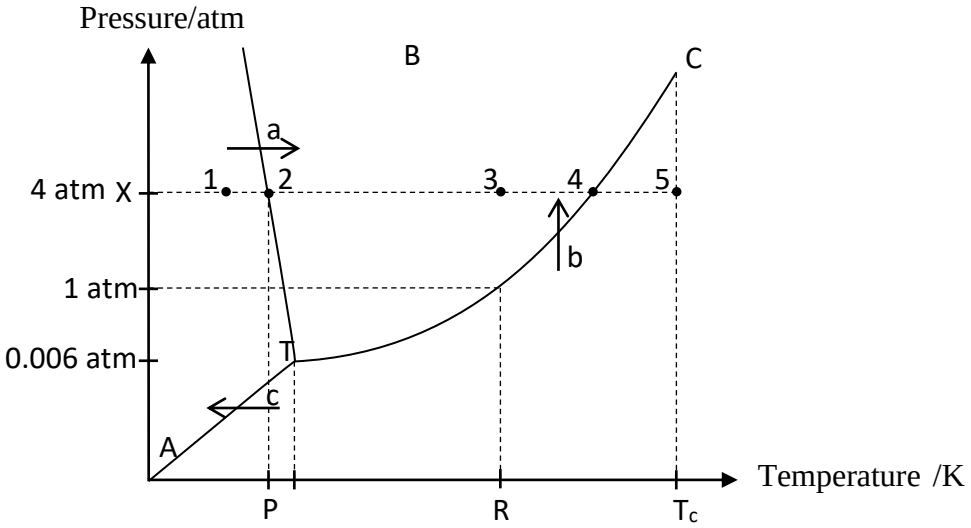
$K_w = 1.0 \times 10^{-14}\ mol^2dm^{-6}$

(v) Though metal cations such as Co^{2+} and Ni^{2+} do not precipitate as sulphides in acid medium when H_2S is passed, they get precipitated as sulphides in a basic medium on passing H_2S. Explain using your knowledge of the solubility product.

K_{sp} (NiS) $= 3.2 \times 10^{-21}$ mol^{2}dm^{-6}

K_{sp} (CoS) $= 5.9 \times 10^{-21}$ mol^{2}dm^{-6}

(b) The phase diagram of water is shown below.



P, Q and R represent temperatures.

(i) Which physical states are in equilibrium at point T?

By what name is point T known?

(ii) What is the maximum temperature at which liquid ⇌ vapour equilibrium exists?

(iii) Name the curves depicting the following equilibria.

- solid ⇌ gas
- liquid ⇌ vapour
- solid ⇌ liquid

(iv) Identity the temperatures R, P and T_C.

R - .....

P - .....

T_C - .....

(v) Write the specific names by which the phase changes indicated by the arrows a, b and c are known.

a - .....

b - .....

c - .....

(vi) In the above phase diagram, the numbers 1, 2, 3, 4 and 5 indicate phases and equilibria that can be identified when the temperature in increased under 4 atm pressure. Write the relevant phase or equilibrium opposite each number.

1. ..... 4. .....

2. ..... 5. .....

3. .....

(vii) Write a use of supercritical fluids (SCF).

04. (a) A, B and C are three hydrocarbons each with two sp^3 hybridized carbon atoms and two sp^2 hybridized carbon atoms.

Only A shows stereoisomerism.

(i) When subject to bromination followed by dehydrohalogenation, A, B and C form D, E and F respectively. D and E are isomers whereas F is not an isomer of D or E. Draw the structures of A, B, C, D, E and F in relevant boxes.

A B C

D E F

(ii) Give one test to distinguish D and E.

(iii) Draw the structure of the product (G) formed when the compound E is reacted with $HgSO_4/H_2SO_4$.

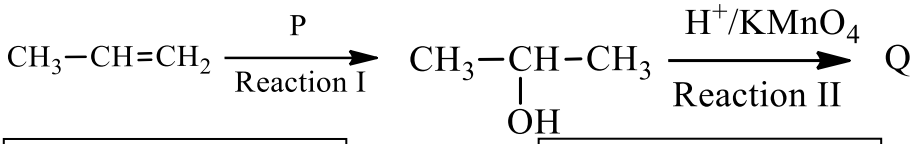
G

(iv) Draw the structure of the product (H) formed when the compound G reacts with 2,4 -DNP.

H

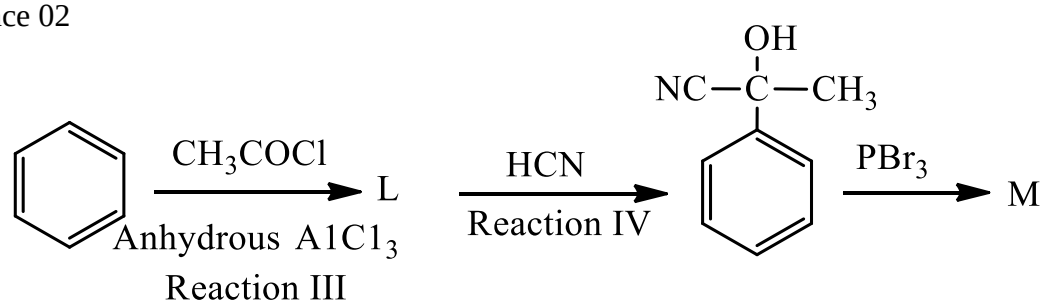
(b) Considering the following reaction sequences, write the appropriate products/reactants in the relevant boxes.

Sequence 01

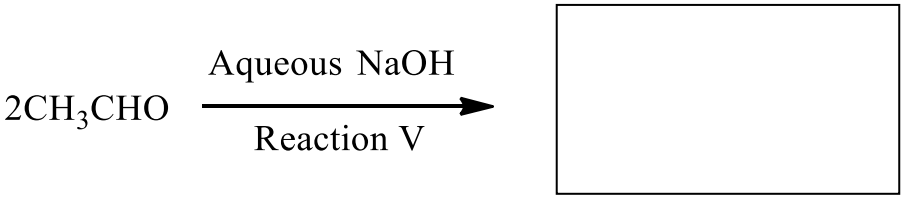


P Q

Sequence 02



Sequence 03



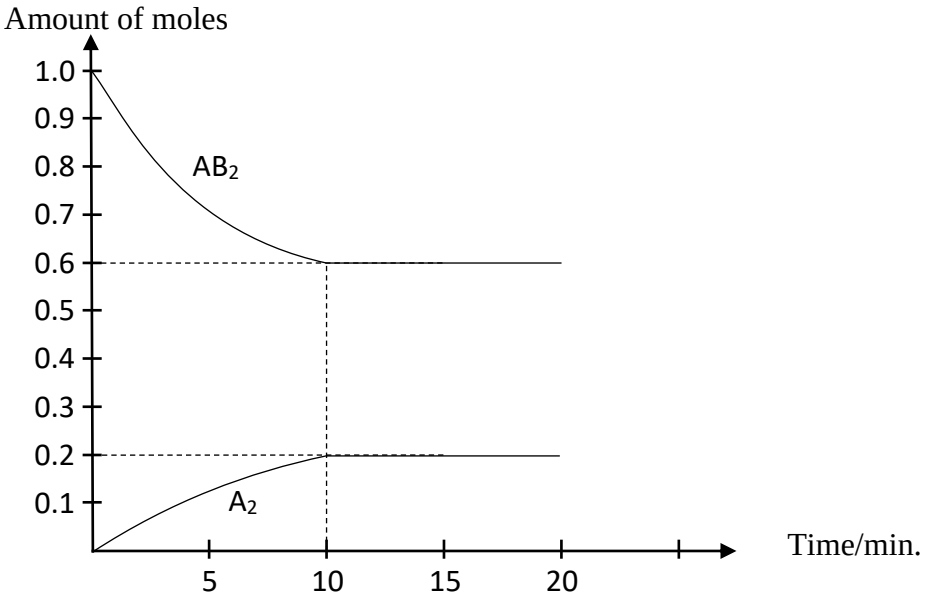
N

PART B - ESSAY

Answer **two questions** only.

05. (a) At 300 K a closed, rigid vessel contains the solid A and the gas AB_2. When the temperature of the vessel was increased to 400 K, the following equilibrium was attained. The figure shows how the amounts of moles of AB_2 and A_2 varied with time.

$$AB_2(g) + A(s) \rightleftharpoons A_2(g) + B_2(g)$$



(i) If the volume of the vessel in 2.0 dm^3, calculate K_C at 400 K.

(ii) Calculate K_P for the system at 400 K.

(iii) If the volume of the system was brought to half the initial volume at 400 K, explain the direction in which the equilibrium point tends to move.

(iv) To the equilibrium system at 400 K, another 0.2 mol of each $AB_2(g)$, $A_2(g)$ and A(s) were added. Predict the direction in which the equilibrium point moves by a suitable calculation based on K_C and Q_C.

(v) When the system in (i) above reached equilibrium at 500 K, K_C was 0.2 mol dm^{-3}. Accordingly, explain whether the forward reaction is exothermic or endothermic.

(b) (i) Using the following data and a thermochemical cycle, calculate the standard enthalpy of formation of liquid benzene.
Standard enthalpy of combustion of C(s,gra) = -393 kJ mol^{-1}
Standard enthalpy of combustion of $H_2(g)$ = -286 kJ mol^{-1}
Standard enthalpy of combustion of $C_6H_6(l)$ = -3262 kJ mol^{-1}

(ii) Standard enthalpy of atomisation of C(s,gra) = 720 kJ mol^{-1}
Standard bond dissociation enthalpy of $H_2(g)$ = +430 kJ mol^{-1}
Calculate the standard enthalpy change for the dissociation of 1 mol of $C_6H_6(l)$ to gaseous atoms.

(iii) The standard entropy values of $C_6H_6(l)$, C(g) and H(g) in J mol^{-1} K^{-1} are 173, 158 and 114 respectively. Calculate the standard entropy change for the dissociation of 1 mol of $C_6H_6(l)$ to gaseous atoms.

(iv) Using the above data, calculate the minimum temperature at which 1 mol of $C_6H_6(l)$ dissociates into gaseous atoms.

(v) Standard bond dissociation enthalpy of C=C = 611 kJ mol^{-1}
Standard bond dissociation enthalpy of C-C = 346 kJ mol^{-1}
Standard bond dissociation enthalpy of C-H = 413 kJ mol^{-1}
Using the above data, calculate the standard enthalpy change for the dissociation of 1 mol of benzene into gaseous atoms.

(vi) Indicate three reasons for the difference in the answers for parts (ii) and (iv) above.

06. (a) The pH value of a fruit juice sample X is 3.5.

(i) Calculate its H^+ concentration.

(ii) When 25.00 cm^3 of the sample X was titrated with a 0.1 mol dm^{-3} NaOH solution, the burette reading obtained was 27.50 cm^3.

(I) Assuming sample X contains only one weak monoprotic (monobasic) acid, calculate the total H^+ concentration in the sample.

(II) Calculate the dissociation constant of the weak acid contained in the sample.

(III) What is the suitable indicator for this titration?

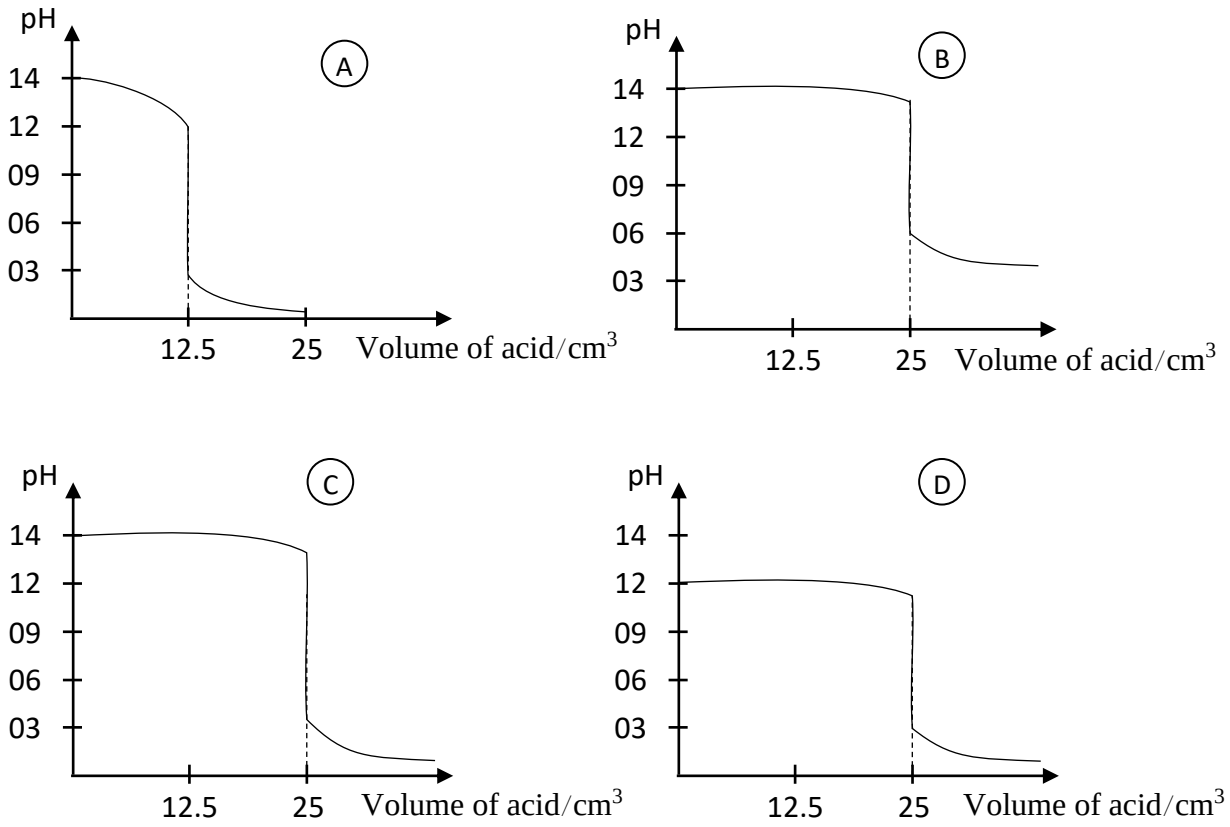
(IV) Write the reason for your choice of the above indicator.

(b) (i) Using Ostwald's dilution law for the weak base $B(OH)_3$, derive an expression for dissociation constant of the weak base.

(ii) At 25 ^{0}C, the dissociation constant of $B(OH)_3$ is 8.5 x 10^{-32} mol^4 dm^{-12}. Calculate the degree of dissociation of $B(OH)_3$ in a solution of it of concentration 1.0 mol dm^{-3}.

(iii) Calculate the pH of that solution at 25 ^{0}C. K_w at 25 ^{0}C = 1.0 x 10^{-14} mol^2 dm^{-6}.

(c) Given below are four pH curves relating to titrations carried out by titrating 25.00 cm^3 of several bases of concentration 0.1 mol dm^{-3} with different acid solutions of 0.1 mol dm^{-3} concentration.

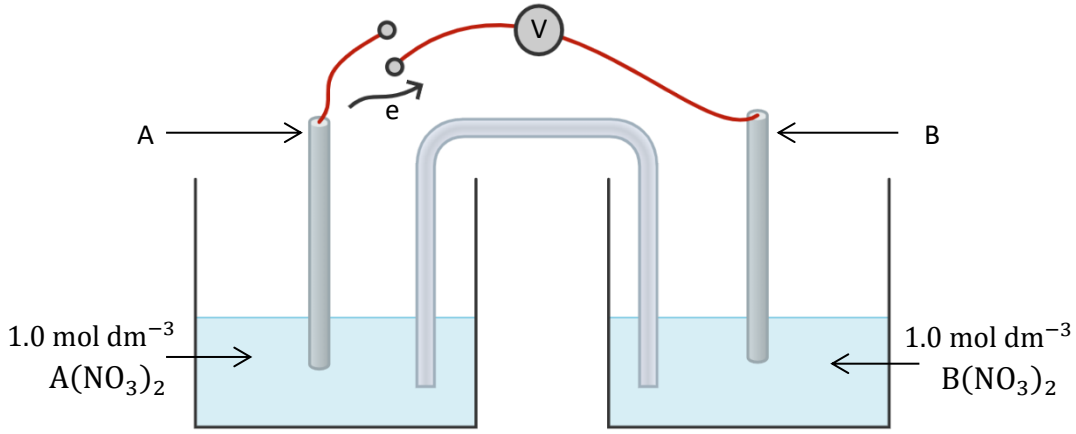


Indicator	P	Q	R	S	T
pH range	1.5 - 3.4	4.2 - 6.3	6.0 - 7.6	8.3 - 10.0	9.0 - 11.0

Complete the following table using the above data.

	Titration	Letter relevant to the graph	Most suitable indicator
(1)	NaOH and HC1		
(2)	NaOH and H_2SO_4		
(3)	KOH and CH_3COOH		
(4)	NH_4OH and HC1		

07. (a) An electrochemical cell was constructed using two metals as shown below. When the switch was kept closed (on) for some time, a deflection in the galvanometer was observed.



(i) Out of the metals Zn, Cu and Ni, select the two metals that should be used as the electrodes A and B to obtain the maximum reading in the Galvanometer.

$$E^0_{zn^{2+}/zn} = -0.76\ \text{V}\ ,\ E^0_{\frac{cu^{2+}}{cu}} = +0.34\ \text{V}\ ,E^0_{\frac{Ni^{2+}}{Ni}} = -0.23\ \text{V}$$

(ii) Using correct chemical symbols, write the half reactions for the above cell.

(iii) Write the total cell reaction (when the cell is in operation).

(iv) Indicate the above cell according to the standard (IUPAC) notation and calculate the cell potential.

(v) Based on the relationship $\Delta G^0 = -nFE^0_{(cell)}$ deduce about the spontaneity of the above cell reaction. (F = 96500 C mol^{-1})

(b) Chromium (Cr) imparts red colour to the gemstone ruby while the glass produced by incorporating chromium (emerald green) assumes a green colour. This question is based on chromium.

(i) Write the complete electron configuration of chromium.

(ii) Write three common oxidation states of chromium.

(iii) When $Cr(NO_3)$ is dissolved in water, solution R is obtained.

I. State the colour of the solution R.

II. Write the chemical formula and the IUPAC name of the species that gives the above colour.

(iv) What do you observe in the following instances?

I. When a dilute NaOH solution is added to solution R.

II. When a H_2O_2 solution is added to the solution in (iv) (I).

III. When a $AgNO_3$ solution is added to the solution in (iv) (II) above.

IV. Write balanced chemical equations for the observations in I, II and III above.

(v) Give the chemical formula of the most stable oxoanion of chromium in acid medium.

(vi) Write separately the balanced ionic equation relevant to the behaviour of that oxoanion as an oxidant in acid medium and the reaction occurring when a base is added to it.

(vii) Write the balanced chemical equation relevant to the thermal decomposition of the ammonium salt containing the oxoanion stated in (v) above. If the products of this decomprsition has any special colour, state the colour with the relevant product.

(ix) What is the special characteristic of the elements in the 'd' block to which chromium belongs that causes ruby to have a red colour while emerald green to have a green colour.

PART C - ESSAY

Answer **only two** questions.

08. (a) (i) Alkyl halides undergo nucleophilic substitution reactions. Explain.

(ii) Chlorobenzene doesn't undergo nucleophilic substitution reactions. Explain.

(b) Cinnamaldehyde is a major component of cinnomon oil. It has the following structure.

$C_6H_5 - CH = CH - CHO$

(i) Suggest a test to show that cinnamaldehyde has a double bond. Write the expected observations as well.

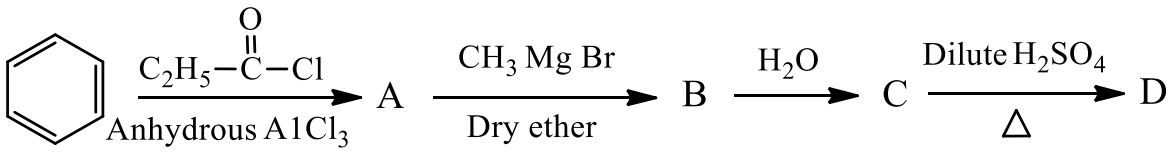
Test	Observation

(ii) Cinnamaldehyde reacts with 2,4 - dinitrophenylhydrazine (Brady's reagent).

I. Draw the structure of the product obtained in the above reaction.

II. State the type of reaction taking place between cinnamaldehyde and Brady's reagent.

(c) Consider the following reaction sequence.



(i) Draw the structures of the compounds A, B, C and D in the appropriate boxes.

A B C D

(ii) Identify the reactions in the above sequence as addition (Ad), elimination (E), rearrangement (R) or substitution (S) and write the letter relevant to the reaction type in the appropriate boxes given below.

Reaction	1	2	3	4
Reaction type				

(iii) State the active species in reactions 1 and 2 and state whether each is an electrophile or a nucleophile.

Reaction	Active species	Whether an electrophile or a nucleophile
1		
2		

09. (a) When an excess of aqueous NaOH solution is added to the coloured compound A at room temperature, a gas B which turns red litmus blue and a coloured solution C is obtained.

When solution C is acidified with dilute HCl, solution D which has a colour similar to that of A is obtained. Passing SO_2 gas through solution D gives the green solution E. When aqueous ammonia is added in excess to E, a dark green precipitate F is obtained. Addition of aqueous NaOH and H_2O_2 to F gives back solution C.

(i) Identify compound A and write its chemical formula.
(ii) Write another test (except testing with litmus) to identify gas B with an observation.
(iii) Write the formulae of the chemical species C, D, E and F.
(iv) State the colours of the compound A, C and D.
(v) Obtain the balanced chemical equation relating to the conversion of F $\rightarrow$ C by writing ion-electron half reactions.
(vi) Write the formula and the IUPAC name of the complex ion formed by the cation in solution E with Cl^- ions. What is the colour of this complex ion?

(b) You are provided with an alloy containing Al, Zn and Sn. How do you determine the percentage by weight of each component in the alloy? Describe briefly.

(c) An industrial effluent contains the ion SO_4^{2-}, IO_3^- and Cl^-. Only Na^+ is present as the cation. The following experimental method was used to determine the concentration of the anions present in this solution.

- To 25.00 cm^3 of the solution, $Ba(NO_3)_2$ solution was added in excess and the precipitate formed was filtered, dried and weighed. Its mass was found to be 0.233 g.
- The filtrate obtained from the above was diluted to 250 cm^3 with distilled water and from it two samples, each of volume 10.00 cm^3 were isolated. To one sample, dilute

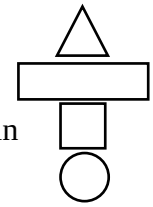
HNO_3 and $AgNO_3$ solution were added and the mass of the dried precipitate obtained was 0.287 g.

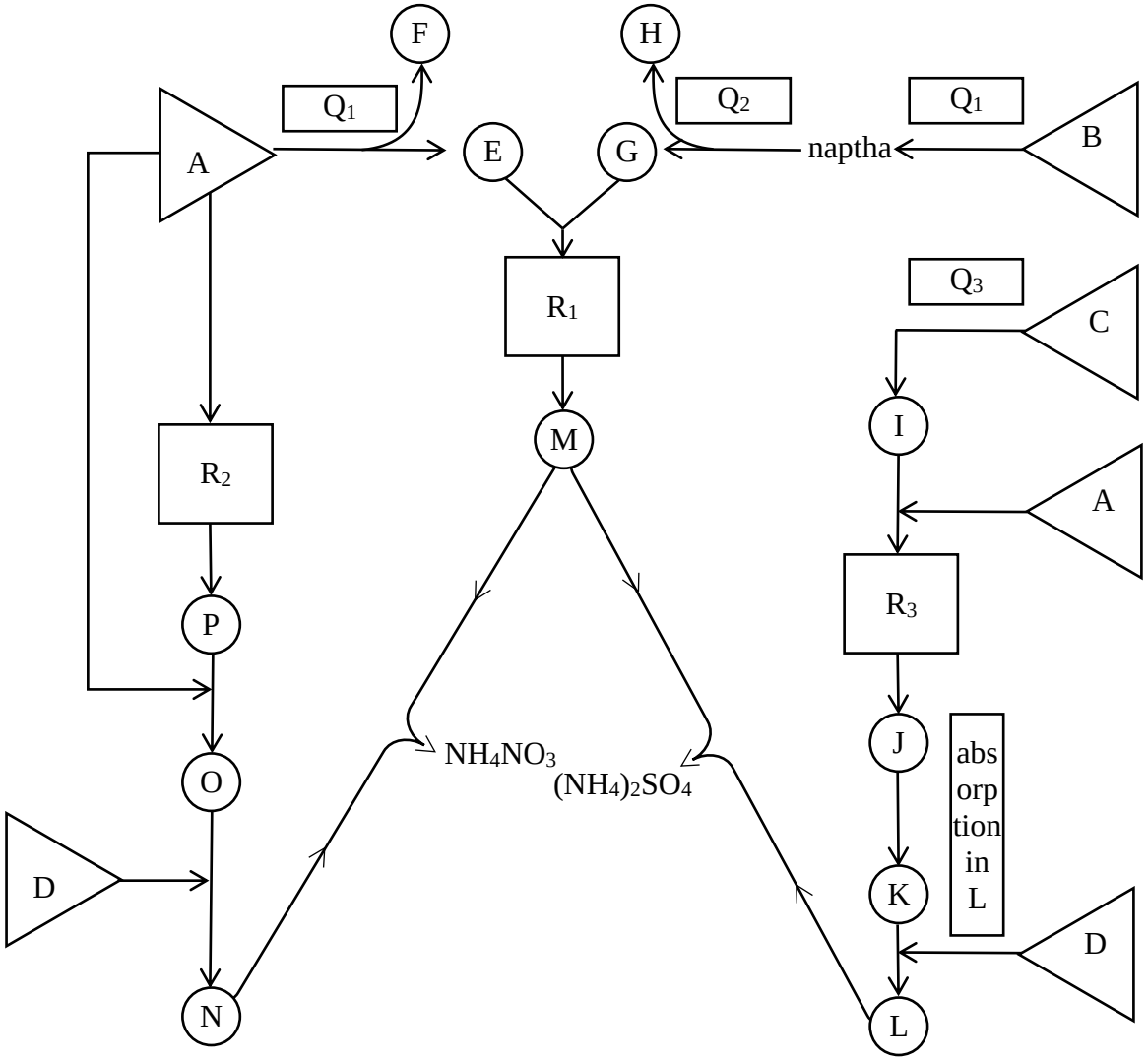
The other 10.00 cm^3 sample was acidified with dilute HCl and excess KI was added to it. To react with the I_2 liberated, 12.00 cm^3 of a 0.01 mol dm^{-3} $Na_2S_2O_3$ solution were required. Calculate the concentration of each anion in the industrial effluent.

(Ba = 137, S = 32, O = 16, Ag = 108, C1 = 35.5)

10. (a) The following flow chart shows how the two fertilizers NH_4NO_3 and $(NH_4)_2SO_4$ are produced using the natural resources A, B, C and D. In the chart substances, processes and conditions are indicated as follows.

Raw materials - A, B, C, D - in
Physical and chemical processes - in
Conditions necessary for chemical processes R_1, R_2, R_3 - in
Reactants and products - from E to P - in





Based on the above flow chart, write the answers for the following questions.

(i) Identify and name the raw materials A, B, C and D.

(ii) State the physical/chemical processes Q_1, Q_2 and Q_3.

(iii) Indicate separately all the reaction conditions R_1, R_2 and R_3.

(iv) Write the chemical symbols/formulae relevant to all the reactants/products from E to P.

(b) (i) Humans add various chemicals to the environment. Entry of these into water bodies has resulted in water pollution.

I. Name two toxic heavy metals present in polluted waters. Write a source from which each heavy metal is added to water and state an unfavourable condition brought about by each heavy metal.

II. State the two ions mainly responsible for the eutrophication of a water body.

III. State three causes leading to the decrease in the dissolved oxygen level in a water body.

(ii) Addition of acidic gases to the atmosphere causes acid rains.

I. Name a gas that causes acid rains and contains nitrogen as its component element.

II. By means of balanced chemical equations, explain how the gas you stated above brings about acid rains.

III. State two unfavourable effects of acid rains on soil.

IV. Though there are acid rains, base rains do not occur. Explain this statement using your knowledge in chemistry.

(iii) Chlorofluorocarbons are derivatives of hydrocarbons with one or two carbon atoms. These strongly contribute to the depletion of the ozone layer.

I. Draw the structure of a chlorofluorocarbon with one carbon atom and a chlorofluorocarbon with two carbon atoms.

II. State two industrial uses of chlorofluorocarbons.

III. Using chemical equations, explain how chlorofluorocarbons deplete the ozone canopy.