Class XI Session 2024-25
Subject - Chemistry
Sample Question Paper - 9

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. Choose the most appropriate answer for the statement, "Rearrangement of atoms occurs whenever a chemical bond breaks or is formed, when **[1]**

   a) a chemical reaction takes place
   b) products appear,
   c) catalysts are produced.
   d) reactants disappear

2. An electron has a **[1]**

   a) negligible mass
   b) relative charge of -1
   c) all of these
   d) the charge is opposite and equal to a proton

3. Which one is the correct unit for entropy? **[1]**

   a) JK^{-1} mol
   b) kJ mol
   c) JK^{-1} mol^{-1}
   d) KJ mol^{-1}

4. According to quantum mechanics ψ^2(r) the wave function squared gives: **[1]**

   a) probability of finding a neutron
   b) probability density of finding an electron
   c) probability of finding an electron
   d) probability density of finding a proton

5. In an open system, which of the following take place? **[1]**

   a) The boundaries prevent the flow of matter into or out of it.
   b) The boundaries permit the flow of matter into or out of it.
   c) The boundaries prevent the flow of matter but not of energy.
   d) The boundaries prevent the flow of energy into it.

6. Usings s,p,d, and f notation, choose the orbital with n=4, l=3 quantum numbers. **[1]**

a) 4p b) 4d

c) 3d d) 4f

7. The oxidation state of iron in $K_4[Fe(CN)_6]$ is: **[1]**

a) +2 b) 3

c) 1 d) 4

8. Sodium cyanide, sulphide, and halide, (-CN, -S, and -H, coming from the organic compound) formed on fusion with sodium are extracted from the fused mass by boiling it with distilled water. This is called: **[1]**

a) Sodium fusion extract b) Sodium fusion ion extraction

c) Ion extract after sodium fusion d) Double distillate

9. Boiling point of alkanes are: **[1]**

a) is independent of branching. b) decreases with increase in molecular mass.

c) is independent of molecular mass. d) increases with increase in molecular mass.

10. According to Mendeleev's periodic law, the physical and chemical properties of elements are a periodic function of their _____. **[1]**

a) atomic radii b) atomic numbers

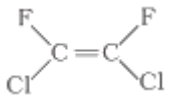
c) atomic masses d) empirical formulae

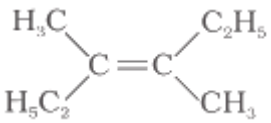
11. Select the incorrect expression from the following. **[1]**

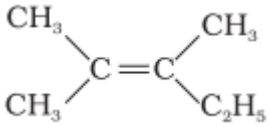
a) $\Delta S_{total} < 0$ (spontaneous process) b) $\Delta G = \Delta H - T\Delta S$

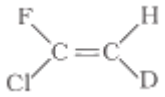
c) $\Delta S_{total} = \Delta S_{system} + \Delta S_{surr}$ d) $\Delta S_{surr} = \frac{\Delta H_{surr}}{T} = -\frac{\Delta H_{sys}}{T}$

12. Which of the following will not show geometrical isomerism? **[1]**

a) 

b) 

c) 

d) 

13. **Assertion (A):** Energy of resonance hybrid is equal to the average of energies of all canonical forms. **[1]**
Reason (R): Resonance hybrid cannot be presented by a single structure.

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):** The octane number of branched chain hydrocarbon is higher than that of unbranched chain hydrocarbons. **[1]**
Reason (R): The branched chain hydrocarbons are more volatile than unbranched chain hydrocarbons.

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):** Line emission spectra help in the study of electronic configuration. **[1]**

Reason (R): Each element has a unique line emission spectrum.

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):** 1 g O_2 and 1 g O_3 have an equal number of atoms. **[1]**

Reason (R): Mass of 1-mole atom is equal to its gram atomic mass.

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. The solubility product of $BaSO_4$ at 25^oC is 1.0×10^{-9}. What would be the concentration of H_2SO_4 necessary to precipitate $BaSO_4$ from a solution of 0.01 M Ba^{2+} ions? **[2]**

18. What is the basic theme of organisation in the periodic table? **[2]**

19. if 6.3 g of $NaHCO_3$ are added to 15.0 g of CH_3COOH solution, the residue is found to weigh 18.0 g. What is the mass of CO_2 released in the reaction? **[2]**

20. Write the chemical equation for combustion reaction of the following hydrocarbons: **[2]**

i. Butane

ii. Pentene

OR

Convert:

i. Ethane to butane

ii. Ethyne to methane

21. Discuss the similarities and differences between a 1s and s 2s orbital. **[2]**

Section C

22. Discuss the hybridisation of Be in gaseous state and solid state. **[3]**

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

(a) Heat capacity (C_p) is an extensive property but specific heat (C) is an intensive property. What will be the relation between C_p and C for 1 mole of water? **[1]**

(b) Predict the sign of ΔS for the following reaction **[1]**

$$CaCO_3(s) \xrightarrow{heat} CaO(s) + CO_2(g)$$

(c) What are the units of entropy? **[1]**

24. Using the data (all values are in kilocalories per mole at 25°C) given below, calculate the bond energy of C-C and C-H bonds. **[3]**

ΔH^o combustion (ethane) = -372.0

ΔH^o combustion (propane) = -530.0

ΔH^o for C (graphite) $\rightarrow$ C(g) = 172.0

Bond energy of H - H = 104.0

$\Delta_f H^o$ of H_2O (l) = - 68.0

ΔH^o for CO_2(g) = - 94.0

25. Write formulas for the following compounds: **[3]**

i. Mercury (II) chloride

ii. Nickel (II) sulphate

iii. Tin (iv) oxide

iv. Thallium (I) sulphate

v. Iron (III) sulphate

vi. Chromium (III) oxide

26. What transition in a hydrogen spectrum would have the same wavelength Balmer transition n = 4 to n = 2 of $\bar{v} = \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ spectrum? **[3]**

27. Consider the ground state electronic configurations given below: **[3]**

i. $1s^2 2s^2 2p^6$

ii. $1s^2 2s^2 2p^4$

iii. $1s^2 2s^2 2p^6 3s^2$

iv. $1s^2 2s^2 2p^6 3s^1$

v. $1s^2 2s^2 2p^5$

a. Which of the above configuration is associated with the lowest and which is associated with the highest ionization enthalpy?

b. Arrange the above configurations in order of increasing negative electron gain enthalpy.

28. A crystalline salt, when heated, becomes anhydrous and losses 51.2 % of its weight. The anhydrous salt on analysis gave the percentage composition as Mg = 20.0 %, S = 26.66 % and O = 53.33 %. **[3]**

Section D

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

The phenomenon of the existence of two or more compounds possessing the same molecular formula but different properties is known as isomerism. Such compounds are called isomers. Compounds having the same molecular formula but different structures (manners in which atoms are linked) are classified as structural isomers. Structural isomers are classified as chain isomer, position isomer, functional group isomer. Meristematic arises due to different alkyl chains on either side of the functional group in the molecule and stereoisomerism and can be classified as geometrical and optical isomerism. Hyperconjugation is a general stabilising interaction. It involves delocalisation of σ electrons of the C-H bond of an alkyl group directly attached to an atom of an unsaturated system or to an atom with an unshared p orbital. This type of overlap stabilises the carbocation because electron density from the adjacent σ bond helps in dispersing the positive charge.

i. Why Isopentane, pentane and Neopentane are chain isomers?

ii. The molecular formula C_3H_8O represents which isomer?

iii. What type of isomerism is shown by Methoxypropane and ethoxyethane?

OR

Why hyperconjugation is a permanent effect?

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

The molecular orbital theory is based on the principle of a linear combination of atomic orbitals. According to

this approach when atomic orbitals of the atoms come closer, they undergo constructive interference as well as destructive interference giving molecular orbitals, i.e., two atomic orbitals overlap to form two molecular orbitals, one of which lies at a lower energy level (bonding molecular orbital). Each molecular orbital can hold one or two electrons in accordance with Pauli's exclusion principle and Hund's rule of maximum multiplicity.

For molecules up to N_2, the order of filling of orbitals is:

$\sigma(1s)^*_\sigma(1s), \sigma(2s)^*_\sigma(2s), \pi(2p_x) = \pi(2p_y), \sigma(2p_z), {}^*_\pi(2p_x) = {}^*\pi(2p_y), {}^*\sigma(2p_z)$

and for molecules after N_2, the order of filling is:

$\sigma(1s)^*_\sigma(1s), \sigma(2s)^*_\sigma(2s), \sigma(2p_z), \pi(2p_x) = \pi(2p_y), {}^*_\pi(2p_x) = {}^*\pi(2p_y), {}^*\sigma(2p_z)$

Bond order = $\frac{1}{2}$[bonding electrons - antibonding electrons]

Bond order gives the following information:

I. If bond order is greater than zero, the molecule/ion exists otherwise not.

II. Higher the bond order, higher is the bond dissociation energy.

III. Higher the bond order, greater is the bond stability.

IV. Higher the bond order, shorter is the bond length.

i. Arrange the following negative stabilities of CN, CN^+ and CN^- in increasing order of bond. (1)

ii. The molecular orbital theory is preferred over valence bond theory. Why? (1)

iii. Ethyne is acidic in nature in comparison to ethene and ethane. Why is it so? (2)

OR

Bonding molecular orbital is lowered by a greater amount of energy than the amount by which antibonding molecular orbital is raised. Is this statement correct? (2)

Section E

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

(a) How will you distinguish between propene and propane? **[1]**

(b) The intermediate carbocation formed in the reactions of HI, HBr and HCl with propene is the same and the bond energy of HCl, HBr and HI is 430.5 kJ mol^{-1}, 363.7 kJ mol^{-1} and 296.8 kJ mol^{-1} respectively. What will be the order of reactivity of these halogen acids? **[1]**

(c) Explain why p-xylene has a higher melting point than the corresponding ortho or meta isomers. **[1]**

(d) Name the simplest alkyne. **[1]**

(e) What are cycloalkanes? **[1]**

(f) Out of $CH_3CH_2CH_2Cl$ and $CH_2 = CH - CH_2 - Cl$, which one is more reactive towards S_N1 reaction? **[1]**

(g) Explain why alkynes are less reactive than alkenes towards addition of Br_2. **[1]**

32. Calculate the pH of the resultant mixtures. **[5]**

a. 10 mL of 0.2 M $Ca(OH)_2$ + 25 mL of 0.1 M HCl

b. 10 mL of 0.01 M H_2SO_4 + 10 mL of 0.01 M $Ca(OH)_2$

c. 10 mL of 0.1 M H_2SO_4 + 10 mL of 0.1 M KOH

OR

The value of K_c = 4.24 at 800K for the reaction,

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

Calculate equilibrium concentrations of CO_2, H_2, CO, and H_2O at 800 K, if only CO and H_2O are present initially at concentrations of 0.10M each.

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

(a) i. **[2.5]**

i. $CH_3—CH_2—CH_2—CH_2—OH$

ii. $CH_3 - CH_2 - \underset{\underset{OH}{|}}{CH} - CH_3$

iii. $CH_3 - \underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{C}} - CH_3$

iv. $CH_3 - \underset{\underset{CH_3}{|}}{CH} - CH_2 - OH$

v. $CH_3—CH_2—O—CH_2—CH$

vi. $CH_3—O—CH_2—CH_2—CH_3$

vii. $CH_3 - O - \underset{\underset{CH_3}{|}}{CH} - CH_3$

Identify the pairs of compounds that represent chain isomerism.

ii. Which of the following represents the correct IUPAC name for the compounds concerned? **[2.5]**

a. 2, 2-Dimethylpentane or 2-Dimethylpentane

b. 2, 4, 7-Trimethyloctane or 2, 5, 7-Trimethyloctane

c. 2-Chloro-4-methylpentane or 4-Chloro-2-methylpentane

d. But-3-yn-1-ol or But-4-ol-1-yne.

OR

i. Write the IUPAC name of the compound from its given structure. **[2.5]**

$\overset{1}{C}H_3 - \overset{2}{C}H_2 - \underset{\underset{OH}{|}}{\overset{3}{C}}H - \overset{4}{C}H_2 - \overset{5}{C}H_2 - \underset{\underset{CH_3}{|}}{\overset{6}{C}}H - \overset{7}{C}H_2 - \overset{8}{C}H_3$

ii. An organic compound contains 69% carbon and 4.8% hydrogen, the remainder being oxygen. Calculate the masses of carbon dioxide and water produced when 0.20 g of this compound is subjected to complete combustion. **[2.5]**

Solution

Section A

1. **(a)** a chemical reaction takes place
   Explanation: In a chemical reaction there is simultaneous ,
   * bond breaking of the reagents
   * bond formation in products &
   * rearrangement of atoms
   resulting into appearance / yield of products .

2. **(c)** all of these
   Explanation: all of these

3. **(c)** JK^{-1} mol^{-1}
   Explanation: As $\triangle S = \frac{q_{rev}}{T}$
   It is an extensive entropy, therefore, the SI unit of entropy change is Joule K^{-1} mol^{-1}.

4. **(b)** probability density of finding an electron
   Explanation: Probability density of finding an electron at a point within an atom, it is possible to predict the region around the nucleus where the electron can most probably be found.
   ψ^2 has no physical significance while ψ^2 represents the probability density of finding an electron.

5. **(b)** The boundaries permit the flow of matter into or out of it.
   Explanation: In an **open system**, there is a flow of matter and energy in and out of the system or vice versa. For example, an air compressor in which the air enters at low pressure and exit at high pressure and there is energy interaction with the surrounding.

6. **(d)** 4f
   Explanation: Here n= principal quantum number, l= azimuthal quantum number. For n = 4 and l = 3 The orbital is 4f (can have a maximum of 14 electrons).

7. **(a)** +2
   Explanation: K_4 $[Fe(CN)_6]$
   4(+1) + x + 6(-1) = 0
   Hence x = +2

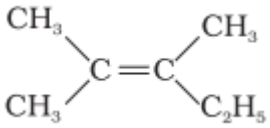
8. **(a)** Sodium fusion extract
   Explanation: Nitrogen, sulphur, halogens, and phosphorus present in an organic compound are detected by “Lassaigne’s test”. The elements present in the compound are converted from the covalent form into the ionic form by fusing the compound with sodium metal. Cyanide, sulphide, and halide of sodium so formed on sodium fusion are extracted from the fused mass by boiling it with distilled water. This extract is known as sodium fusion extract.

9. **(d)** increases with increase in molecular mass.
   Explanation: As molecular mass increases, the magnitude of Van der Waals forces of attraction increases and hence boiling point increases accordingly.

10. **(c)** atomic masses
    Explanation: atomic masses

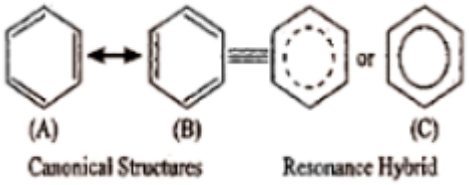
11. **(a)** ΔS_{total} < 0 (spontaneous process)
Explanation: For spontaneous process, ΔS_{total} > 0
$T\Delta S_{system}$ - ΔH_{system} > 0 - (ΔH_{system} - $T\Delta S_{system}$) > 0

12. **(c)**



Explanation: This is because geometrical isomerism is not possible if three groups are same.

13. **(d)** A is false but R is true.
Explanation: Canonical structures always have more energy than a resonance hybrid. Resonance hybrids are always more stable than any of the canonical structures. The delocalization of electrons lowers the orbitals' energy and gives stability.



14. **(b)** Both A and R are true but R is not the correct explanation of A.
Explanation: Branched chain hydrocarbons produce less knocking.

15. **(b)** Both A and R are true but R is not the correct explanation of A.
Explanation: Line emission spectra gives information about electronic configuration which is unique to element by virtue of having that type of electronic arrangement.

16. **(b)** Both A and R are true but R is not the correct explanation of A.
Explanation: Mass of 1 mole is its gram- atomic mass
1 mol of O_2 → 2 atoms.

Therefore no. of atoms in 1g O_2 = $3/21\times2\times6.02\times10^{23}$ = $6.02\times10^{23}/16$

Similarly, no. of atoms in 1g O_3 = $4/81\times3\times6.02\times10^{23}$ = $6.02\times10^{23}/16$

They have the same no. of atoms.

Section B

17. According to the question, the solubility product of $BaSO_4$ at 25°C is 1.0×10^{-9}.

Precipitation will take place when, ionic product > solubility product
Reaction:
$BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$
$K_{sp} = \left[Ba^{2+}\right]\left[SO_4^{2-}\right]$
$\therefore S = \frac{1.0\times10^{-9}}{0.01}$
$= 10^{-7}$ mol/L

18. The basic theme of organisation of elements in the periodic table is to classify the elements in periods and groups according to their properties. This systematic arrangement makes the study of elements and their compounds, simple to understand and easy to interpert.

19. $NaHC0_3 + CH_3COOH \rightarrow \underbrace{H_2O + CH_3COO^{-}Na^{+}}_{\text{Residue}} + CO_2$

Sum of the masses of reactants = 6.3 + 15 = 21.3 g
Sum of the masses of products = x + 18

21.3 = x + 18; x = 21.3 - 18 = 3.3 g

Thus, the mass of the CO_2 released is 3.3 g.

20. i. $\underset{\text{Butane}}{C_4H_{10}(g)} + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(g)$

ii. $\underset{\text{Pentene}}{C_5H_{10}(g)} + \frac{15}{2}O_2(g) \rightarrow 5CO_2(g) + 5H_2O(g)$

OR

i. $\underset{\text{Ethane}}{CH_3CH_3} \xrightarrow[\text{Sunlight}]{CI_2} \underset{\text{Ethyle chloride}}{CH_3CH_2CI} \xrightarrow[\text{Wurtz reaction}]{\text{2Na, ether}} \underset{\text{Butane}}{CH_3CH_2CH_2CH_3}$

ii. $\underset{\text{Ethyne}}{HC \equiv CH} \xrightarrow[\text{HgSO4}]{H^+, H_2O} \underset{\text{Ethanal}}{CH_3CHO} \xrightarrow[K_2Cr_2O_7, H^+]{[O]} CH_3COOH \xrightarrow{NaOH} \underset{\substack{\downarrow NaOH, CaO \\ CH_4 \\ \text{Methane}}}{CH_3COONa}$

21. Similarities:

i. Both have a spherical shape.

ii. Both have same angular momentum

As it is = $\sqrt{1(1+1)}\frac{h}{2\pi}$

Differences

i. Is has no node while 2s has one node.

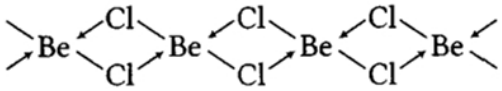
ii. Energy of 2s is greater than that of 1s.

Section C

22. In gaseous state at high temperature, $BeCl_2$ exists as linear molecule, Cl - Be - Cl, thus the hybridisation of the central atoms is sp.

$\underset{\substack{\textit{Structure of BeCI in} \\ \textit{gaseous state}}}{CI - Be - CI}$

In solid state, it has a polymeric structure with chlorine bridges as follows.



Two Cl-atoms are listed to be atom by two coordination bonns and two by covalent bonds.

For these bonds to be formed, Be in the excited state with the configuration $1s^2 2s^1 2p_x^1 2p_y^0 2p_z^0$

undergoes sp^3 hybridisation.

Two half-filled hybrid orbitals will form normal covalent bonds with two Cl-atom. The other two Cl-atoms are coordinated to Be-atom by donating electron pairs into the empty hybrid orbitals.

23. Answer:

(i) We know that, Specific heat(C) of water is = 4.18 $Jg^{-1}K^{-1}$

Now, Heat capacity(Cp) of water is = 18 $\times$ C

= 18 $\times$4.18 JK^{-1}

= 75.3 JK^{-1}

(ii) ΔS is positive.

(iii) SI units of ΔS = JK^{-1} mol^{-1}

24. We are given

i. $C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + H_2O$; ΔH^o = -372.0 kcal

ii. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O$; ΔH^o = -530.0 kcal

iii. $C(s) \rightarrow C(g)$; ΔH^o = 172.0 kcal

iv. $H_2(g) \rightarrow 2H(g)$; ΔH^o = 104.0 kcal

v. $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$; ΔH^o = -68.0 kcal

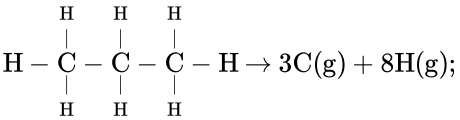
vi. $C(g) + C_2(g) \rightarrow CO_2(g)$; ΔH^o = -94.0 kcal

Suppose the bond energy of C-C bond = x kcal mol^{-1} and that of C-H bond = y kcal mol^{-1}. Then for C_2H_6 (g),

i.e. $H - \underset{\substack{| \\ H}}{\overset{\substack{H \\ |}}{C}} - \underset{\substack{| \\ H}}{\overset{\substack{H \\ |}}{C}} - H \rightarrow 2C(g) + 6H$;

$\Delta H = x + 6y$ ...(vii)

and for $C_3H_8(g)$; i.e.



$\Delta H = 2x + 8y$ ...(viii)

To get Eq. (vii), operate Eq. (i) + 2 × Eq. (iii) + 3 × Eq. (iv) - 3 × Eq. (v) - 2 × Eq. (vi).

It gives ΔH = 676 kcal

It get Eq. (viii) operate Eq. (ii) + Eq. (iii) + 4 × Eq (iv)

-4 × Eq. (v) - 3 × Eq (vi)

It gives ΔH = 956 kcal

Thus, x + 6y = 676,

2x + 8y = 956

On solving these equations, we get

x = 82, y = 99

Hence, C-C bond energy = 82 kcal mol^{-1} and C-H

bond energy = 99 kcal mol^{-1}

25. i. $HgCI_2$

ii. $NiSO_4$

iii. SnO_2

iv. TI_2SO_4

v. $Fe_2(SO_4)_3$

vi. Cr_2O_3

26. For an atom, $\bar{v} = \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For He^+ spectrum : Z = 4,n_2 = 4,n_1 = 2

$\therefore$ For hydrogen spectrum: $\bar{v} = \frac{3R_H}{4}$ and Z = 1

$\therefore \bar{v} = \frac{1}{\lambda} = R_H \times 1 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

or $R_H \left(\frac{1}{n_1^2} - \frac{1}{m_2^2}\right) = \frac{3R_H}{4}$ or $\frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{3}{4}$

This corresponding to n_1 = 1,n_2 = 2 and means that the transition has taken Lyman series from n = 2 to n = 1.

Thus, the transition is from n_2 to n_1 in case of hydrogen spectrum.

27. a. Lowest ionisation enthalpy = D

Highest ionisation enthalpy = A

b. Order of increasing negative electron gain enthalpy is:

A < C < D < B < E

28.

Element	**% of mass**	**Atomic mass**	**Relative no. of moles element**	**Simple molar ratio**
Mg	20	24	$\frac{20}{24} = 0.8333$	0.8333/ 0.8125 = 1.02 =1
S	26	32	$\frac{26}{32} = 0.8125$	0.8125 / 0.8125 =1
O	53.33	16	$\frac{53.33}{16} = 3.333125$	3.33125 / 0.8125 = 4.1 =4

Since, Mg : S : O = 1:1:4

Therefore, The empirical formula of the anhydrous salt = $MgSO_4$.

Empirical formula mass = 1 × Mg + 1 × S +4 × O = 1 × 24 + 1 × 32 + 4 × 16 =24 + 32 + 64 =120.

Molecular mass = 120.

Now, n = $\frac{Molecular\ Mass}{Empirical\ formula\ Mass}$ = $\frac{120}{120}$ = 1

Hence, molecular formula = n × (Empirical formula) = $MgSO_4$.

As crystalline salt on becoming anhydrous loses 51.2 % by mass, this means 48.8 g of anhydrous salt contain H_2O = 51.2 g.

Therefore, 120 g of anhydrous salt contains = $\frac{51.2}{48.8} \times 120g = 126g = \frac{126}{18}$ molecules $= 7H_2O$

Hence, the molecular formula of crystalline salt = $MgSO_4.7H_2O$

Section D

29. i. Isopentane, pentane and Neopentane are chain isomers because they have a similar molecular formula but a different carbon skeleton.

ii. The molecular formula C_3H_8O represents positional isomers because they differ in the position of substituent functional group(OH) on the carbon skeleton.

iii. Methoxypropane and ethoxyethane are metamers because none of its side are similar to each other.

OR

The σ electrons of C-H bond of the alkyl group enter into partial conjugation with the attached unsaturated system or with the unshared p orbital therefore hyperconjugation is permanent effect.

30. i. The increasing order of negative stabilities of CN, CN^+ and CN^- is $CN^+ > CN > CN^-$.

ii. The molecular orbital theory is preferred over valence bond theory because molecular orbital theory explains the magnetic nature of the molecule.

iii. In ethyne, hydrogen atoms are connected to sp hybridized carbon atoms, but in ethene, they are attached to sp^2 hybridized carbon atoms and in ethane, they are attached to sp^3 hybridized carbons.

OR

The given statement is not correct because the bonding molecular orbital is lowered by a lesser amount of energy than the amount by which antibonding molecular orbital is raised.

Section E

31. Attempt any five of the following:

(i) Pass them through dilute cold $KMnO_4$ solution (purple) or Br_2 in CCl_4 solution (rud). Propene will decolourise both the solutions but propane does not react.

(ii) The bond dissociation enthalpy decreases in the order HCl > HBr > Hl, the order of reactivity of these halogen acids is in the reverse order i.e., Hl > HBr > HCl.

(iii) The para isomer has a more symmetrical structure, allowing it to fit better into the crystal lattice than ortho or meta isomer.

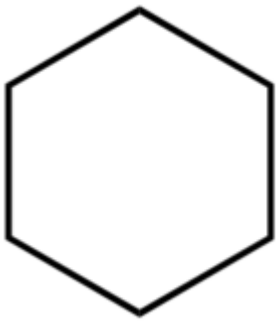
So, p-xylene has a higher melting point than the corresponding ortho or meta isomers.

(iv) Ethyne is the simplest alkyne. Formula of ethyne is C_2H_2.

Structure: $H - C \equiv C - H$

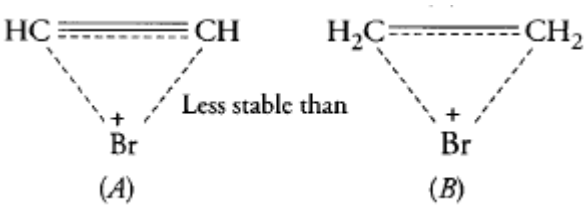
(v) **Cycloalkanes:** When carbon atoms form a closed chain or ring structures, they are known as cycloalkanes.

Example: Cyclohexane



(vi) $CH_2 = CH - CH_2Cl$

(vii) The triple bonds of alkynes, because of its high electron density, are easily attacked by electrophiles, but less reactive than alkenes due to the compact C-C electron cloud. The three-membered ring bromonium ion formed from the alkyne (A) has a full double bond causing it to be more stained and less stable than the one from the alkene (B),



Also, the carbon's of (A) that are part of the bromonium ion has more s-character than (B), further making (A) less stable than (B).

32. a. 10 mL of 0.2 M $Ca(OH)_2 = 10 \times 0.2$ millimoles = 2 mmol of $Ca(OH)_2$

25 mL of 0.1 M HCl $= 25 \times 0.1$ mmol = 2.5 mmol of HCl

$Ca(OH)_2 + 2HCl \rightarrow CaCl_2 + 2H_2O$

0.1 mmol of $Ca(OH)_2$ reacts with 2 mmol of HCl

∴ 2.5 mmol of HCl will react with 1.25 mmol of $Ca(OH)_2$

∴ $Ca(OH)_2$ left = 2 - 1.25 =0.75 mmol (HCl is the limiting reactant)

Total volume of the solution = 10 + 25 = 35 mL

∴ Molarity of $Ca(OH)_2$ in the mixture solution $= \frac{0.75}{35} M$ = 0.0214 M

∴ $[OH^{-1}] = 2 \times 0.0214M$ = 0.0428 M $= 4.28 \times 10^{-2}$

$pOH = -\log(4.28 \times 10^{-2}) = 2 - 0.6314 = 1.3686 \cong 1.37$

∴ pH = 14 - 1.37 = 12.63

b. 10 mL of 0.01M $H_2SOI_4 = 10 \times 0.01$ mmol = 0.1 mmol

10 mL of 0.01 M $Ca(OH)_2 = 10 \times 0.01$ mmol = 0.1 mmol

$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$

1 mole of $Ca(OH)_2$ reacts with 1 mole of H_2SO_4

∴ 1 mmol of $Ca(OH)_2$ will react completely with 0.1 mmol of H_2SO_4. Hence, solution will be neutral with pH = 7.0

c. 10 mL of 0.1 M H_2SO_4 = 1 mmol

10 mL of 0.1 M KOH = 1 mmol

$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$

1 millimole of KOH will react with 0.5 mmol of H_2SO_4

∴ H_2SO_4 left = 1 - 0.5 = 0.5 mmol

Volume of reaction mixture = 10 + 10 = 20 mL

∴ Molarity of H_2SO_4 in the mixture solution $= \frac{0.5}{20} = 2.5 \times 10^{-12} M$

$[H^+] = 2 \times 2.5 \times 10^{-2} = 5 \times 10^{-2}$

$pH = -\log(5 \times 10^{-2}) = 2 - 0.699 = 1.3$

OR

For the reaction CO (g) + H_2O (g) $\rightleftharpoons$ CO_2(g) + H_2(g) (The value of K_c = 4.24 at 800K)

Initial concentration:

0.1M, 0.1M, 0, 0

Let x mole per litre of each of the products being formed.

At equilibrium:

(0.1 - x)M, (0.1-x)M, x M, x M

where x is the amount of CO_2 and H_2 at equilibrium.

The equilibrium constant can be written as,

$K_c = \frac{[CO_2][H_2]}{[CO][H_2O]} = \frac{x^2}{(0.1-x)^2}$ = 4.24

$x^2 = 4.24(0.01 + x^2 - 0.2x)$

$x^2 = 0.0424 + 4.24x^2 - 0.848x$

$3.24x^2 - 0.848x + 0.0424 = 0$

a = 3.24, b = -0.848, c = 0.0424

(for quadratic equation $ax^2 + bx + c = 0$

x = $\frac{(-b \pm \sqrt{b^2-4ac})}{2a}$

$x = \frac{-(-0.848) \pm \sqrt{(-0.848)^2 - 4(3.24)(0.0424)}}{2(3.24)}$

$x = \frac{-0.848 \pm 0.4118}{6.48}$

x_1 = (0.848 – 0.4118)/6.48 = 0.067

x_2 = (0.848 + 0.4118)/6.48 = 0.194

the value 0.194 should be neglected because it will give concentration of the reactant which is more than initial concentration. Therefore, the equilibrium concentrations of CO_2, H_2, CO and H_2O at 800 K are,

$[CO_2] = [H^{2-}] = x = 0.067$ M

$[CO] = [H_2O] = 0.1 – 0.067 = 0.033$ M

33. Answer:

(i) i. When two or more compounds have a similar molecular formula but different carbon skeletons, these are referred to as chain isomers and the phenomenon is termed as chain isomerism.
(i) and (iii); (i) and (iv); (ii) and (iii); (ii) and (iv) are chain isomers.

ii. a. 2, 2-Demethylpentane
b. 2, 4,7-Trimethyloctane. For two alkyl groups on the same carbon its locant is repeated twice, 2, 4, 7-locant set is lower than 2, 5, 7.
c. 2-Chloro-4-methylpentane. Alphabetical order of substituents.
d. But-3-yn-1-ol. Lower locant for the principal functional group, i.e., alcohol.

OR

i.
- The functional group present is alcohol (-OH). Hence the suffix is '-ol'.
- The longest chain containing -OH has eight carbon atoms. Hence the corresponding saturated hydrocarbon is octane.
- The -OH is on carbon atom 3. In addition, a methyl group is attached at 6^{th} carbon atom.
  Hence, the systematic name/IUPAC name of this compound is **6-Methyloctan-3-ol.**

ii. **Step I.** Calculation of mass of CO_2 produced

Mass of compound = 0.20 g

Percentage of carbon = 69%

$$\text{Percentage of carbon} = \frac{12}{44} \times \frac{\text{Mass of carbon dioxide formed}}{\text{Mass of compound}} \times 100$$

$$69 = \frac{12}{44} \times \frac{\text{Mass of carbon dioxide formed}}{(0.20\,\text{g})} \times 100$$

$\therefore$ Mass of CO_2 formed = $\frac{69 \times 44 \times (0.20\,\text{g})}{12 \times 100}$ = 0.506 g

Step II. Calculation of mass of H_2O produced

Mass of compound = 0.20 g

Percentage of hydrogen = 4.8%

$$\text{Percentage of hydrogen} = \frac{2}{18} \times \frac{\text{Mass of water formed}}{\text{Mass of compound}} \times 100$$

$$4.8 = \frac{2}{18} \times \frac{\text{Mass of water formed}}{(0.20\ \text{g})} \times 100$$

$\therefore$Mass of H_2O formed = $\frac{4.8 \times 18 \times (0.20\,\text{g})}{2 \times 100}$ = 0.0864 g