Class XI Session 2023-24
Subject - Chemistry
Sample Question Paper - 5

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 atoms present in one mole of an element is equal to Avogadro number. Which of the following element contains the greatest number of atoms? **[1]**

a) 12g He
b) 0.40g Ca
c) 46g Na
d) 4g He

2. Energy of an electron in stationary state is given by the formula **[1]**

$$E_{n^m} R_H \left(1 - \frac{1}{\mathrm{n}^2}\right)$$

where n = 1,2,3........ In this equation, R_H is called

a) Rydberg's constant
b) Planck's constant
c) Proportionality constant
d) Avagadro's Number

3. According to the first law of thermodynamics $\Delta U = q + w$, here what is a sign of q and w? **[1]**

a) q is negative if heat is transferred into the system and w is negative if work is done on the system.
b) q is positive if heat is transferred into the system and w is positive if work is done by the system.
c) q is negative if heat is transferred from the system and w is negative if work is done by the system.
d) q is positive if heat is transferred into the system and w is positive if work is done on the system.

4. Photoelectric effect established that light can also **[1]**

a) behave like rays
b) behave like waves
c) behave like magnetic fields
d) behave like particles

5. Enthalpy of combustion of carbon to CO_2 is 393.5 kJ mol^{-1}. Calculate the heat released upon formation of 35.2 g of CO_2 from carbon and dioxygen gas. **[1]**

a) -275 kJ
b) -375 kJ
c) -398 kJ
d) -315 kJ

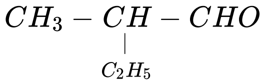
6. Which of the following is responsible to rule out the existence of definite paths or trajectories of electrons? **[1]**

a) Hund’s rule of maximum multiplicity.
b) Aufbau principle.
c) Heisenberg’s uncertainty principle
d) Pauli’s exclusion principle.

7. If an excess of P_4 is treated with F_2, then_____will be produced wherein the oxidation number of P is +3. The compound is________. **[1]**

a) PF
b) PF_5
c) PF_3
d) PF_6

8. The IUPAC name of the following compund is **[1]**



$CH_3 - \underset{\underset{C_2H_5}{|}}{CH} - CHO$

a) 3-methyl isobutyraldehyde
b) 2-methylbutanal
c) 2-ethylpropanal
d) butan - 2- aldehyde

9. Which product is obtained by passing ethanol vapours over heated alumina? **[1]**

a) C_2H_2
b) C_2H_6
c) C_2H_4
d) CH_4

10. d-Block Elements are characterized by the: **[1]**

a) inner d orbitals are not filled.
b) absence of d orbital electrons.
c) filling of outer d orbitals.
d) filling of inner d orbitals by electrons.

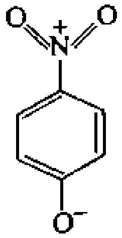
11. The reaction of cyanamide, NH_2CN (s), with dioxygen was carried out in a bomb calorimeter, and ΔU was found to be 742.7 kJ mol^{-1} at 298 K. Calculate enthalpy change for the reaction at 298 K. **[1]**

$NH_2CN(s) + \frac{3}{2}O_2(g) + N_2(g) + CO_2(g) + H_2O(l)$?

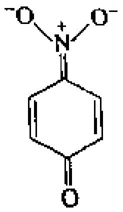
a) -741.5 kJ
b) -767.8 kJ
c) +741.5 kJ mol^{-1}
d) -702.2 kJ

12. The most unlikely representation of resonance structures of p-nitrophenoxide ion is: **[1]**

a)

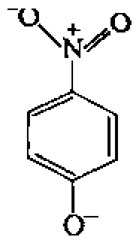


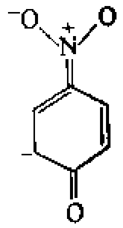
b)



c)

d)





13. **Assertion (A):** 59 g of an amide obtained from a carboxylic acid, RCOOH, liberated 17 g of ammonia upon heating with alkali. **[1]**

Reason (R): The acid is formic acid.

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:** Rates of nitration of benzene and Hexadeuterobenzene are different. **[1]**

Reason: Nitration depends upon the availability of nucleophile.

a) If both Assertion & Reason are true and the reason is the correct explanation of the assertion.

b) If both Assertion & Reason are true but the reason is not the correct explanation of the assertion.

c) If Assertion is true statement but Reason is false.

d) If both Assertion and Reason are false statements.

15. **Assertion (A):** Electronic configuration of an element is $1s^2\ 2s^1$. **[1]**

Reason (R): In 2s, 2 signifies the maximum capacity of s-subshell.

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):** Law of conservation of mass hold good for nuclear reaction. **[1]**

Reason (R): Law states that mass can be neither created nor destroyed in a chemical reaction.

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. SO_3^{2-} is Bronsted base or acid and why? **[2]**

18. Match the correct atomic radius with the element. **[2]**

Element	Atomic radius (pm)
Be	74
C	88
O	111
B	77
N	66

19. Use the data given in the following table to calculate the molar mass of naturally occurring argon isotopes: **[2]**

Isotope	**Isotopic molar mass**	**Abundance**
^{36}Ar	35.96755 g mol^{-1}	0.337%
^{36}Ar	37.96272 g mol^{-1}	0.063%
^{40}Ar	39.9624 g mol^{-1}	99.600%

20. Sodium salt of which acid will be needed for the preparation of propane? Write chemical equation for the reaction. **[2]**

OR

Name the organic products of the reaction of but-2-ene with each of the following reagents and write a balanced equation for each reaction.

i. Hydrogen bromide
ii. Bromine dissolved in tetrachloromethane

21. Show the distribution of electrons in oxygen atom (atomic number 8) using orbital diagram. **[2]**

Section C

22. What is meant by hybridisation of atomic orbitals? Describe the shapes of Sp, Sp^2 & Sp^3 hybrid orbitals. **[3]**

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

(i) Define a system. **[1]**

(ii) For the same increase in volume, why work is done is more if the gas is allowed to expand reversibly at a higher temperature? **[1]**

(iii) 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]**

24. 1 mole of an ideal gas undergoes reversible isothermal expansion from an initial volume of V_1 to a final volume of 10 V_1 and does 10 kJ of work. The initial pressure was 1×10^7 Pa. **[3]**

i. Calculate V_1.
ii. If there were 2 moles of gas what must its temperature have been?

25. Which of the following species, do not show a disproportionation reaction and why? **[3]**

ClO^-, ClO_2^-, ClO_3^- and ClO_4^-

Also, write the reaction for each of the species that disproportionate.

26. The Balmer series in the hydrogen spectrum corresponds to the transition from n_1 = 2 to n_2= 3,4, ... This series lies in the visible region. Calculate the wave number of line associated with the transition in Balmer series when the electron moves to n= 4 orbit. (R_H= 109677 cm^{-1}) **[3]**

27. What are the various factors due to which the ionization enthalpy of the main group elements tends to decrease down the group? **[3]**

28. How many significant figures are present in **[3]**

a. 4.01×10^2
b. 8.256
c. 100

Section D

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

Chromatography is an important technique extensively used to separate mixtures into their components, purify compounds and also test the purity of compounds. Based on the principle involved, chromatography is classified into different categories. Two of these are Adsorption chromatography and Partition chromatography. Two main types of chromatographic techniques are based on the principle of differential adsorption column chromatography, and thin-layer chromatography. Adsorption chromatography is based on the fact that different compounds are adsorbed on an adsorbent to different degrees. Column chromatography involves the separation of a mixture over a column of adsorbent (stationary phase) packed in a glass tube. Thin-layer chromatography (TLC) is another type of adsorption chromatography, which involves the separation of substances of a mixture over a thin layer of an adsorbent coated on a glass plate. Partition chromatography is based on the continuous differential partitioning of components of a mixture between stationary and mobile phases.

(i) Which adsorbent is used in adsorption chromatography?

OR

Which chromatography is shown in following image?

(ii) How do you visualize colourless compounds after separation in Paper Chromatography?

(iii) Why paper chromatography is a type of partition chromatography?

30. **Read the text carefully and answer the questions:** **[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:

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

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

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

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.

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

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

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?

Section E

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

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

(ii) Can a catalyst change the position of equilibrium in a reaction? **[1]**

(iii) How will you convert ethanoic acid into ethene? **[1]**

(iv) Why are Alkenes called olefins? **[1]**

(v) What is a Lindlars' catalyst? **[1]**

(vi) To which category of compounds does cyclohexane belong? **[1]**

(vii) How would you convert ethene to ethane molecule? **[1]**

32. Bromine monochloride (BrCl) decomposes into bromine and chlorine and reaches the equilibrium: **[5]**

$2BrCl(g) \rightleftharpoons Br_2(g) + Cl_2(g)$

for which K_c is 32 at 500 K. If initially pure BrCl is present at a concentration of $3.3 \times 10^{-3} mol\ L^{-1}$, what is its molar concentration in the mixture at equilibrium?

OR

Ethyl acetate is formed by the reaction of ethanol and acetic acid and the equilibrium is represented as:

$CH_3COOH(l) + C_5H_5OH(l) \rightleftharpoons CH_3COOC_2H_5(l) + H_2O(l)$

a. Write the concentration ratio (reaction quotient), Q_c, for this reaction (note: water is not in excess and is not a solvent in this reaction)

b. At 293 K, if one starts with 1.00 mol of acetic acid and 0.18 mol of ethanol, there is 0.171 mol of ethyl acetate in the final equilibrium mixture. Calculate the equilibrium constant.

c. Starting with 0.5 mol of ethanol and 1.0 mol of acetic acid and maintaining it at 293 K, 0.214 mol of ethyl acetate is found after some time. Has equilibrium been reached?

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

(i) i. Identify the pairs of compounds that represent position isomerism. **[2.5]**

$CH_3—C(CH_3)\ (OH)\text{-}CH_3$

$CH_3—CH(CH_3)—CH_2—OH$

$CH_3—O—CH_2—CH_2—CH_3$

$CH_3—O — CH(CH_3)—CH_3$

$CH_3\text{-}\ CH_2\text{-}\ CH_2\text{-}CH_2\text{-}OH$

$CH_3—CH_2—CH(OH)—CH_3$

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

OR

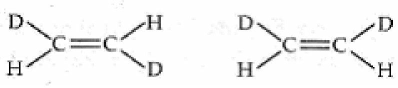
i. Giving justification, categorise the following molecules/ions as nucleophile or electrophile: **[2.5]**

HS^-, BF_3, $C_2H_5O^-$, $(CH_3)_3$ N:,

$C\overset{+}{l}, CH_3 - \overset{+}{C} = O, H_2N\overset{-}{:}, \overset{+}{N}O_2$

ii. 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.

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

Solution

Section A

1. **(a)** 12g He

   Explanation:

   i. 12 g He = 3 moles of He
      No. of atoms of He = $3 \times N_A = 3 \times 6.022 \times 10^{23}$
   ii. 4 g He = 1 mole of He
      No. of atoms Of He = $1 \times N_A = 1 \times 6.022 \times 10^{23}$
   iii. 46 g of Na = 2 moles of Na
      No. of atoms of Na = $2 \times N_A = 2 \times 6.022 \times 10^{23}$
   iv. 0.40 g Ca = 0.1 mole of Ca
      No. of atoms of Ca = $0.1 \times N_A = 0.1 \times 6.022 \times 10^{23}$

   Hence, 12 g of He contains maximum number of atoms.

2. **(a)** Rydberg's constant

   Explanation: The Rydberg constant, symbol R_∞ for heavy atoms or R_H for hydrogen, named after the Swedish physicist Johannes Rydberg, is a physical constant relating to atomic spectra, in the science of spectroscopy.

3. **(d)** q is positive if heat is transferred into the system and w is positive if work is done on the system.

   Explanation: The first law is simply the conservation of energy equation. q is positive if heat is added to the system, and negative if heat is removed; w is positive if work is done on the system, and negative if work is done by the system.

4. **(d)** behave like particles

   Explanation: The photoelectric effect is the emission of electrons when light is shown into a material. Here the light behaves like a stream of particles (photons).

5. **(d)** -315 kJ

   Explanation: When 1 mole of CO_2 is produced energy released is –393.5 kJ mol^{-1}. Moles of CO_2 given = $\frac{35.2}{44}$ = 0.8 moles

   So energy released = 0.8 × -393.5 kJ/mol = -315 kJ/mol

6. **(c)** Heisenberg's uncertainty principle

   Explanation: Werner Heisenberg, a German physicist in 1927, stated the uncertainty principle which is the consequence of the dual behavior of matter and radiation. It states that it is impossible to determine simultaneously, the exact position and exact momentum (or velocity) of an electron. It rules out the existence of definite paths or trajectories of electron and other similar particles.

7. **(c)** PF_3

   Explanation: Whenever a reaction between an oxidising agent and a reducing agent is carried out, a compound of lower oxidation state is formed if the reducing agent is in excess and a compound of higher oxidation state is formed if the oxidising agent is in excess. This can be illustrated as follows: P_4 and F_2 are reducing and oxidising agents respectively. If an excess of P_4 is treated with F_2, then PF_3 will be produced, wherein the oxidation number (O.N.) of P is +3.

   PF_4(excess)+$F_2 \longrightarrow PF_3$

8. **(b)** 2-methylbutanal

   Explanation: The longest chain of C atoms contains 4 C and the functional group present is an aldehyde (-CHO). So the IUPAC name is 2-methylbutanal.

9.

(c) C_2H_4

Explanation: It is an example of dehydration of alcohols to give alkenes.

$$\underset{alcohol}{RCH_2 - CH_2OH} \xrightarrow[-H_2O]{Al_2O_3,623K} \underset{alkene}{RCH = CH_2}$$

For example,

$$\underset{ethanol}{C_2H_5OH} \xrightarrow[-H_2O]{Al_2O_3,623K} \underset{ethene}{CH_2 = CH_2}$$

Thus, when ethanol vapours are passed over heated alumina, the alcohol gets dehydrated to form ethene, as given above.

10.

(d) filling of inner d orbitals by electrons.

Explanation: d-Block elements also known as transition elements are characterized by the filling of inner d orbitals by electrons before the valence-shell s orbital.

11. **(a)** -741.5 kJ

Explanation: Here, $\Delta n_g = 2 - (\frac{3}{2}) = \frac{1}{2}$

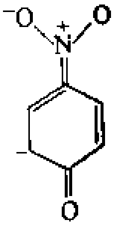
$\Delta H° = \Delta U° + \Delta n_g RT$

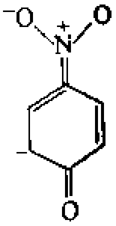
$\Delta H° = - 742.7 \text{ kJ/mol} + (0.5 \text{ mol} \times 8.314 \times 10^{-3} \text{kJ/mol} \times 298\text{K})$

$\Rightarrow \Delta H° = (- 742.7 \text{ kJ} + 1238.786 \times 10^{-3} \text{kJ}) \text{ mol}^{-1}$

$\Rightarrow \Delta H° = - 741.46 \text{ kJ mol}^{-1}$

12.

(d) 

Explanation: 

13.

(c) A is true but R is false.

Explanation: $RCOOH \rightarrow RCONH_2 \rightarrow NH_3$

Since, 17g of NH_3 is liberated from 59 g of acid amide, the amide has molecular mass of 59, i.e., $RCONH_2 = 59$

R + 12 + 16 + 14 + 2 = 59

R + 44 = 59

R = 15

Hence, R is CH_3 group and thus acid is CH_3COOH(Acetic acid)

14.

(d) If both Assertion and Reason are false statements.

Explanation: Rates of nitration of benzene and hexadeutero benzene are the same because nitration depends upon the availability of electrophile. C-D bond is stronger than the C - H bond. Here changing a hydrogen atom to deuterium in C- H bond represents a 100% increase in mass. Here the mass of an atom affects the vibration frequency of the chemical bond that it forms, even if the electron configuration is nearly identical. Heavier atoms will lead to lower vibration frequencies or will have lower zero-point energy. With lower zero-point energy, more energy must be supplied to break the bond, resulting in higher activation energy for bond cleavage, thus C-D bond is stronger than the C- H bond.

15.

(c) A is true but R is false.

Explanation: 1 and 2 are principal quantum numbers, n identifies the shell, determines the size of the orbital and also to a large extent the energy of the orbital. Maximum capacity of s-subshell is two because it has only one orbital.

16.

(d) A is false but R is true.

Explanation: Law of conservation of mass does not hold good for nuclear reaction due to mass defect.

Section B

17. SO_3^{2-} is Bronsted base because it can accept H^+.

$$\underset{Sulphite\ ion}{SO_3^{2-}} + H^+ \rightarrow \underset{Hydrogen\ sulphite\ ion}{HSO_3^-}$$

$$HSO_3^- + H^+ \rightarrow \underset{Sulphorous\ acid}{H_2SO_3}$$

18. All the given elements are of same period and along a period, atomic radii decreases because effective nuclear charge increases. Thus, the order of atomic radii is O < N < C < B < Be or, Be =111 pm, O = 66 pm, C = 77 pm, B = 88 pm, N = 74 pm.

19. Molar mass of argon (Ar) = $\left[\left(35.96755 \times \frac{0.337}{100}\right) + \left(37.96272 \times \frac{0.063}{100}\right) + \left(39.9624 \times \frac{90.60}{100}\right)\right]$ $gmol^{-1}$

= [0.121 + 0.024 + 39.802] $gmol^{-1}$

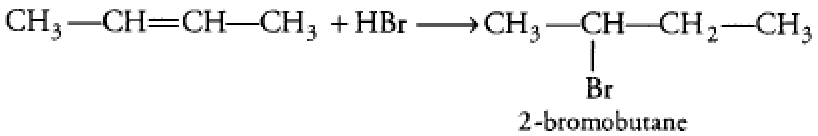
= 39.947 $gmol^{-1}$

20. Sodium salt of Butanoic acid is needed for the preparation of propane. Sodium salt of butanoic acid is treated with sodiumhydroxide in the presence of CaO to give propane and Sodium carbonate is formed as byproduct in this reaction.

$CH_3CH_2CH_2COO^-Na^+ + NaOH \xrightarrow{CaO} CH_3CH_2CH_3 + Na_2CO_3$

OR

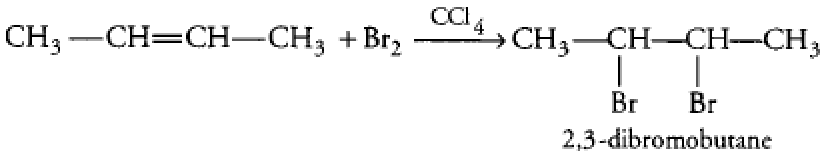
i. But-2-ene is a symmterical alkene and reaction with HBr gives 2-Bromobutane.



$$CH_3{-}CH{=}CH{-}CH_3 + HBr \longrightarrow CH_3{-}\underset{\underset{Br}{|}}{CH}{-}CH_2{-}CH_3$$

2-bromobutane

ii. But-2-ene reacton with bromine dissolved in tetrachloromethane gives 2,3-dibromobutane. In reaction, Br_2 water loses its red-brown colour and becomes colourless. This decolourisation of bromine is often used as a test for a carbon-carbon double bond.

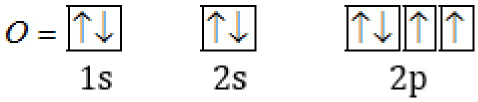


$$CH_3{-}CH{=}CH{-}CH_3 + Br_2 \xrightarrow{CCl_4} CH_3{-}\underset{\underset{Br}{|}}{CH}{-}\underset{\underset{Br}{|}}{CH}{-}CH_3$$

2,3-dibromobutane

21. The electronic configuration of oxygen ($_8O$) = $1s^2\ 2s^2\ 3p^4$.

Distribution of electrons in oxygen ($_8O$) is



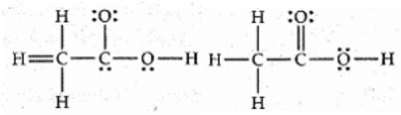
Section C

22. Hybridisation: It is defined as the process of intermixing of atomic orbitals of slightly different energies to give rise to newly hybridized orbitals having equivalent energy and identical shapes.

Shapes of Orbitals:

sp hybridisation: When one S and one p orbital intermix is called sp-hybridisation. For example, in BeF_2. Be atom undergoes sp-hybridisation. It has a linear shape. Bond angle 180°.

Sp^2 hybridisation: One S and two p-orbitals get hybridized to form three equivalent hybrid orbitals. The three hybrid orbitals directed towards three corners of an equilateral triangle. It is, therefore, known as trigonal hybridisation.



Sp^3 hybridization: One S and three p orbitals get hybridized to form four equivalent hybrid orbitals. These orbitals are directed towards the four corners of a regular tetrahedron.

23. Answer:

(i) A system in thermodynamics refers to that part of the universe in which observations are made.

(ii) For isothermal reversible expansion,

$W = -p_{\text{int}} \times \Delta V$.

At higher temperatures, an internal pressure of the gas is more. So, the work done is more.

Hence, for the same increase in volume, work done is more.

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

Now, Heat capacity(Cp) of water is = 18 × C

= 18 × 4.18 JK^{-1}

= 75.3 JK^{-1}

24. According to the question, n = 1, Initial volume = V_1, final volume = 10 V_1, W = 10 kJ, p = 1 × 10^7 Pa.

i. W = $-2.303nRT\log\frac{V_2}{V_1}$

$10 \times 10^3\text{J} = -2.303 \times 1 \times 8.314 \times T \times \log\frac{10V_1}{V_1}$

⇒ T = 522.3 K

For initial conditions, $p_1V_1 = n_1RT$

$\Rightarrow \left(10^7\right)V_1 = 1 \times 8.314 \times 522.3$

$\Rightarrow V_1 = 4.342 \times 10^{-4}\text{m}^3$

$= 4.342 \times 10^2\text{cm}^3$

= 434.2 cm^3

ii. If there were 2 moles of the gas, applying $p_1V_1 = n_1RT$, we get

$\left(10^7\right)\left(4.342 \times 10^{-4}\right) = 2 \times 8.314 \times T$

$\Rightarrow T = 261.1$ K

25. Among the oxoanions of chlorine listed above, ClO_4^- does not disproportionate because in this oxoanion chlorine is present in its highest oxidation state that is, +7. The disproportionation reactions for the other three oxoanions of chlorine are as follows:

$3\overset{+1}{\text{Cl}}\text{O}^- \rightarrow 2\overset{-1}{\text{Cl}^-} + \overset{+5}{\text{Cl}}\text{O}_3^-$

$6\overset{+3}{\text{Cl}}\text{O}_2^- \xrightarrow{hv} 4\overset{+5}{\text{Cl}}\text{O}_3^- + 2\overset{-1}{\text{Cl}^-}$

$4\overset{+5}{\text{Cl}}\text{O}_3^- \rightarrow \overset{-1}{\text{Cl}^-} + 3\overset{+7}{\text{Cl}}\text{O}_4^-$

26. From Rydberg formula,

Wave number, $\bar{v} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]\text{cm}^{-1}$; Where R_H = 109677 cm^{-1}

Here n_1 =2, n_2=4 (Transition in Balmer series)

$\bar{v} = 109677\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$ = $109677\left[\frac{1}{4} - \frac{1}{16}\right]$ = 20564.44 cm^{-1}

27. **Atomic size.** With the increase in atomic size, the number of electron shells increase.Therefore, the force that binds the electrons with the nucleus decreases.Therefore ionization enthalpy decreases with the increase in atomic size.

Screening or shielding effect of inner shell electron. With the addition of new shells, the number of inner electron shells which shield the valence electrons increases. As a result, the force of attraction of the nucleus for the valence electrons further decreases so less amount of energy is requied to remove the valence electron and hence the ionization enthalpy decreases.

28.

S.No.	Value	Significant figures
1.	4.01×10^2	Three
2.	8.256	Four
3.	100	One

Section D

29. **Read the text carefully and answer the questions:**

Chromatography is an important technique extensively used to separate mixtures into their components, purify compounds and also test the purity of compounds. Based on the principle involved, chromatography is classified into different categories. Two of these are Adsorption chromatography and Partition chromatography. Two main types of chromatographic techniques are based on the principle of differential adsorption column chromatography, and thin-layer chromatography. Adsorption chromatography is based on the fact that different compounds are adsorbed on an adsorbent to different degrees. Column chromatography involves the separation of a mixture over a column of adsorbent (stationary phase) packed in a glass tube. Thin-layer chromatography (TLC) is another type of adsorption chromatography, which involves the separation of substances of a mixture over a thin layer of an adsorbent coated on a glass plate. Partition chromatography is based on the continuous differential partitioning of components of a mixture between stationary and mobile phases.

(i) In column chromatography adsorbent is silica gel or alumina while in paper chromatography adsorbent is cellulose.

OR

Column chromatography.

(ii) In paper chromatography the spots of the separated colourless components may be observed either under ultra-violet light or by the use of an appropriate spraying agent.

(iii)Partition chromatography is based on continuous differential partitioning of components of a mixture between stationary and mobile phases as doner in paper chromatography.

30. **Read the text carefully and answer the questions:**

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:

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

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

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

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

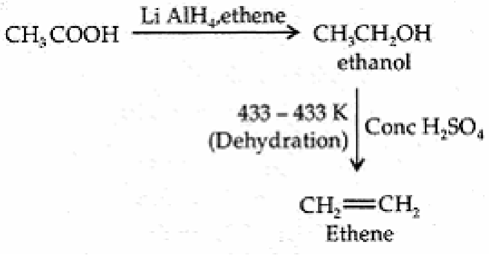
Bond dissociation energy of C—H bonds is 414 kJ mol^{-1}.

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.

(ii) A catalyst speeds up the forward and back reaction to the same extent. Because adding a catalyst doesn't affect the relative rates of the two reactions, a catalyst cannot change the position of equilibrium in a chemical reaction

(iii)



(iv) Alkenes are commonly known as olefins because the lower members form oily products on treatment with chlorine or bromine.

(v) **Lindlar's catalyst:** Partially deactivated palladised charcoal is known as Lindlar's catalyst.

Uses: Alkynes on partial reduction with calculated amount of dihydrogen in the presence of palladised charcoal partially deactivated with poisons like sulphur compounds or quinoline give alkenes.

(vi) Cyclohexane belongs to saturated alicyclic hydrocarbons.

(vii) Unsaturated alkene (ethene) is get converted into saturated alkane (ethane) by the process of reduction in the presence of reducing agents like Pt/Pd/Ni etc.

$CH_2 = CH_2$ (ethene) + $H_2 \xrightarrow{Pt/Pd/Ni}$ $CH_3 - CH_3$ (ethane)

32. Let x moles of BrCl decompose in order to attain the equilibrium. The initial molar concentration and the molar concentration at equilibrium point of different species may be represented as follows:

$$\begin{array}{lccc} & 2BrCl\ (g) & \rightleftharpoons Br_2(g) & +Cl_2(g) \\ Initial\ molar/litre & 0.0033 & 0 & 0 \\ Moles/litres\ at\ eqn.\ po\text{int} & 0.0033-x & x/2 & x/2 \end{array}$$

Applying law of chemical equilibrium,

$K_c = \frac{[Br_2][Cl_2]}{[BrCl]^2}$

$\Rightarrow 32 = \frac{\left[\frac{x}{2}\right]\left[\frac{x}{2}\right]}{[0.0033-x]^2}$

$\Rightarrow 5.656 = \frac{\left[\frac{x}{2}\right]}{[0.0033-x]}$ taking sqaure root on both sides

$\frac{x}{(0.0033-x)} = 11.31$

or 12.31x = 0.037

$x = \frac{0.037}{12.31} = 0.003$

$\therefore$ Molar concentration of BrCl at equilibrium point = 0.0033 - 0.003

= 0.0003 mol $L^{-1} = 3 \times 10^{-4}\ mol\ L^{-1}$

OR

a. The concentration ratio (concentration quotient) Q_c for the reaction is:

$Q_c = \frac{[CH_3COOC_2H_5(l)][H_2O(l)]}{[CH_3COOH(l)][C_2H_2OH(l)]}$

b.

$$\begin{array}{lcccc} & CH_3COOH(l)+ & C_2H_5OH(l) \rightleftharpoons & CH_3COOC_2H_2(l)+ & H_2O(l) \\ Initial\ molar\ conc. & 1.0\ mol & 0.18\ mol & 0 & 0 \\ Molar\ conc.\ at & (1-0.171) & (0.18-0.171) & 0.171\ mol & 0.171\ mol \\ equilibrium\ po\text{int} & =0.829\ mol & =0.009 & & \end{array}$$

Applying Law of Chemical equilibrium

$K_c = \frac{[CH_3COOC_2H_3](l)[H_2O(l)]}{[CH_3COOH](l)[C_2H_3OH(l)]}$

$= \frac{(0.171\ mol)\times(0.171\ mol)}{(0.829\ mol)(0.009\ mol)} = 3.92$

Therefore, the equilibrium constant is 3.92.

c.

$$\begin{array}{lcccc} & CH_3COOH(l)+ & C_2H_5OH(l) \rightleftharpoons & CH_3COOC_2H_5(l) & +H_2O(l) \\ Initial\ molar\ conc. & 1.0\ mol & 0.5\ mol & 0.214 & 0.214 mol \\ Molar\ conc.\ at & 1.0-0.214 & 0.5-0.214 & & \\ equilibrium & =0.786 & =0.286\ mol & & \end{array}$$

$Q_c = \frac{[CH_3COOC_2H_5(l)][H_2O(l)]}{[CH_3COOH(l)][C_2H_2OH(l)]}$

$= \frac{(0.214 mol)\times(0.214\ mol)}{(0.286\ mol)(0.786\ mol)} = 0.204$

Since Q_c value 0.204 is less than K_c, value 3.92 this means that the equilibrium has not been reached. The reactants are still taking part in the reaction to form the products.

33. Answer:

(i) i. In position isomerism, two or more compounds differ in the position of substituent, functional group or multiple bonds but molecular formula is same. In the given structures, I and II, III and IV, and VI and VII are position isomers.

I. CH_3—$C(CH_3)$ (OH)-CH_3 and CH_3—$CH(CH_3)$—CH_2—OH are position isomers.

II. CH_3—O—CH_2—CH_2—CH_3 and CH_3—O — CH(CH_3)—CH_3 are position isomers.

III. CH_3- CH_2- CH_2-CH_2-OH and CH_3—CH_2—CH(OH)—CH_3 are position isomers.

ii. Column chromatography, paper chromatography and thin layer chromatography.

OR

i. Nucleophiles(reagent that brings electron pair): HS^-, $C_2H_5O^-$, $(CH_3)_3N$:, $H_2N:^-$

These species have unshared pair of electrons, which can be donated and shared with an electrophile.

Electrophiles(reagent which takes away electron pair): $BF_3, C\overset{+}{l}, CH_3 - \overset{+}{C} = O, \overset{+}{N}O_2$

Reactive sites have only six valence electrons; can accept electron pair from a nucleophile.

ii. 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