Class XI Session 2024-25
Subject - Chemistry
Sample Question Paper - 2

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

1. There are 33 questions in this question paper with internal choice.
2. SECTION A consists of 16 multiple-choice questions carrying 1 mark each.
3. SECTION B consists of 5 very short answer questions carrying 2 marks each.
4. SECTION C consists of 7 short answer questions carrying 3 marks each.
5. SECTION D consists of 2 case-based questions carrying 4 marks each.
6. SECTION E consists of 3 long answer questions carrying 5 marks each.
7. All questions are compulsory.
8. The use of log tables and calculators is not allowed

Section A

1. The number of moles of solute present in 1 kg of a solvent is called________. **[1]**

a) Molarity (M) b) ppm

c) Normality(N) d) Molality (m)

2. Photoelectric effect established that light **[1]**

a) behaves like particles b) behaves like magnetic fields

c) behaves like waves d) behaves like rays

3. Calculate the enthalpy change on freezing of 1.0 mol of water at 10.0°C to the ice at -10.0° C. $\Delta_{fus} H = 6.03$ kJ mol^{-1} at 0°C. **[1]**

a. $C_P[H_2O(l)] = 75.3\ Jmol^{-1}K^{-1}$

b. $C_P[H_2O(s)] = 36.8\ Jmol^{-1}K^{-1}$

a) $\Delta H = -5.231\ kJmol^{-1}$ b) $\Delta H = -7.151\ kJ\ mol^{-1}$

c) $\Delta H = -6.114 kJmol^{-1}$ d) $\Delta H = -\ 7.415 kJ\ mol^{-1}$

4. Find the energy of the photons which correspond to light of frequency 3×10^{15} Hz (Hint: h = Planck's constant = 6.626×10^{-34} Js)? **[1]**

a) 2.988×10^{-18} J b) 0.988×10^{-18} J

c) 1.308×10^{-18} J d) 1.988×10^{-18} J

5. What will be the value of logarithm of equilibrium constant K_p if the standard free energy change of a reaction is **[1]**

ΔG^o = -115 kJ at 298 K will be

a) 13.83
b) 2.015
c) 20.15
d) 2.303

6. Lines in the hydrogen spectrum which appear in the infrared region of the electromagnetic Spectrum, then they are called as **[1]**

a) Balmer series
b) Hydrogen line series
c) Hydrogen series
d) Paschen series

7. Dalda is prepared from oils by________. **[1]**

a) hydrolysis
b) reduction
c) distillation
d) oxidation

8. Which solution is used for the separation of a mixture of phenol and aromatic carboxylic acid? **[1]**

a) Na_2CO_3
b) $NaHCO_3$
c) NaOH
d) CaO

9. An aqeous solution of compound A gives ethane on electrolysis. The compound A is ....? **[1]**

a) Sodium propionate
b) Sodium acetate
c) Sodium ethoxide
d) Ethyl acetate

10. The elements charecterised by the filling of 4 f-orbitals, are: **[1]**

a) Alkali metals
b) Alkaline earth metals
c) Lanthanoids
d) Transition elements

11. Given $N_2(g) + 3H_2(g) \rightarrow NH_3(g)$; $\Delta_r H° = -92.4\ kJ\ mol^{-1}$. What is the standard enthalpy of formation of NH_3 gas? **[1]**

a) $-41.3\ kJ\ mol^{-1}$
b) $-46.2\ kJ\ mol^{-1}$
c) $-56.5\ kJ\ mol^{-1}$
d) $-36.9\ kJ\ mol^{-1}$

12. In the following sequence of reactions, the alkene is converted to compound B **[1]**

$\mathrm{CH_3CH = CHCH_3} \overset{O_3}{\rightarrow} \mathrm{A} \overset{H_2O,Zn}{\rightarrow} B$

The compound B--------- is?

a) $\mathrm{CH_3CH_2CHO}$
b) $\mathrm{CH_3CHO}$
c) $\mathrm{CH_3COCH_3}$
d) $\mathrm{CH_3CH_2COCH_3}$

13. **Assertion (A):** Components of a mixture of red and blue inks can be separated by distributing the components between stationary and mobile phases in paper chromatography. **[1]**

Reason (R): The coloured components of inks migrate at different rates because paper selectively retains different components according to the difference in their partition between the two phases.

a) Both A and R are true and R is the correct explanation of A.
b) Both A and R are true but R is not the correct explanation of A.
c) A is true but R is false.
d) A is false but R is true.

14. **Assertion (A):** Trans-2-butene on reaction with Br_2 gives a meso-2,3-dibromobutane. **[1]**

Reason (R): The reaction involves the syn-addition of bromine.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

15. **Assertion (A):** In the dissociation of PCl_5 at constantp ressure and temperature, addition of helium at equilibrium increases the dissociation of PCl_5. **[1]**

Reason (R): Helium reacts with Cl_2 and hence shifts the equilibrium in forward direction.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

16. **Assertion (A):** In 285cm there are 3 significant figures. **[1]**

Reason (R): Zero preceding to first non-zero digit are not significant.

a) Both A and R are true and R is the correct explanation of A.

b) Both A and R are true but R is not the correct explanation of A.

c) A is true but R is false.

d) A is false but R is true.

Section B

17. Classify the following species into Lewis acids and Lewis bases and show how these act as Lewis acid/base: **[2]**

a. OH^-

b. F^-

c. H^+

d. BCl_3

18. How does the reactivity of non–metals changes in a period and group? **[2]**

19. Calculate: Mass of 2.5 gram atoms of magnesium, **[2]**

20. Complete the following reactions: **[2]**

i. Isopropyl bromide $\xrightarrow[\text{Heat}]{\text{alc. KOH}} \text{A} \xrightarrow[\text{Peroxide}]{\text{HBr}} \text{B}$

ii. n-Propyl alcohol $\xrightarrow[\text{443 K}]{\text{Conc. } H_2SO_4} \text{A} \xrightarrow[\text{Heat}]{O_2,\text{ Ag}} \text{B}$

OR

Define resonance energy. What is resonance energy of benzene?

21. The uncertainty in the position of a moving bullet of mass 10 g is $\Delta x\ m\Delta v = \frac{h}{4\pi}$. Calculate the uncertainty in its velocity? **[2]**

Section C

22. Explain the structure of the CO_2 molecule. **[3]**

23. **Answer:** **[3]**

(a) At 298 K, K_p for the reaction $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ is 0.98. Predict whether the reaction is spontaneous or not. **[1]**

(b) Define specific heat. **[1]**

(c) State Hess's law. **[1]**

24. Give the relationship between ΔU and ΔH for gases. **[3]**

25. Justify that the following reactions are redox reactions: **[3]**

   i. $CuO + H_2(g) \longrightarrow Cu(s) + H_2O(g)$
   ii. $Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g)$
   iii. $4BCl_3(g) + 3LiAlH_4(s) \longrightarrow 2B_2H_6(g) + 3LiCl(s) + 3\ AlCl_3(s)$

26. A photon of wavelength 4×10^{-7} m strikes on the metal surface, the work function of metal being 2.13 eV. Calculate **[3]**

   i. the energy of the photon (eV),
   ii. the kinetic energy of emission,
   iii. the velocity of the photoelectron. ($1\ eV = 1.6020 \times 10^{-19}$ J).

27. How would you explain the fact that the first ionization enthalpy of sodium is lower than that of magnesium but its second ionization enthalpy is higher than that of magnesium? **[3]**

28. Describe what you need to do in the laboratory to test **[3]**

   i. the law of conservation of mass,
   ii. the law of definite proportion
   iii. the law of multiple proportions.

Section D

29. **Read the following text carefully and answer the questions that follow:** **[4]**

Once an organic compound is extracted from a natural source or synthesised in the laboratory, it is essential to purify it. Various methods used for the purification of organic compounds are based on the nature of the compound and the impurity present in it. Finally, the purity of a compound is ascertained by determining its melting or boiling point. This is one of the most commonly used techniques for the purification of solid organic compounds. In crystallisation Impurities, which impart colour to the solution are removed by adsorbing over activated charcoal. In distillation Liquids having different boiling points vaporise at different temperatures. The vapours are cooled and the liquids so formed are collected separately. Steam Distillation is applied to separate substances which are steam volatile and are immiscible with water. Distillation under reduced pressure: This method is used to purify liquids having very high boiling points.

   i. Which method can be used to separate two compounds with different solubilities in a solvent?
   ii. Distillation method is used to separate which type of substance?
   iii. Which technique is used to separate aniline from aniline water mixture?

   OR

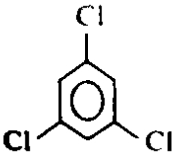
   Why chloroform and aniline are easily separated by the technique of distillation?

30. **Read the following text carefully and answer the questions that follow:** **[4]**

Covalent molecules formed by heteroatoms bound to have some ionic character. The ionic character is due to shifting of the electron pair towards A or B in the molecule AB. Hence, atoms acquire small and equal charge but opposite in sign. Such a bond which has some ionic character is described as a polar covalent bond. Polar covalent molecules can exhibit a dipole moment. The dipole moment is equal to the product of charge separation, q and the bond length, d for the bond. The unit of dipole moment is Debye. One Debye is equal to 10^{-18} esu cm.

The dipole moment is a vector quantity. It has both magnitude and direction. Hence, the dipole moment of molecules depends upon the relative orientation of the bond dipole, but not the polarity of bonds alone. The symmetrical structure shows a zero dipole moment. Thus, a dipole moment help to predict the geometry of the molecules. Dipole moment values can be used to distinguish between cis- and trans-isomers; ortho-, meta- and para-forms of a substance, etc. The percentage of ionic character of a bond can be calculated by the application of the following formula:

% ionic character = $\frac{\text{Experimental value dipole moment}}{\text{Theoretical value of dipole moment}} \times 100$

i. Out of  and  which compounds have zero dipole moments? (1)

ii. A diatomic molecule has a dipole moment of 1.2D. If the bond length is 1.0×10^{-8}cm, what fraction of charge does exist on each atom? (1)

iii. The dipole moment of NF_3 is very much less that of NH_3. Why? (2)

OR

A covalent molecule, x-y, is found to have a dipole moment of 1.5×10^{-29} cm and a bond length 150 pm. What will be the percentage of ionic character of the bond? (2)

Section E

31. **Attempt any five of the following:** **[5]**

(a) What is hydrogenation? **[1]**

(b) Why do the C—C bonds rather than C—H bonds break during cracking of alkanes? **[1]**

(c) Which conformation of ethane is more stable? **[1]**

(d) What happens when 2-bromobutane is being treated with KOH (alcoholic)? **[1]**

(e) Identify the structure of A and B; **[1]**

$$\mathrm{CH_3 - CH_2COOH} \xrightarrow{\text{KOH}} \mathrm{A} \xrightarrow{\text{Kolbe's electrolysis}} \mathrm{B}$$

$$\mathrm{CH_3 - CH_2COOH} \xrightarrow{\text{KOH}} \underset{\mathrm{A}}{\mathrm{CH_3CH_2COO^-K^+}} \xrightarrow{\text{Kolbe's electrolysis}} \underset{\mathrm{B}}{\mathrm{CH_3CH_2CH_2CH_3}}$$

(f) How will you separate propene from propyne? **[1]**

(g) Why is t-butyl bromide more reactive towards S_N1 reaction as compared to n-butyl bromide? **[1]**

32. On the basis of Le Chatelier principle explain how temperature and pressure can be adjusted to increase the yield of ammonia in the following reaction: **[5]**

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$\Delta H = -92.38\ \text{kJmol}^{-1}$

What will be the effect of the addition of argon to the above reaction mixture at constant volume?

OR

Determine the degree of ionization and pH of a 0.05M of ammonia solution. The ionization constant of ammonia can be taken from table given below.

Base	K_b
Dimethylamine, $(CH_3)_2NH$	5.4×10^{-4}
Triethylamine, $(C_2H_5)_3N$	6.45×10^{-5}
Ammonia, NH_3 or NH_4OH	1.77×10^{-5}

Quinine, (A plant product)	1.10×10^{-6}
Pyridine, C_5H_5N	1.77×10^{-9}
Aniline, $C_6H_5NH_2$	4.27×10^{-10}
Urea, CO $(NH_2)_2$	1.3×10^{-14}

Also, calculate the ionization constant of the conjugate acid of ammonia.

33. **Answer:** **[5]**

(a) i. An organic liquid decomposes below its boiling point. How will you purify it? **[2.5]**

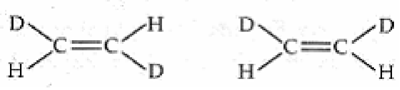
ii. Name three types of chromatography? **[2.5]**

OR

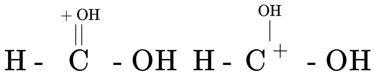
i. What is the relationship between the members of following pairs of structures? Are they structural or geometrical isomers or resonance contributors? **[2.5]**

i.

ii.



iii.



$\text{H} - \overset{+\text{OH}}{\overset{\|}{\text{C}}} - \text{OH} \quad \text{H} - \overset{\text{OH}}{\overset{|}{\text{C}^+}} - \text{OH}$

ii. A sample of 0.50 g of an organic compound was treated according to Kjeldahl's method. The ammonia evolved was absorbed in 50 mL of 0.5 M H_2SO_4. The residual acid required 60 mL of 0.5 M solution of NaOH for neutralisation. Find the percentage composition of nitrogen in the compound. **[2.5]**

Solution

Section A

1.

(d) Molality (m)

Explanation: Molality is defined as no. of moles of solute present per kg of solvent. It is denoted as " m ". Mathematically,
Molality (m) = [number of moles of the solute] / kg of solvent
Since this mode of expressing the strength of a solution involves (weight/weight) relationship of solute and solvent, the molality of the solution is not affected by variation in temperatures of the solution.

2. **(a)** behaves like particles

Explanation: The emission of free electrons from a metal surface when light is shone on it is called the photoemission or the photoelectric effect. This effect led to the conclusion that light is made up of packets or quantum of energy. Einstein already associated the light quantum with momentum. This strongly supported the particle nature of light and these particles were named photons. Thus, the wave-particle duality of light came into the picture. Einstein won the Nobel Prize for Physics not for his work on relativity, but for explaining the photoelectric effect.

3.

(b) ΔH = -7.151 kJ mol^{-1}

Explanation: Water (10.0^{o}C) $\rightarrow$ ice (-10.0^{o}C) $\Delta H = ?$

The enthalpy change for the conversion of 1 mole liquid water at 10.0^{o}C into 1 mole liquid water 0^{o}C, water (10.0^{o} C) $\rightleftharpoons$ water(0^{o} C).

$\triangle H_1 = C_p \times H_2O(l) \times \triangle T$ = -75.3 Jmol^{-1} K^{-1} = -753 J mol^{-1}

Enthalpy of fusion, water (0^{o} C) $\rightleftharpoons$ ice(0^{o} C) , $\Delta H_2 = \Delta_{fus} H$

$l\triangle H_2 \ = \ \triangle H_{freezing} = -\triangle H_{fusion}$ = -6.06 kJ mol^{-1}

Enthalpy change for conversion of 1 mole of ice at 0^{o}C to 1 mole of ice at 10^{o}C, Ice (0^{o} C) $\rightleftharpoons$ ice(10.0^{o} C);

$\Delta H_3 = C_p[H_2O(s)]\Delta T$ = -36.8 Jmol^{-1}K^{-1} x 10K =-368 J mol^{-1}

$\Delta H = \ \Delta H_1 + \ \Delta H_2 + \ \Delta H_3$ = - (0.753 + 6.03 + 0.368)kJ mol^{-1} = -7.151 kJmol^{-1}

4.

(d) 1.988 $\times$ 10^{-18} J

Explanation: We know Planck's equation is
E = hv
where E is energy, h is Planck’s constant and v is frequency.

E = 6.626 $\times$ 10^{-34} $\times$ 3 $\times$ 10^{15} = 1.988 $\times$ 10^{-18} J

5.

(c) 20.15

Explanation: ΔG^o = -115 $\times$ 10^{3} J

T = 298 K, R = 8.314 JK^{-1} mol^{-1}

-ΔG^o = 2.303 RT log$_{10}$ K$_p$

-(-115 $\times$10^{3}) = 2.303 $\times$ 8.314 $\times$ 298 log$_{10}$ K$_p$

log$_{10}$ K$_p$ = $\frac{115000}{2.303 \times 8.314 \times 298}$ = 20.15

6.

(d) Paschen series

Explanation: The Lyman series lies in the ultraviolet, whereas the Paschen, Brackett, and Pfund series lies in the infrared.

7.

(b) reduction

Explanation: Oils are esters of unsaturated fatty acids whereas Dalda is an ester of saturated fatty acids. The former is converted into the latter by catalytic hydrogenation i.e., reduction.

8.

(b) $NaHCO_3$

Explanation: $NaHCO_3$ solution is used for the separation of a mixture of phenol and aromatic carboxylic acid.

9.

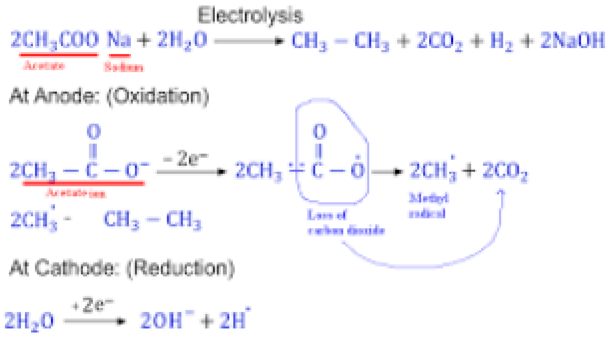
(b) Sodium acetate

Explanation:

This is an example of Kolbe's electrolysis method. The reaction is:

$$2CH_3COONa + 2H_2O \overset{electrolysis}{\longrightarrow} CH_3.CH_3 + 2NaOH + H_2 + 2CO_2$$

The step-wise redox reactions occuring in the electrolytic cell are depicted as under



$2H^- \rightarrow H_2$

10.

(c) Lanthanoids

Explanation: The two rows of elements at the bottom of the Periodic Table, called the Lanthanoids, Ce(Z = 58) – Lu(Z = 71) and Actinoids, Th(Z = 90) – Lr (Z = 103) are characterized by the outer electronic configuration $(n-2)f^{1-14}$ $(n-1)d^{0-1}ns^2$. The last electron added to each element is filled in f- orbital. These two series of elements are hence called the Inner-Transition Elements (f-Block Elements).

11.

(b) -46.2 kJ mol^{-1}

Explanation: Given, $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$; $\Delta_r H° = –92.4$ kJ mol^{-1}.

Chemical reaction for the enthalpy of formation of NH_3 (g) is as follows:

$$\frac{1}{2}N_2\ (g)\ + \frac{3}{2}H_2(g)\ \rightarrow NH_3(g)$$

Therefore, $\Delta_f H^\circ = \frac{-92.4}{2} =$ - 46.2 kJ/mol

12.

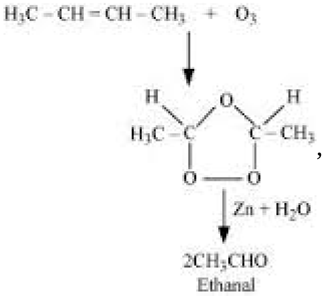
(b) CH_3CHO

Explanation: The given sequence of conversion steps represent Ozonolysis of 2-Butene, which follows the following path,

i. Formation of an unstable intermediate/ozonide(A)

ii. Cleavage of the intermediate/ozonide by $(Zn + H_2O)$ to smaller molecules, giving out the compound$B$, which is **CH_3 CHO (Ethanal)**

The reaction is well depicted as below,



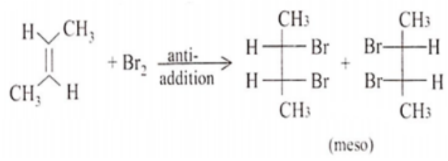
13. **(a)** Both A and R are true and R is the correct explanation of A.

Explanation: In paper chromatography, a special quality paper known as chromatography paper is used. Chromatography paper contains water trapped in it, which acts as the stationary phase. A strip of chromatography paper spotted at the base with the solution of the mixture is suspended in a suitable solvent or a mixture of solvents. This solvent acts as the mobile phase. The solvent rises up the paper by capillary action and flows over the spot. The paper selectively retains different components according to their differing partition in the two phases. The paper strip so developed is known as a chromatogram. The spots of the separated coloured compounds are visible at different heights from the position of the initial spot on the chromatogram.

14.

(c) A is true but R is false.

Explanation: With trans-2-butene, the product of Br_2 addition is optically inactive due to the formation of symmetric meso compounds.



15.

(c) A is true but R is false.

Explanation: Equilibrium shift in backword direction.

16.

(b) Both A and R are true but R is not the correct explanation of A.

Explanation: All non-zero digits are significant. For example, in 285 cm, there are three significant figures and in 0.25 mL, there are two significant figures.

Section B

17. a. Hydroxyl ion (OH^-) acts as a Lewis base as it can donate an electron lone pair.

b. Fluoride ion (F^-) acts as a Lewis base as it can donate any one of its four electron lone pairs.

c. A proton (H^+) acts as a Lewis acid as it can accept a lone pair of electrons from bases like hydroxyl ion and fluoride ion.

d. BCl_3 acts as a Lewis acid as it can accept a lone pair of electrons from species like ammonia or amine molecules.

18. The reactivity of non – metals is measured in terms of its tendency to gain electrons to form an ion. The reactivity of non – metals increases from left to right in a period because of increase in nuclear charge due to succesive addition of electron in same shell whereas reactivity decreases in a group as we go down the group because of increase in atomic size and decrease in nuclear charge. Therefore, the tendency to accept electrons decreases down the group.

19. Since one gram atom of Mg represents a quantity = Atomic mass of Mg (ie. 24 gms.)

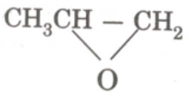
1 gram atom of Mg = 24 g

2.5-gram atoms of Mg = 24 × 2.5 = 60 g

20. i. $\underset{\underset{\text{Br}}{|}}{CH_3CHCH_3} \xrightarrow[\text{Heat}]{\text{alc. KOH}} \underset{\underset{\text{Propene}}{\text{(A)}}}{CH_3CH = CH_2} \xrightarrow[\text{peroxide}]{\text{HBr}} \underset{\underset{\text{1−Bromopropene}}{\text{(B)}}}{CH_3CH_2CH_2Br}$

ii. $CH_3CH_2CH_2OH \xrightarrow[\text{Heat}]{\text{cone } H_2SO_4} \underset{\underset{\text{Propene}}{\text{(A)}}}{CH_3CH = CH_2} \xrightarrow[\text{Heat}]{O_2,\ Ag}$

1-Bromopropane



(B)

Propylene oxide

OR

Resonance energy is the difference in energy between actual structure of compound and most stable resonating structure. The resonance energy of benzene is 150.325 j mol^{-1}

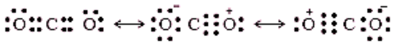
21. According to the uncertainty principle,

$\Delta x.\ m\ \Delta v = \frac{h}{4\pi}$ or $\Delta v = \frac{h}{4\pi m \Delta x}$ h = 6.625 × 10^{-34} kg m^2s^{-1} m = 10 g = 10^{-2} K

$\Delta x = 10^{-5}$ m; $\Delta v = \frac{(6.626\times10^{-34} \text{kgm}^2\text{s}^{-1})}{4\times3.143\times(10^{-2}\text{kg})\times(10^{-5}\text{m})}$ = 5.27 × 10^{-28} mv

Section C

22. The experimentally determined carbon to oxygen bond length in CO_2 is 115 pm. The lengths of a normal carbon to oxygen double bond (C = O) and carbon to oxygen triple bond (C ≡ O) are 121 pm and 110 pm respectively. The carbon-oxygen bond lengths in CO_2 (115 pm) lie between the values for C = O and C≡O. Obviously, a single Lewis structure cannot depict this position and it becomes necessary to write more than one Lewis structures and to consider that the structure of CO_2 is best described as a hybrid of the canonical or resonance forms I, II and III.



23. Answer:

(i) Given, At 298 K, $\mathrm{N_2O_4}(g) \rightleftharpoons 2\mathrm{NO_2}(g)$.
We know that, $\Delta_r G^\circ = -2.303RT \log K_p$
According to the question, K_p = 0.98.
As, K_p < 1, $\Delta_r G^\circ$ will be positive. $[\because \log(0.98) = -0.0087]$
Hence, the reaction is non-spontaneous.

(ii) **Specific heat:** The quantity of heat required to raise the temperature by one degree Celsius (or one Kelvin) of one unit mass of a substance is known as specific heat.

(iii)The change of enthalpy of a reaction remains same whether the reaction is carried out in one step or several steps.
$\Delta H = \Delta H_1 + \Delta H_2 + \Delta H_3$--------

24. Let V_A be the total volume of gaseous reactants,

V_B be the total volume of gaseous product.

Let n_A be the number of moles of the reactant,

n_B be the number of moles of the product,

At constant pressure and temperature,
$pV_A = n_ART$,
$pV_B = n_BRT$
$\Rightarrow pV_B - pV_A = (n_B - n_A)$ RT
$\Rightarrow$p $\Delta V = (\Delta n)_g$RT
Here, $(\Delta n)_g = n_B - n_A$ is equal to the difference between the number of moles of gaseous products and gaseous reactants.
We know that,
$\Delta H = \Delta U + (\Delta n)_g RT$
Now, $\Delta H = q_p$(heat change under constant pressure),

$\Delta U = q_v$(heat change under constant volume).

Therefore, $q_p = q_v + (\Delta n)_g RT$

25. The given equations for different reactions are :

$$\text{i. } \overset{+2-2}{\mathrm{CuO}}(\mathrm{s}) + \underset{2}{\overset{0}{\mathrm{H}}}(\mathrm{g}) \rightarrow \overset{0}{\mathrm{C}}\mathrm{u(s)} + \overset{+1-2}{\mathrm{H_2O}}(\mathrm{g})$$

As per above equation, it is noted that.

a. an atom of oxygen (O) is removed from CuO,
∴ it is reduced to Cu, while

b. O is added to H_2 to form H_2O
∴ it is oxidized.
Further,
Oxidation number. of Cu decreases from +2 in CuO to 0 in Cu,
oxidation number of H increases from 0 in H_2 to +1 in H_2O.
∴ CuO is reduced to Cu but H_2 is oxidized to H_2O.
Thus, the reaction is a redox reaction.

ii. $\overset{+3}{Fe_2}\overset{-2}{O_3}(s) + 3\overset{+2}{CO}(g) \rightarrow 2\overset{0}{F}e(s) + 3C\underset{2}{\overset{+4}{O}}(g)$

In the above equation for reaction, it is seen that

a. The oxidation number of Fe decreases from +3 in Fe_2O_3 to 0 in Fe, and

oxidation number of C increases from +2 in CO to +4 in CO_2.

Further,

oxygen is removed from Fe_2O_3, and

added to CO to form CO_2

therefore, Fe_2O_3 is reduced while CO is oxidized.

Thus, the given reaction is a redox reaction.

iii. Similarly, in the given equation ,

$4B^{+3}Cl^{-1}{}_3(g) + 3Li^{+1}\,Al^{+3}\,H^{-1}{}_4\,(s) \longrightarrow 2\,B^{-3}{}_2\,H^{-1}{}_6\,(g) + 3LI^{+1}\,Cl^{-1}\,(s) + 3\,Al^{+3}\,Cl^{-1}{}_3$

Oxidation number of B decreases from +3 in BCl_3 to -3 in B_2H_6

while,

oxidation number of H increases from -1 in $LiAlH_4$ to +1 in B_2H_6.

Therefore, BCl_3 is reduced and

$LiAlH_4$ is oxidized.

Further, it is noted that,

H is added to B forming B_2 H6 from BCl_3 but is removed from $LiAlH_4$,

therefore,

BCl_3 is reduced while $LiAlH_4$ is oxidised.

Thus,

the redox nature of above reaction is justfied.

26. i. The energy of the photon

Energy (E) = $\frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\,Js)\times(3\times10^{8}\,ms^{-1})}{(4\times10^{-7}\,m)}$ = 4.97×10^{-19}

= $\frac{(1eV)}{(1.602\times10^{-19}\,J)} \times (4.97 \times 10^{-19}\ J) = 3.1\ eV$

ii. The kinetic energy of emission

Kinetic energy of emission = E - work function (i.e. kinetic energy of emitted electron)

= (3.1 - 2.13) = 0.97 eV

iii. Velocity of photoelectron

KE of emission = $\frac{1}{2}mv^2 = 0.97\ eV$

$= 0.97 \times 1.602 \times 10^{-19}\ J = 0.97 \times 1.602 \times 10^{-19}\ kg\ m^2\ s^{-2}$

or $v^2 = \frac{2\times0.97\times1.602\times10^{-19}\,(kgm^2s^{-2})}{(9.1\times10^{-31}\,kg)} = 0.34 \times 10^{12}\ m^2s^{-2}$

or $v = (0.34 \times 10^{12}\ m^2\ s^{-2})^{1/2} = 0.583 \times 10^{6}\ ms^{-1} = 5.83 \times 10^{5}\ ms^{-1}$

27. Electronic configurations of Na and Mg are

Na = $1s^22s^22p^63s^1$

Mg = $1s^22s^22p^63s^2$

The 1st ionization enthalpy of magnesium is higher than that of Na due to higher nuclear charge and slightly smaller atomic radius of Mg than Na.

Electronic configurations of Na and Mg after loosing 1 electron are

$Na^+ = 1s^22s^22p^6$

$Mg^+ = 1s^22s^22p^63s^1$

After the loss of the first electron, Na^+ formed has the electronic configuration of neon (2,8). The higher stability of the completely filled noble gas configuration leads to very high second ionization enthalpy for sodium. On the other hand, Mg^+ formed after losing the first electron still has one more electron in its outermost orbital. Therefore, the second ionization enthalpy of magnesium is much smaller than that of sodium.

28. i. In order to test the law of conservation of mass, a reaction would have to be carried out in which the mass of the reactants and the mass of the products are weighed and shown to be the same.

ii. The law of definite proportions could be shown by demonstrating that no matter, how a compound is obtained, the reactants remain at the same proportions by mass. This can be done by decomposing a compound and showing that the masses of the elements present are always in the same whole number ratio.

iii. To test the law of multiple proportions, two different compounds made up of the same elements combining with that of the elements in different samples would have to be in the small whole number ratio.

Section D

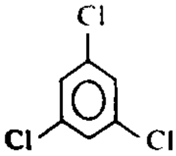
29. i. Fractional crystallizationis used to separate two compounds with different solubilities in a solvent.

ii.
- volatile liquids from nonvolatile impurities.
- the liquids having sufficient difference in their boiling points.

iii. Aniline is separated from aniline water mixture by steam distillation as one of the substances in the mixture is water and the other, a water insoluble substance.

OR

Chloroform and aniline are easily separated by the technique of distillation because chloroform and aniline have sufficient difference in their boiling points.

30. i. Both the molecules have zero dipole moments since both  and  shows symmetrical structure.

ii. Fraction of electronic charge = $\frac{1.2\times10^{-10}}{4.8\times10^{-10}} = 0.25$

iii. Because of different direction of moment of N-H and N-F bonds.

OR

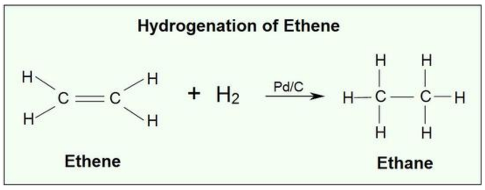
% ionic character = $\frac{1.5\times10^{-29}}{2.4\times10^{-29}} \times 100$ = 62.5

Section E

31. Attempt any five of the following:

(i) **Hydrogenation:** Addition of hydrogen to alkenes and alkenes in the presence of finely divided catalysts like Pt, Pd or Ni to form alkanes is known as hydrogenation.

Example:



(ii) Bond dissociation energy of C—C bonds is 348 kJ mol^{-1}.

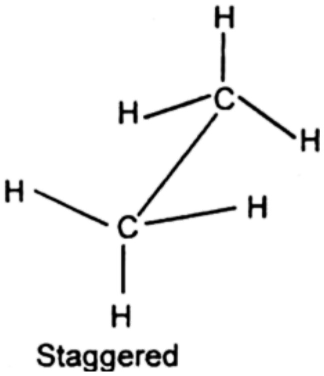
Bond dissociation energy of C—H bonds is 414 kJ mol^{-1}.

Clearly, bond dissociation energy of C—C bonds is lower than bond dissociation energy of C—H bonds.

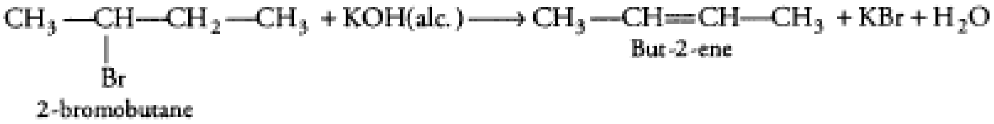
Therefore, during cracking of alkanes, C—C bonds break more easily than C—H bonds.

(iii) Staggered conformation of ethane is more stable.

Structure:



(iv)When 2-bromobutane is treated with KOH(alcoholic), But-2-ene is formed.



$$\underset{\text{2-bromobutane}}{CH_3-\underset{\underset{Br}{|}}{CH}-CH_2-CH_3} + KOH(alc.) \longrightarrow \underset{\text{But-2-ene}}{CH_3-CH=CH-CH_3} + KBr + H_2O$$

(v) A → CH_3 - CH_2COO^- - K^+;

B → $CH_3 - \underset{\text{Butane}}{CH_2} - CH_2 - CH_3$

(vi)We can separate, propene from propyne by passing the mixture through ammonical $AgNO_3$ solution or ammoniacal CuCl solution. Propyne reacts with ammonical $AgNO_3$ due to presence of acidic terminal hydrogen while propene passes over.

(vii)Due to higher stability of 3^o / tertiary carbocation

32. We have $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, $\Delta H = -92.38\ kJ\ mol^{-1}$.

Hence in accordance with Le Chatelier’s principle, raising the temperature will shift the equilibrium to the backward direction and decreases the equilibrium concentration of ammonia. Similarly, an increase in pressure shifts the equilibrium in the forward direction. In other words, low temperature and high pressure are favorable for high yield of ammonia. Hence for better yield of ammonia, an optimum condition of temperature and pressure of 500^oC and 200 atm respectively is used in the presence of suitable catalysts.

There will be no change in equilibria on the addition of argon (Ar) at constant volume to the above mixture at equilibrium because the addition of Ar at constant volume doesn't change the partial pressure of the substances involved in the reaction.

OR

The ionization of NH_3 in water is represented by the equation:

$NH^3 + H_2O\ NH_4^+ + OH^-$

We use equation (7.33) to calculate hydroxyl ion concentration,

$[OH^-] = c\ \alpha = 0.05\ \alpha$

$K_b = 0.05\ \alpha^2 / (1 - \alpha)$

The value of α is small, therefore the quadratic equation can be simplified by neglecting α in comparison to 1 in the denominator on right-hand side of the equation,

Thus,

$K_b = c\ \alpha^2$ or $\alpha = \sqrt{}(1.77 \times 10^{-5} / 0.05)$

= 0.018.

$[OH^-] = c\ \alpha = 0.05 \times 0.018 = 9.4 \times 10^{-4}$ M.

$[H^+] = K_w / [OH^-] = 10^{-14} / (9.4 \times 10^{-4})$

$= 1.06 \times 10^{-11}$

pH = $-\log(1.06 \times 10^{-11}) = 10.97$.

Now, using the relation for conjugate acid-base pair,

$K_a \times K_b = K_w$

using the value of K_b of NH_3 from table.

We can determine the concentration of conjugate acid NH_4^+

$K_a = K_w / K_b = 10^{-14} / 1.77 \times 10^{-5}$

$= 5.64 \times 10^{-10}$

33. Answer:

(i) i. By distillation under reduced pressure.
 ii. Column chromatography, paper chromatography and thin layer chromatography.

OR

i. i. Structural isomers (actually position isomers as well as metamers)
 ii. Geometrical isomers
 iii. Resonance contributors because they differ in the position of electrons but not atoms

ii. Volume of the acid taken = 50 mL of 0.5 M H_2SO_4

$= 25 \text{ mL of } 1.0 \text{ M } H_2SO_4$

Volume of alkali used for neutralisation of excess acid

$= 60 \text{ mL of } 0.5 \text{ M NaOH}$
$= 30 \text{ mL of } 1.0 \text{ M NaOH}$
$H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

1 mole of $H_2SO_4 = 2 \text{ moles of NaOH}$

Hence, 30 mL of 1.0 M NaOH = 15 mL of 1.0 M H_2SO_4

$\therefore$ Volume of acid used by ammonia = 25-15 = 10 mL
% of nitrogen $= \frac{1.4 \times N_1 \times \text{ vol. of acid used}}{w}$
(where, N_1 = normally of acid and w = mass of the organic compound taken)

% of nitrogen $= \frac{1.4 \times 2 \times 10}{0.5}$ = 56.0