

Version No.			

ROLL NUMBER						



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1	1	1	1
2	2	2	2
3	3	3	3
4	4	4	4
5	5	5	5
6	6	6	6
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8	8	8	8
9	9	9	9

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2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6
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Answer Sheet No. _____

Sign. of Candidate _____

Sign. of Invigilator _____

CHEMISTRY HSSC-I (2nd Set Solution)

SECTION – A (Marks 17)

Time allowed: 25 Minutes

Section – A is compulsory. All parts of this section are to be answered on this page and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. **Do not use lead pencil.**

Q.1 Fill the relevant bubble for each part. Each part carries one mark.

- The least number of molecules are present in 30g of:

A. N ₂ O	<input type="radio"/>	B. NO	<input type="radio"/>
C. NO ₂	<input type="radio"/>	D. N ₂ O ₃	<input checked="" type="radio"/>
- The largest bond angle is present in:

A. CH ₄	<input type="radio"/>	B. SCl ₂	<input type="radio"/>
C. NH ₃	<input type="radio"/>	D. BCl ₃	<input checked="" type="radio"/>
- The difference in angular momentum of electron which jumps from 3rd orbit to 6th orbit of hydrogen atom will be:

A. $3\left(\frac{h}{2\pi}\right)$	<input type="radio"/>	B. $3\left(\frac{h}{\pi}\right)$	<input checked="" type="radio"/>
C. $6\left(\frac{h}{2\pi}\right)$	<input type="radio"/>	D. $6\left(\frac{h}{\pi}\right)$	<input type="radio"/>
- Which one of the following salts turns red litmus blue upon hydrolysis?

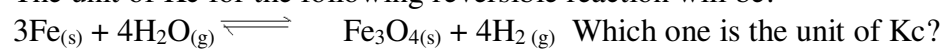
A. K ₂ SO ₄	<input type="radio"/>	B. NaCl	<input type="radio"/>
C. Na ₂ CO ₃	<input checked="" type="radio"/>	D. NH ₄ Cl	<input type="radio"/>
- Identify the unit of rate constant (K) for the given reaction:
 $2A+B \longrightarrow \text{Product}$ when $\text{Rate} = K[A][B]$

A. s ⁻¹	<input type="radio"/>	B. mol dm ⁻³ s ⁻¹	<input type="radio"/>
C. dm ³ mol ⁻¹ s ⁻¹	<input checked="" type="radio"/>	D. dm ⁶ mol ⁻² s ⁻¹	<input type="radio"/>
- The 3rd line in the Balmer Series of Bohr's Hydrogen spectrum is due to the transition of electron:

A. From 4 th shell to 1 st shell	<input type="radio"/>
B. From 4 th shell to 2 nd shell	<input type="radio"/>
C. From 5 th shell to 1 st shell	<input type="radio"/>
D. From 5 th shell to 2 nd shell	<input checked="" type="radio"/>

7. If Principal quantum number (n) = 3, the total magnetic quantum numbers (m) will be:
 A. 3 B. 6
 C. 9 D. 12
8. A gas x diffuses four times faster than SO_2 gas. The molar mass of gas x will be:
 A. 2 g/m B. 4 g/m
 C. 16 g/m D. 64 g/m
9. A real gas that obeys Vander Wall's equation ($p + \frac{an^2}{v^2} + (v - nb) = nRT$) behaves like an ideal gas when
 A. 'a' is large & 'b' is small
 B. 'a' is small & 'b' is large
 C. 'a' & 'b' are large
 D. 'a' & 'b' are small
10. NaCl is a crystalline solid which has face centered cubic structure. The Na^+ ion at the face of the unit cell is shared by:
 A. Two unit cells B. Four unit cells
 C. Six unit cell D. Eight unit cells
11. The transition temperature of tin grey and tin white is:
 A. 13.2°C B. 18°C
 C. 95.5°C D. 128.5°C
12. The vapor pressure of a liquid depends upon the following, **EXCEPT**:
 A. Nature of liquid B. Temperature
 C. Inter molecular forces D. Amount of liquid
13. The standard electrode potential of different elements are measured with the help of Standard Hydrogen Electrode (SHE). The standard conditions at which SHE is operated are:
 A. 2.00M HCl solution, 1 atm H_2 at 0 K.
 B. 1.00M HCl solution, 1 atm H_2 at 298 K.
 C. 1.00M HCl solution, 2 atm H_2 at 0 K.
 D. 1.00M HCl solution, 1 atm H_2 at 273 K.
14. 20 grams of glucose dissolved in water to prepare a solution of 10 % w / v concentration. The volume of the solution will be:
 A. 100 cm^3 B. 200 cm^3
 C. 2000 cm^3 D. 2500 cm^3
15. A buffer solution resists the change of its pH upon adding small amount of strong acid or base. Which one of the following is an example of a buffer solution?
 A. Mixture of $\text{NH}_4\text{Cl}_{(\text{aq})}$ and $\text{NH}_4\text{NO}_3_{(\text{aq})}$
 B. Mixture of $\text{NH}_4\text{Cl}_{(\text{aq})}$ and $\text{NaCl}_{(\text{aq})}$
 C. Mixture of $\text{CH}_3\text{COONa}_{(\text{aq})}$ and $\text{NH}_4\text{Cl}_{(\text{aq})}$
 D. Mixture of $\text{NH}_4\text{Cl}_{(\text{aq})}$ and $\text{NH}_4\text{OH}_{(\text{aq})}$
16. If enthalpy of neutralization of the given reaction (a) is -57.3 k J / mol. What would be the enthalpy change of reaction (b)?
 (a) $\text{KOH}_{(\text{aq})} + \text{HCl}_{(\text{aq})} \rightarrow \text{KCl}_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})}$
 (b) $\text{H}_2\text{SO}_4_{(\text{aq})} + 2\text{KOH}_{(\text{aq})} \rightarrow \text{K}_2\text{SO}_4_{(\text{aq})} + 2\text{H}_2\text{O}_{(\text{l})}$
 A. -28.65 k J B. -114.6 k J
 C. -171.9 k J D. -229.2 k J

17. The unit of K_c for the following reversible reaction will be:



Which one is the unit of K_c ?

A. No unit



B. $\text{mole}^2\text{dm}^{-3}$



C. $\text{mole}^{-2}\text{dm}^{+6}$



D. $\text{mol}^{-1}\text{dm}^3$





Federal Board HSSC-I Examination
Chemistry Model Question Paper
(Curriculum 2006)

Time allowed: 2.35 hours

Total Marks: 68

Note: Answer any fourteen parts from Section 'B' and attempt any two questions from Section 'C' on the separately provided answer book. Write your answers neatly and legibly.

SECTION – B (Marks 42)

Q.2 Attempt any **FOURTEEN** parts from the following. All parts carry equal marks.

(14 × 3 = 42)

i. Justify the following:

a. One mole of CO₂, CH₄ & H₂O has different masses but have same number of molecules.

Ans. One mole CO₂ = 6.022 × 10²³ molecules = 44g

One mole CH₄ = 6.022 × 10²³ molecules = 16g

One mole of H₂O = 6.022 × 10²³ molecules = 18g

This shows that one mole of different substances has same number of particles but different masses. This is because atomic mass, molecular masses or formula mass is equal to mole depends upon nature or molecules.

b. Energy of 3d sub shell is greater than 4s.

Ans. 3d = n+1 Rule

$$3 + 2 = 5$$

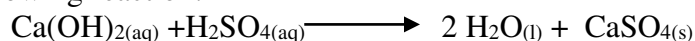
$$4s \quad n+1$$

$$4 + 0 = 4$$

According to (n+1) rule, the orbital with lower (n+1) will have lower energy. So 3d having greater

(n + 1) value will have higher in energy than 4s.

ii. For the following reaction:



Calculate the mass of calcium hydroxide needed to produce 680g of calcium sulphate? (Ca = 40, O = 16, S = 32, H = 1 g/mol)



$$m_{\text{Ca(OH)}_2} = ?$$

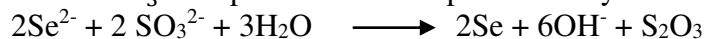
$$m_{\text{CaSO}_4} = 680\text{g}$$

$$13 \text{ g of CaSO}_4 \text{ is produced by Ca(OH)}_2 = 74\text{g}$$

$$1\text{g of CaSO}_4 \text{ is produced by Ca(OH)}_2 = 74/136 \text{ g}$$

$$1 = 680 \text{ g of CaSO}_4 \text{ is produced by Ca(OH)}_2 = (74/136 \text{ g}) * 680 \\ = 370\text{g}$$

iii. Se²⁻selenide and SO₃²⁻Sulphite ions react spontaneously



E°cell = 0.35v If E°Sulphite is -0.57 v, calculate E°for selenium.



$$E^0(\text{SO}_3^{2-}) = -0.57 \text{ V} \qquad E_{\text{CELL}} = 0.35 \text{ V}$$

$$E_{(\text{Se}^{2+})} = ?$$

$$\text{Se}^{2+} + 2 e^- \rightarrow \text{Se} \qquad E_{\text{cathode}} = E_0 = ? \quad (\text{cathode})$$

$$2e^- + 2\text{SO}_3^{2-} + 3\text{H}_2\text{O} \rightarrow 6\text{OH}^- + \text{S}_2\text{O}_3 \quad E = +0.57 \text{ (anode)}$$

$$\text{S}_2\text{O}_3 + 6\text{OH}^- \rightarrow 3\text{H}_2\text{O} + 2\text{SO}_3^{2-} + 2e^- \quad E^0 = 0.57 = E_{\text{anode}}$$

$$E_{\text{CELL}}^0 = E_{\text{cathode}} - E_{\text{anode}}$$

$$0.35 = E_{\text{cathode}} - (-0.57)$$

$$E_{\text{cathode}} = 0.35 \text{ V} - 0.57 \text{ V}$$

$$E_{(\text{Se}^{2+})} = E_{\text{cathode}} = -0.22 \text{ volts}$$

iv. What is metallic bond? Describe electron sea theory.

Ans. Metallic bonding is a type of bonding that arises from electrostatic forces of attraction between electrons and positively charged metal ions.

Electron Sea/ Electron Gas Theory:

In metallic solids the positively charged portion of metallic atoms is surrounded by an atmosphere of free electrons. This is called electron sea or electron gas.

Two types of forces are responsible for metallic bonding.

- i) Attractive forces between electrons and positive ions.
- ii) Repulsive forces between positively charged nuclei.

The forces are equal and opposite so metallic solids are neutral as a whole.

v. How Mosley used x-rays Spectrum to predict the atomic number of elements? Give one use of x-rays in medical field and chemistry.

Ans. Mosely proved that the frequency of x-rays increase in a regular manner as number of protons increases in the nucleus. The plot of frequency of x rays versus the square of protons number atomic number (Z) of elements is called x ray spectrum. From that x ray spectrum if frequency of x ray emitted by unknown element is measured than unknown element can be predicted from its atomic number.

Use of X-ray In Medical Field.

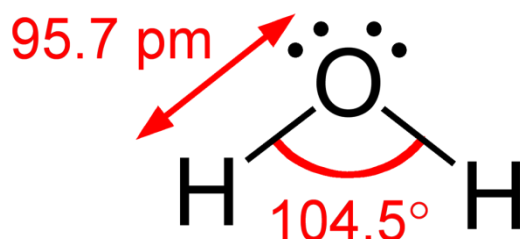
- X-rays are used in radiography to locate fracture in bones.

Use of X- Rays In Chemistry

- X ray diffraction (XRD) technique is used to study crystal structure. X rays are also used to ionize gases.

vi. The species H_2O , NH_3 and CH_4 have bond angles of 104.5° , 107.5° , 109.5° respectively. Prove by VSEPR theory, by drawing their structures.

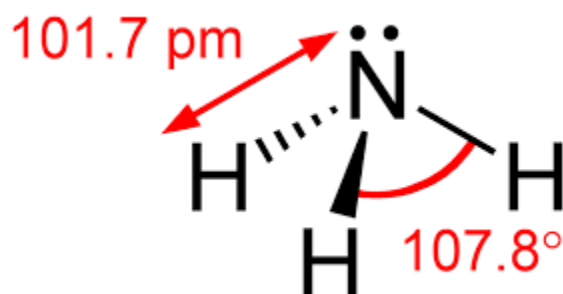
Water



It is AB_2E_2 type molecule with two bond pairs and two lone pairs. As repulsion between two lone pairs is greater than repulsion between two bond pairs, so bond angle decreases from 109.5 to 104.5

Total electron pair	Bond pair	Lone Pair
4	2	2

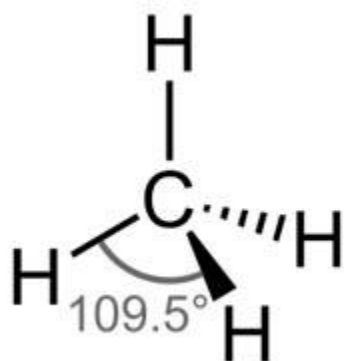
Ammonia:



The expected angle in NH_3 is 109.5° as it has 4 electron pairs, but as one of electron pair is a lone pairs and three bond pairs so the angle decreases to 107.5° . Lone pair bond pair repulsion is greater than bond pair repulsion. Hence angle is reduced to 107.5° . It is AB_3E .

Total electron pair	Bond pair	Lone Pair
4	3	1

Methane:



It has perfect tetrahedral geometry because 4 electron pairs are bond pairs, so these are arranged in such a way that there is maximum distance and minimum repulsion between them, so the angle is 109.5° . It is AB_4 type.

Total electron pair	Bond pair	Lone Pair
4	4	0

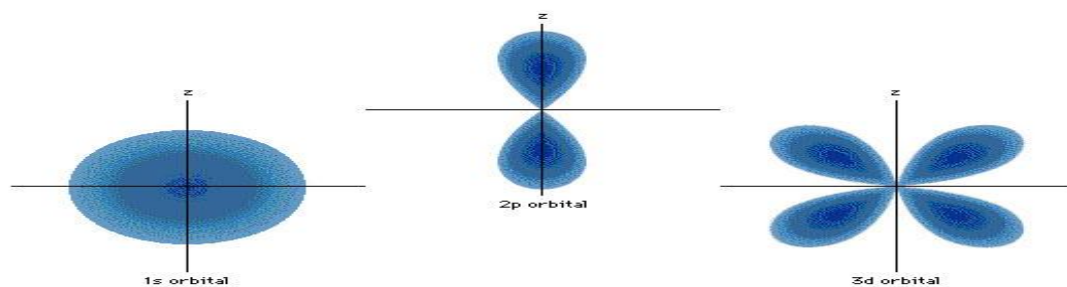
vii. Briefly describe the shape of subshells when the values of l are 0, 1 & 2.

Ans.

$l=0$ s subshell-----spherical

$l=1$ p subshell-----dumbell shape

$l=2$ d subshell----- sausage shape



$l=0$ s subshell-----spherical

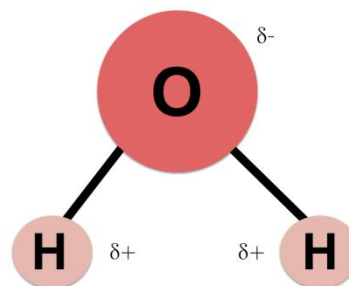
$l=1$ p subshell-----dumbell shape

$l=2$ d subshell----- sausage shape

viii. Explain the shape and polarity of H₂O on the basis of dipole moment.

Ans.

Molecules having zero dipole moment are non polar molecules. Molecules having some value of dipole moment are polar. Water is a triatomic V- shaped molecule because it is polar and has dipole moment 1.84D. This is because of vector sum of the forces are not equal to zero. That is why water is a polar molecule.



ix. State Joule Thomson Effect and give one application.

Ans.

Statement: When a highly compressed gas is allowed to escape out through a throttle, the temperature of the gas falls to such an extent, that it changes into liquid form.

Application: Self cooling pop can (container)

A small container holding liquid CO₂ is built right into the can. When the can is opened, the liquid CO₂ vaporizes and escapes out of the top of the can. The heat absorbed by the vaporizing CO₂ can lower the temperature of the POP by 16 °C in a few seconds. Thus the temperature is lowered considerably.

x. Boiling point of HF (19.5°C) is low as compared to H₂O (100°C) although the electronegativity of Fluorine is greater than Oxygen. Explain.

Ans. Though the strength of single hydrogen bond in HF is stronger than H₂O. But the no of hydrogen bonds formed by water molecules with neighboring molecules are more than in HF. Hydrogen is trapped in between two fluorine atoms and form one hydrogen bond while in H₂O two hydrogen bonds are formed. That is why boiling point of H₂O is greater than HF.



xi. Briefly describe the factors on which London forces depend?

Ans. Factors affecting London dispersion force are:

1. **Atomic or Molecular Size:** With the increase in size of atom or molecule, the dispersion becomes easy and these forces become prominent.

2. **Polarizability:** It is a quantitative measure of the ease with which electron charge density is distorted. Large atoms have more electrons and large electronic cloud than small atoms. Polarizability increases with increased molecular and atomic size.

3. **No of atoms in a molecule:** Elongated molecules make contact with neighbouring molecules over a greater surface than do small molecules. Greater the no of atoms, greater will be London dispersion forces of the molecule.

xii. Give three properties of covalent crystals.

Ans. **Properties of Covalent Crystals:**

1. They are bad conductors of electricity with the exception of graphite.

2. They have definite shape and oriented in three directions with a network structure.

3. They may be called as macromolecules due to their giant covalent structures.

xiii. How can you measure the depression in freezing point using Beckman's Freezing point apparatus.

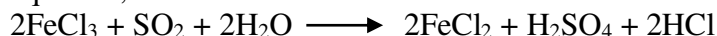
Ans. There are many methods but Beckmann's method is easy to perform. The apparatus consists of three major parts:

- A freezing tube with a side arm. It contains solvent or solution and is fitted with a stirrer and Beckmann's thermometer.
- An outer larger tube into which the freezing tube is adjusted. The air jacket in between these tubes help to achieve a slower and more uniform rate of cooling.
- A large jar containing a freezing mixture. Around 20 to 25 g of the solvent is taken in the freezing tube. The bulb of the thermometer is immersed in the solvent. First of all, approximate freezing point of the solvent is measured by directly cooling the freezing point tube in the freezing mixture.

The freezing tube is then put in the air jacket and cooled slowly. In this way, accurate freezing point of the solvent is determined. Now, the solvent is re-melted by removing the tube from the water bath and weighed amount of 0.2 to 0.3 g of the solute is introduced in the side tube. The freezing point of the solution is determined while stirring the solution. The difference of the two freezing points gives the value of ΔT , and the following formula is used to calculate the molar mass of solute.

$$M_2 = \frac{K_f \cdot 1000 \cdot W_2}{\Delta T \cdot W_1}$$

xiv. What is the oxidation numbers of the relevant elements on each side of the following equation, state which atom is oxidized and which is reduced? Show your working.

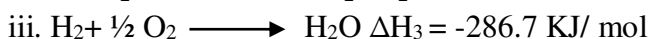
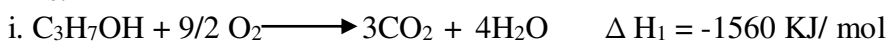


Ans. Fe is reduced while SO_2 is oxidized.

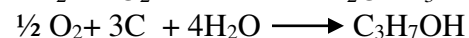
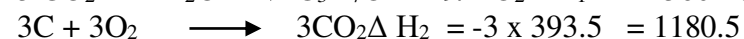
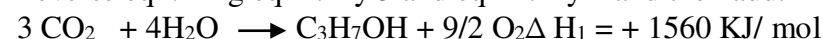


xv. Standard enthalpy change of combustion of a substance is energy change when one mole of a substance is completely burnt in oxygen at standard conditions i.e 25 °C and 1 atm pressure. Using following standard enthalpy changes of combustion of propanol
 $\Delta H_{\text{CO}_2} = -293 \text{ KJ/mol}$ $\Delta H_{\text{H}_2\text{O}} = -286 \text{ KJ/mol}$ $\Delta H_{\text{C}_3\text{H}_7\text{OH}} = -1560 \text{ KJ/mol}$
 Calculate enthalpy change of formation of propanol.

Ans.



Reverse eq i. xing eq ii. By 3 and eq iii. By 4 and then add.



$$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$$

$$= 1560 - 1180.5 - 1146.8$$

$$\Delta H = -767.3 \text{ KJ/mol}$$

xvi. The dissociation constant of an acid is a measure of its strength. Derive an expression for the dissociation constant of an acid "CH₃COOH".

Ans.

Suppose a weak acid CH₃COOH is dissolved in water.



$$K_c = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}][\text{H}_2\text{O}]}$$

$$K_c [\text{H}_2\text{O}] = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

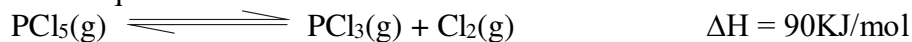
As water is a solvent its concentration will remain constant

$$K_c [\text{H}_2\text{O}] = K_a$$

So

$$K_a = \frac{[\text{H}_3\text{O}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]}$$

xvii. In the equilibrium

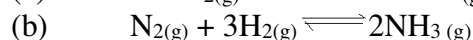


predict the effect on the position of equilibrium if temperature is increased and pressure is decreased.

Ans. a. Reaction will move forward because reaction is endothermic. So decomposition of PCl_5 is favourable at high temperature.

b. When pressure is decreased reaction will move forward because number of moles of product is greater than reactants.

xviii. Values of equilibrium constants can be calculated from measured values of concentrations or partial pressures. Write relationship between K_p and K_c in the following reactions?



$$\text{Ans. } K_p = K_c (RT)^{\Delta n}$$

$$a. \quad \Delta n = 2 - 1 = 1$$

$$K_p = K_c (RT)^1$$

$$K_p = K_c RT.$$

$$b. \quad \Delta n = 2 - 4 = -2$$

$$K_p = K_c (RT)^{-2}$$

xix. A solution containing 0.13M potassium acetate and 0.07M acetic acid. Calculate the pH of buffer solution. The value of ionization constant for acid is 1.81×10^{-5} .

$$\begin{aligned} \text{Ans. } [\text{CH}_3\text{COOK}] &= 0.13 \text{ M} & K_a &= 1.808 \times 10^{-5} & \text{pKa} &= -\log K_a \\ & & &= -\log 1.808 \times 10^{-5} \\ & & &= 4.74 \end{aligned}$$

$$\text{pH} = \text{pKa} + \text{Log} \frac{[\text{CH}_3\text{COOK}]}{[\text{CH}_3\text{COOH}]}$$

$$= 4.74 + \log \frac{0.13}{0.07}$$

$$\text{pH} = 5$$

xx. Calculate the molarity of 4.6% w/w solution of NaOH.

Ans. 4.6 % w/v NaOH means.

4.6 g NaOH in = 100 cm^3 of solution

$$\text{Mole} = 46 / 40$$

Mole = 1.15 mol

Molarity = $\frac{\text{No of mole of solute}}{\text{Volume of solution in dm}^3}$

Molarity = 1.15 / 1

Molarity = 1.15 M

SECTION – C(Marks 26)

Note: Attempt any **TWO** questions. All questions carry equal marks. (2×13 = 26)

Q.3 a. Derive energies expression for ${}^4_2\text{He}^{+1}$ according to Bohr's atomic model. (7)

Ans. The total energy E of an electron revolving around the nucleus is the sum of its kinetic and the potential energies.

$$E_T = \text{K.E.} + \text{P.E.} \quad \text{----- (i)}$$

The kinetic energy of moving electron of mass m and velocity v is

$$\text{K.E.} = \frac{1}{2}mv^2 \quad \text{----- (ii)}$$

The potential energy is given by the following equation

$$\text{P.E.} = -\frac{Ze^2}{4\pi\epsilon_0 r} \quad \text{----- (iii)}$$

Taking the sum of equations (i) and (ii),

$$E_n = \frac{1}{2}mv^2 + \left(-\frac{Ze^2}{4\pi\epsilon_0 r}\right)$$

$$E_n = \frac{1}{2}mv^2 - \frac{Ze^2}{4\pi\epsilon_0 r} \quad \text{----- (iv)}$$

We know that the electron can revolve only in those orbits, where the centripetal force $\frac{mv^2}{r}$ and the coulombic forces are equal. So comparing the centripetal and coulombic forces we get the following equation

$$\frac{mv^2}{r} = \frac{Ze^2}{4\pi\epsilon_0 r^2}$$

or $mv^2 = \frac{Ze^2}{4\pi\epsilon_0 r} \quad \text{----- (v)}$

Eliminate the factor of velocity v from equation (iv) by using equation (v).

$$E = +\frac{Ze^2}{8\pi\epsilon_0 r} - \frac{Ze^2}{4\pi\epsilon_0 r} \quad \text{----- (vi)}$$

By simplifying we get the following Equation (vii) which gives the expression for radius of orbit (r). Put value of r from equation (vii) into equation (vi) we get equation (viii) which gives the energies of n orbits.

$$r = \frac{n^2 h^2 \epsilon_0}{\pi m z e^2} \quad \text{----- (vii)}$$

so $E_n = -\frac{Z^2 e^4 m}{8\epsilon_0^2 n^2 h^2} \quad \text{----- (viii)}$

The value of Z (atomic number) of Helium is 2. Put $Z = 2$ in equation (viii).

$$E_n = -\frac{e^4 m}{8\epsilon_0^2 h^2} \times \left(\frac{Z^2}{n^2}\right)$$

$$E_n = -\frac{e^4 m}{8\epsilon_0^2 h^2} \times \left(\frac{2^2}{n^2}\right)$$

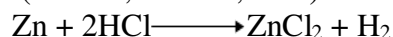
$$E_n = -\frac{e^4 m}{8\epsilon_0^2 h^2} \times \left(\frac{4}{n^2}\right)$$

$$E_n = -\frac{e^4 m}{2\epsilon_0^2 h^2} \times \left(\frac{1}{n^2}\right) \quad \text{----- (ix)}$$

Equation ix gives the energy of the n orbitals of He⁺

- b. 40dm³HCl (g) at STP reacts with 50g Zn which is placed in water to form ZnCl₂ and H₂. Calculate the mass of H₂ produced and unreacted reactant left.

(Zn =65, Cl=35.5, H=1)



(3+3)

Ans.

Mass of H₂ Produced

Moles of Zn = 50 / 65 = 0.769

Moles of HCl = 40/22.414 = 1.784

Mole ratio:

Zn : H₂

1 : 1

0.769 : x

X = 0.769

Mole Ratio:

HCl : H₂

2 : 1

1.784 : x

X = 1.784 x 1 / 2 = 0.892

Since Zn produced less number of moles of H₂ hence it is a limiting reactant and the moles of H₂ produced will be = 0.769

Mass of H₂ = 0.769 x 2 = 1.538 gm

Mass of non limiting reactant left:

The number of moles of HCl required to react with 0.769 mol of Zn can be calculated by applying mol ratio between them according to the balance chemical equation.

Mol Ratio

Zn : HCl

1 : 2

0.769 : x

X = 0.769 x 2 = 1.538

Moles of HCl left unreacted = 1.784 - 1.538 = 0.246

Mass of HCl left unreacted = 0.246 x 36.5 = 8.979 gm

- Q.4** a. Explain and draw stepwise Born Haber Cycle for measurement of $\Delta H_{\text{lattice}}$ for potassium chloride (KCl) by using supposed values according to the steps. (5+3)

Ans. Lattice energy cannot be determined directly. However, it can be determined indirectly by means of Born Haber's cycle.

Suppose the enthalpy formation of KCl(s) ΔH_f is -x kJ/mol. The formation reaction can be considered as taking place in several steps, one of which is the formation of lattice. This complete sequence of reaction is called a Born Haber cycle.

Step-I: Sublimation of solid potassium.

Let the energy of sublimation for K (s) is a kJ mole⁻¹



Step-II: Ionization of K_(g) atom to form K⁺_(g) ion. This process corresponds to the first ionization energy for K.



Step-III: Dissociation of Cl₂ molecules. We need to form one mole of Cl atoms by breaking the Cl-Cl bond in 1 mole of Cl₂ molecules. The energy required to break this bond is known as enthalpy of atomization for Cl₂.



All these three steps are endothermic.

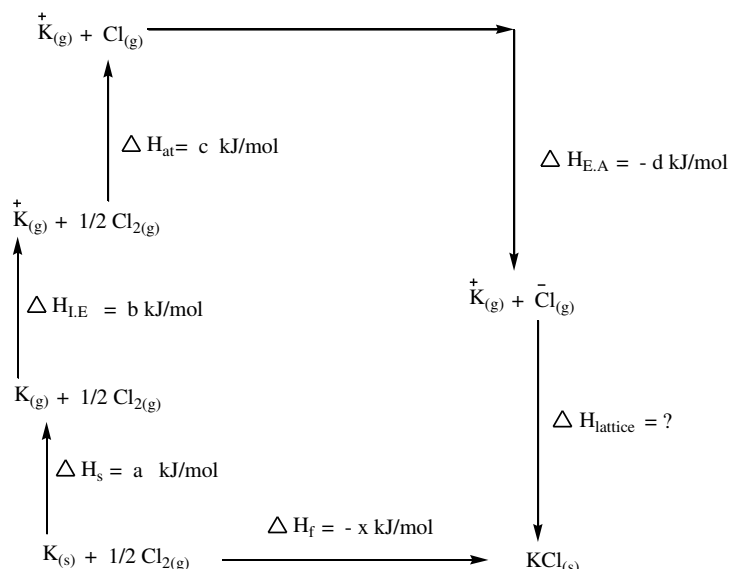
Step-IV: Formation of Cl_(g) ion. Energy is released in this step equal to the electron affinity for Cl.



Step-V: Formation of solid KCl from the gaseous $\text{K}^{+}_{(g)}$ and $\text{Cl}^{-}_{(g)}$ ions. This corresponds to the lattice energy (ΔH_l) for KCl(s) which is to be calculated.



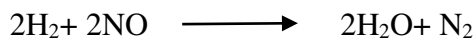
Born Haber cycle



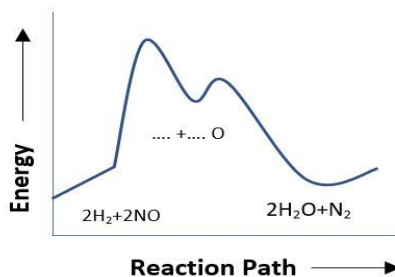
$$\Delta H_f = \Delta H_s + \Delta H_{I.E} + \Delta H_{at} + \Delta H_{E.A} + \Delta H_{lattice}$$

$$\Delta H_{lattice} = \Delta H_f - (\Delta H_s + \Delta H_{I.E} + \Delta H_{at} + \Delta H_{E.A})$$

- b. Explain the potential energy diagram for the given reaction and propose reaction mechanism (3+2)



$$\text{Rate} = k[\text{H}_2][\text{NO}]^2$$

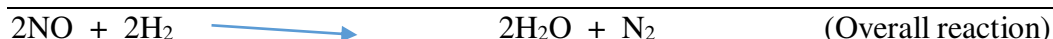


Ans. The given potential energy diagram shows two peaks. Thus the reaction mechanism must involve two elementary steps.

The activation energy for step 1 is higher than step 2. Which suggests that step 1 will be slow and rate determining step.

The rate law suggests that two molecules of NO and one molecule of H_2 are involved in the slow or rate determining step.

The proposed mechanism of the reaction could be.



- Q.5** a. Define the following terms with suitable example: **(2+2+2)**
- i. Isomorphism
 - ii. Polymorphism
 - iii. Anisotropy

Ans.

Isomorphism

Different crystalline substances having the same crystalline shapes are called Isomorphs, and this phenomenon is called isomorphism. This is due to the same ratio of atoms in different crystalline substances.

For example

ZnSO₄ and NiSO₄ are isomorphism because both have the same crystalline shape, i.e. orthorhombic.

Polymorphism

The substance existing in more than one crystalline form is called polymorphous substance and the phenomena as polymorphism.

For example NaCl is found in cubic and octahedral forms.

Anisotropy

A crystalline substance shows different intensity of properties in different directions this phenomenon is called anisotropic. It is because crystal has different arrangements in different directions. For example Refractive index, co-efficient of thermal expansion, electrical and thermal conductivities give different intensity of properties in different directions.

- b. Summarize and illustrate the elevation of boiling point using graph. **(4+3)**

Ans.

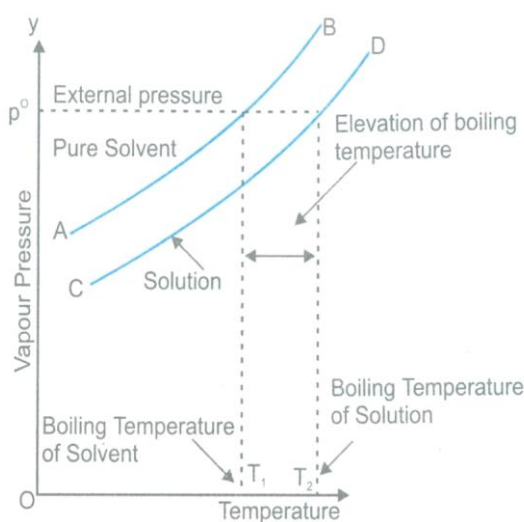
Boiling Point:

A liquid boils at a temperature where its vapour pressure becomes equal to the atmospheric pressure. This temperature is called boiling point of that liquid.

Elevation of boiling point:

When a non-volatile and non-electrolyte solute is added to a solvent, its vapour pressure is decreased due to the decrease of the number of solvent surface particles. This decreases the rate of evaporation of solvent, which in turn decreases the vapour pressure. Therefore, a solution must be heated to a higher temperature than the boiling point of pure solvent to equalize its vapour pressure to the external pressure. Thus addition of solute to a pure solvent causes an elevation of the boiling point of solution.

The difference between the boiling point of solution and that of pure solvent is called Elevation of Boiling Point.



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