रसायन विज्ञान
Chemistry

कक्षा / Class XI

2025-26

विद्यार्थी सहायक सामग्री
Student Support Material

केन्द्रीय विद्यालय संगठन~Kendriya Vidyalaya Sangathan

संदेश

विद्यालयी शिक्षा में शैक्षिक उत्कृष्टता प्राप्त करना एवं नवाचार द्वारा उच्च - नवीन मानक स्थापित करना केन्द्रीय विद्यालय संगठन की नियमित कार्यप्रणाली का अविभाज्य अंग है। राष्ट्रीय शिक्षा नीति 2020 एवं पी. एम. श्री विद्यालयों के निर्देशों का पालन करते हुए गतिविधि आधारित पठन-पाठन, अनुभवजन्य शिक्षण एवं कौशल विकास को समाहित कर, अपने विद्यालयों को हमने ज्ञान एवं खोज की अद्‌भुत प्रयोगशाला बना दिया है। माध्यमिक स्तर तक पहुँच कर हमारे विद्यार्थी सैद्धांतिक समझ के साथ-साथ, रचनात्मक, विश्लेषणात्मक एवं आलोचनात्मक चिंतन भी विकसित कर लेते हैं। यही कारण है कि वह बोर्ड कक्षाओं के दौरान विभिन्न प्रकार के मूल्यांकनों के लिए सहजता से तैयार रहते हैं। उनकी इस यात्रा में हमारा सतत योगदान एवं सहयोग आवश्यक है - केन्द्रीय विद्यालय संगठन के पांचों आंचलिक शिक्षा एवं प्रशिक्षण संस्थान द्वारा संकलित यह विद्यार्थी सहायक-सामग्री इसी दिशा में एक आवश्यक कदम है । यह सहायक सामाग्री कक्षा 9 से 12 के विद्यार्थियों के लिए सभी महत्वपूर्ण विषयों पर तैयार की गयी है। केन्द्रीय विद्यालय संगठन की विद्यार्थी सहायक- सामग्री अपनी गुणवत्ता एवं परीक्षा संबंधी सामग्री संकलन की विशेषज्ञता के लिए जानी जाती है और शिक्षा से जुड़े विभिन्न मंचों पर इसकी सराहना होती रही है। मुझे विश्वास है कि यह सहायक सामग्री विद्यार्थियों की सहयोगी बनकर निरंतर मार्गदर्शन करते हुए उन्हें सफलता के लक्ष्य तक पहुँचाएगी।

शुभाकांक्षा सहित ।

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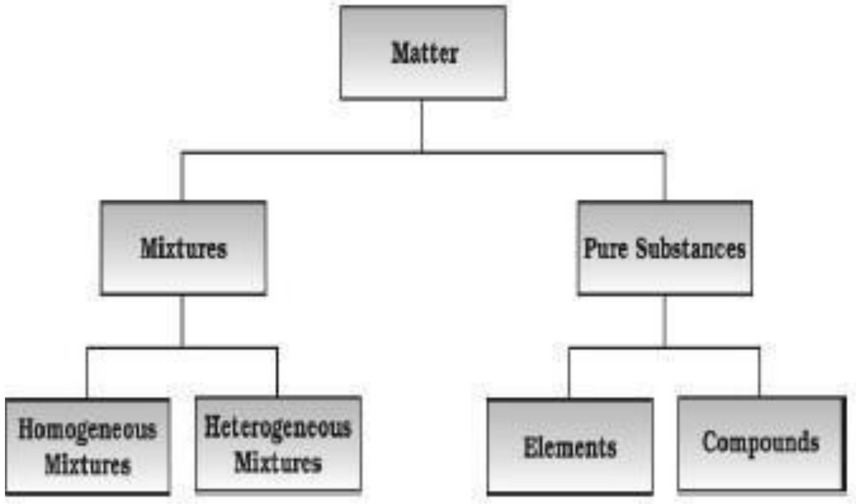
CHAPTER 1

SOME BASIC CONCEPTS OF CHEMISTRY

SUMMARY

- **Chemistry** is the branch of science that deals with the properties, structure and composition of matter
- **Matter**: Matter is anything that occupies space, has a definite mass and can be perceived by any of our sense organs.
- **Chemical Classification of matter---:**



- **PROPERTIES OF MATTER -** Properties are broadly classified as physical and chemical properties.
- **Physical properties and its SI units:**

Base Physical Quantity	Symbol for Quantity	Name of SI Unit	Symbol for SI Unit
Length	l	metre	m
Mass	m	kilogram	kg
Time	t	second	s
Electric current	I	ampere	A
Thermodynamic temperature	T	kelvin	K
Amount of substance	n	mole	mol
Luminous intensity	I_v	candela	cd

- **Uncertainty in Measurement: Precision and Accuracy**

Precision refers to the closeness of various measurements for the same quantity. But, accuracy is the agreement of a particular value to the true value of the result.

- **Scientific Notation: In which any number can be represented in the form $N \times 10^n$**

e.g. We can write 232.508 as 2.32508×10^2 in scientific notation. Similarly, 0.00018 can be written as 1.8×10^{-4}.

- **Significant figures are meaningful digits which are known with certainty**

There are certain rules for determining the number of significant figures. These are:

a) All non-zero digits are significant.
b) Only zeros preceding to the first non-zero digit are not significant.

c) Zeros between two non-zero digits are significant.
d) Zeros at the end or right of a number are significant provided they are on the right side of the decimal point.
e) point; otherwise, they are not significant.
f) Exact numbers have an infinite number of significant figures.

- **Laws of chemical combinations**

(a) Law of conservation of mass- It states that matter neither be created nor be destroyed.e.g.-
$CaCO_3 \longrightarrow CaO + CO_2$ (mass of reactant and product are equal)

(b) Law of definite proportions-It states that a given compound always contains exactly the same proportion of elements by weight e.g. pure sample of water (source; river,tapetc) always contains hydrogen and oxygen in the ratio of 1:8 by mass

(c)Law of Multiple Proportions- When two elements combine with one another to give more than one product then the masses of one of the element which combine with fixed mass of the other, bear a simple whole number ratio e.g. in CO, 12 part by mass of carbon combine with 16 part by mass of oxygen whereas in CO2 ,12 part by mass of carbon combine with 32 part by mass of oxygen. Ratio of oxygen which combine with fixed mass of carbon in these compound is 1:2

(d) Gay Lussac's Law of Gaseous Volumes – When gases combine or produced in a chemical reaction they do so in a simple ratio by volume provided all gases are at same temperature and pressure. $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$. the volumes of hydrogen and oxygen which combine together bear a simple ratio of 2:1

(e) Avogadro's Law- Equal volume of all gases under similar condition contain equal number of molecule.

- **DALTON'S ATOMIC THEORY**

The important postulates of this theory are:
1. Matter is made up of minute and indivisible particles called atoms.
2. Atoms can neither be created nor be destroyed.
3. Atoms of same element are identical in their properties and mass. While atoms of different elements have different properties and mass.
4. Atoms combined to form compound atoms called molecules.
5. When atoms combine, they do so in a fixed ratio by mass

- Atomic Mass = $\dfrac{\text{Mass of an atom of an element}}{\text{1/12 x mass of an atom of carbon (C-12)}}$

Average Atomic mass of isotope

$$\frac{(\text{mass of isotope A x \%}) + (\text{mass isotope B x \%})}{100}$$

- **Molecular mass:** Molecular mass is the sum of atomic masses of the elements present in a molecule.

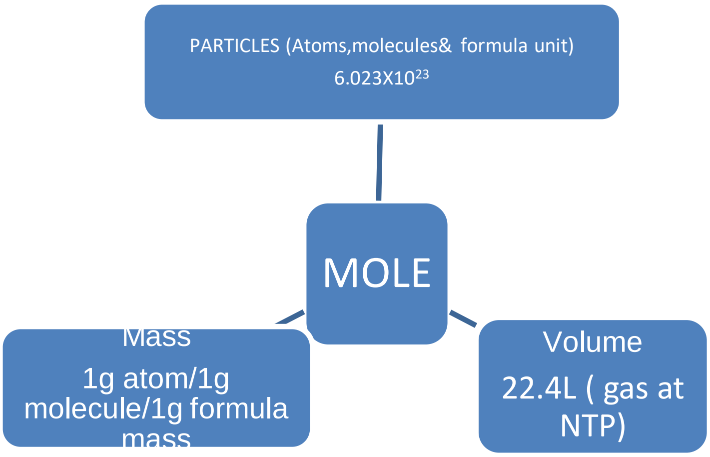
  For e.g. molecular mass of H_2SO_4 is calculated as: 2 x 1 + 32 + 4 x 16 = 98 u.

- **Formula mass –** in case of ionic compounds (NaCl etc.),the compound does not represent its molecule, but only represents the ratio of different inos in the compounds. This is called Formula unit of the compound, in such compound instead of molecular

mass we use formula mass. Formula mass is obtained by adding atomic masses of all the atoms in a formula unit.
e.g. Formula mass of NaCl = atomic mass of Na + atomic mass of chlorine
(23u+35.5u)=58.5u

- **MOLECONCEPT**

$$\text{*MOLES=}\frac{\mathbf{Givenmass}}{\mathbf{Molarmass}}\ \text{X}\ N_A$$



- **PERCENTAGE COMPOSITION**- It is the relative mass of the each of the constituent elements in 100 part of it.

$$\textbf{Mass\% of an element} = \frac{\text{Mass of an element}}{\text{Molar mass of comp.}} \times 100$$

- **Empirical Formula and Molecular Formula—**
An **empirical formula** represents the simplest whole number ratio of various atoms present in a Compound. eg. CH is the empirical formula of benzene.
The **molecular formula** shows the exact number of different types of atoms present in a molecule of a compound e.g. C_6H_6 is the molecular formula of benzene
Relationship between Empirical and molecular formula, M.F.= nx E.F

$$n = \frac{\text{Molecular formula mass}}{\text{Empirical formula mass}}$$

- **Limiting Reagent-** The reactant which gets consumed first or limits the amount of product formed is known as limiting reagent.
- **Reactions in solutions:**

$$\text{1.}\textbf{Mass \%=} \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$$

$$\text{2.}\textbf{Mole fraction=} \frac{\text{Number of moles of a component}}{\text{Total number of moles of the system}} \times 100$$

$$\text{3.}\textbf{Molarity} = \frac{\text{Number of moles of solute}}{\text{Volume of solution in L}}$$

$$\text{4.}\textbf{Molality =} \frac{\textbf{Number}\text{ of moles of solute}}{\text{Mass of solvent in kg}}$$

****

QUESTION BANK

SECTION – A (1 MARK)

Q.1…Following concentration method varies with temperature.
(a) Molarity (b) Molality (c) Mole fraction(d) Mass percentage

Q.2 A system has three components, its total mole fraction will be
(a) 3 (b) 2 (c) 1 (d)1.5

Q.3 Find out the correct statement
(a) 28 g CO contains 12g Carbon and 16g Oxygen
(b) One mole of CO reacts completely with half mole of O_2 to form CO_2
(c) N_2 and CO has same molar mass
(d) All of these

Q.4 The significant figures in 3400 are
(a) 2 (b) 5 (c) 6 (d) 4

Q.5 ……………. Is the SI unit of Luminous Intensity?
(a) Candela (b) Kelvin (c) Mole (d) Ampere

Q.6 Ratio of empirical formula mass to molecular formula mass of benzene will be
(a) 1:6 (b) 2:3 (c) 6:1 (d) 3:2

Q.7 In CH_4 the mass % of C and H will be
(a) 60 & 40 % respectively (b) 75 & 25% respectively
(c) 80 & 20% respectively (d) 40 and 60 % respectively

Q8. One 'u' stands for the mass of
(a) An atom of C-12 (b) 1/12th of C-12
(c) 1/12th of hydrogen atom (d) one atom of any of the elements

Q.9 Element X forms five stable oxides with oxygen of formula X_2O,XO,X_2O_3,X_2O_4 and X_2O_5. The formation of these oxides explains:
(a) Law of definite proportions (b) Law of partial pressure
(c) Law of multiple proportions (d) Avogadro's law

Q.10 Gay Lussac law is not valid in
(a) $H_{2\,(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$ (b) $3H_{2\,(g)} + N_{2(g)}$ $2NH_{3(g)} \longrightarrow$
(c) $2SO_{2\,(g)} + O_{2(g)} \longrightarrow 2SO_{3(g)}$ (d) $CaCO_{3(s)}\Delta$ $CaO_{(S)} + CO_{2(g)} \longrightarrow$

ASSERTIONREASON TYPE QUESTIONS

In the following questions a statement of **Assertion** (A) followed by a statement of Reason (R) is given.

Choose the correct option out of the choices given below each question.
(a) **Assertion** is correct, reason is correct; reason is a correct explanation for **assertion**.
(b) **Assertion** is correct, reason is correct; reason is not a correct explanation for **assertion**
(c) **Assertion** is correct, reason is incorrect
(d) **Assertion** is incorrect, reason is correct.

Q.11.**Assertion**: There are four significant numbers in 1007.
Reason: Zeros between two non-zeros are significant.

Q.12**Assertion**: The average atomic mass of chlorine is 35.5.
Reason: Chlorine has three naturally occurring isotopes.

Q.13**Assertion**: Matter can neither be created nor be destroyed -law of conservation of mass
Reason: It is applicable for all type of reactions.

Q14 .**Assertion**: A limiting reagent stops the formation of product in a reaction.
Reason: Limiting reagent is completely consumed during the reaction.

Q15. **Assertion**: Compounds are prepared by mixing two or more substances in a fixed ratio.
Reason: Compounds can be prepared by physical methods only.

ANSWERS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
a	C	d	a	a	A	b	b	C	D	A	c	c	A	c

SECTION-B (2 MARKS)

Q.1 Justify that 0.50 mol Na_2CO_3 and 0.50 M Na_2CO_3 are not same.
[Hint:0.50 M Na_2CO_3 means 0.50 mol,.53 g of Na_2CO_3 are present in I L of the solution]

Q2. A solution contains 10 mol of sucrose in 1 kg of solvent. Calculate the molality of solution.
[Hint: 10 mol /kg]

Q3. Adjust the following numbers to four significant figures.
(a) 1.81234×10^3 (b) 0.008837
[Hint: a-1.812×10^3, b-8.8837×10^{-3}]

Q4. Nitrogen occurs in nature inthe form of two isotopes with atomic mass 14 and 15 respectively. If average atomic mass of nitrogen is 14.0067, what is the % abundance of two isotopes?]
[Hint: N-14= 99.3 & N-15= 0.67; Ref summary for formula]

Q5. A compound has C=54.54%,H=9.09% and O=36.37%. Determine the molecular formula of the compound if its vapour density is 88.
[Hint: Atomic wt. of C=12,H=1, O= 16, M.M= 2 X Vapourdensity, Molecular formula $C_8H_{16}O_4$]

SECTION - C(3 MARKS)

Q1. Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction
$4HCl(aq) + Mn0_2(s) \longrightarrow 2H_2O(l) + MnCl_2(aq) + Cl_2(g)$
How many grams of HCl react with 5.0 g of manganese dioxide?
(Atomic mass of Mn = 55 u)
[Hint:1 Mol MnO_2 (87g) reacts with 146 g of HCl, so 5 g will react=(146/87)X 5= 8.4 g]

Q2. Calculate (a) the no of atoms in 3 mol of NH_3 (b) the no. of molecules in 1ml of CO_2 at STP.
[Hint: a- $3 \times 4 \times 6.023 \times 10^{23}$, b- 1ml CO_2 contains= $6.023 \times 10^{23}/22400$ molecules]

Q3. Out of 1M KCI and 1m KCI, which one is stronger justify your answer with suitable reason.
[Hint: 1M KCl is studied in solution]

Q4. Calculate the amount of carbon dioxide that could be produced when-
(i)1 mole of carbon is burnt in air.
(ii)1 mole of carbon is burnt in 16 g of dioxygen.

(iii) 2 moles of Carbon is burnt in 16 g of dioxygen

[Hint: i- 44 g, ii- 22 g,iii- 22g]

Q5. Are the following terms same?, if not give possible reason/ comment.

a. Empirical formula and Molecular formula

b. Calculate the molecular mass of Sucrose($C_{12}H_{22}O_{11}$) and Fructose($C_6H_{12}O_6$)

[Hint :a-Ref: Summary b- 342 and 120]

SECTION – D CASE BASED QUESTIONS (4 MARKS)

Read the following passage carefully and give answers of the questions

1.Chemistry is the science of molecules and their transformations. It is the science not so much of the one hundred elements but of the infinite variety of molecules that may be built from them. Chemistry plays a central role in science and is often intertwined with other branches of science. Chemistry has very important role in our daily life. It is used in several industries like fertilizer, pharmaceuticals, textile, cosmetic etc. Insecticides and pesticides like D,D,T., GAMMEXANE,etc are prepared by chemical processes. Several lifesaving drugs such as CISPLATIN and TAXOL (used in cancer therapy) and AZT (Aidothymidine is used in treatment of AIDS) are also prepared by chemical process.

It has important role in making preservatives, dyes, Water purifier etc.

Q. (i). ………… is used as an insecticide

(a) AZT (b) CISPLATIN (c) TAXOL (d) D.D.T

Q(ii). The Drug used in treatment of cancer is

(a) Taxol (b) Gammexane (c) Aspirine (d) AZT

Q(iii). Give an example of each natural and synthetic preservative

[Hint: i-d, ii- a,]

2.At **Standard Temperature and Pressure (STP)** (0°C and 1 atm pressure), 1 mole of any ideal gas occupies 22.4 liters of volume. This means that gases with the same number of moles will have the same volume when measured at STP, regardless of their chemical nature. In this case, you are working with two different gases—oxygen (O_2) and hydrogen (H_2)—and comparing their volumes. This comparison allows us to understand the ideal behavior of gases and how they relate to each other in terms of volume when they are under the same temperature and pressure conditions.

(i) At STP, how many liters of hydrogen gas would contain the same number of molecules as 11.2 liters of oxygen gas?

[Hint: Use Avogadro's law to find the relation]

(ii) At STP 0.5 mole of oxygen will have volume…….

(a) 22.4 L (b) 11.2 L (c) 0.8 L (d) 16 L

(iii) The number of molecule present in 1ml of O_2 at NTP will be

(a) 6.023×10^{23} (b) 2.69×10^{19} (c) 3.023×10^{23} (d) 3.023×10^{19}

[Hint: (ii)-b (iii) –b]

SECTION - E(5 MARKS)

1. Is there any unit for mole fraction If not why ? A solution is prepared by adding 360gof glucose to 864g of water. Calculate the mole fraction of glucose

(M.M. of glucose is 180g mol^{-1})

[(Hint- no, mole fraction is a ratio, $X_{glucose}$= $\underline{n_{glucose}}$/ n_{H2O} +$_{nglucose}$, Ans= 0.04]

2. Calcium carbonate reacts with aqueous HCl to give $CaCl_2$ and CO_2 according to the reaction given : $CaCO_{3(s)} + 2HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O_{(l)}$

   What mass of $CaCl_2$ will be formed when 250 ml of 0.76 M HCl reacts with 1000 g of $CaCO_3$?

   Name the limiting reagent. Calculate the number of moles of $CaCl_2$ formed in the reaction

   [Hint: Moles of HCl= 0.76x0.25= 0.19moles,Moles of $CaCO_3$ = 10 moles
   10 mole $CaCO_3$ reacts with 20 moles of HCl,So H is limiting reagent
   Moles of $CaCl_2$ formed= 1/2X0.19= 0.095 moles]

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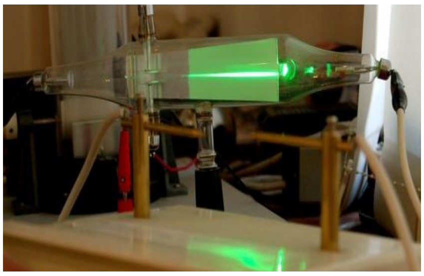
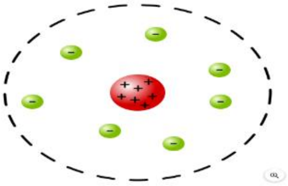
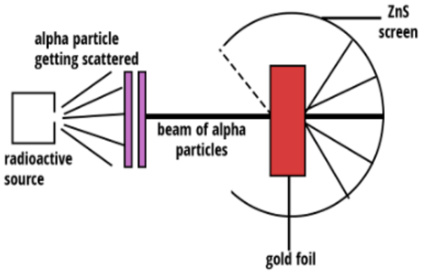
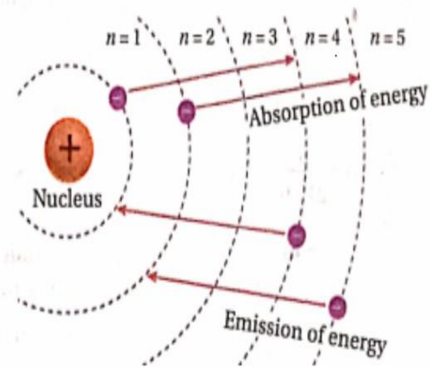
STRUCTURE OF ATOM
SUMMARY

The **atomic structure** of an element describes the arrangement of subatomic particles **protons**, **neutrons**, and **electrons** in an atom.

Dalton's Atomic Theory (1803) Atoms constitute matter.atoms are indivisible and indestructible. Similar atoms constitute an element. But later discovery of subatomic particles contradicted this concept of indivisibility of atoms.	**Limitations** could not account for the existence of isotopes.. No clear explanation of the atom's internal structure.
J.J. Thomson proposed the atom as a positively charged sphere and negatively charged electrons embedded within it, Thomson discovered the electron through his cathode ray experiment, which demonstrated that atoms are divisible. **Limitations:** Could not expalin atom's stability and discovery of nucleus	Cathode ray experiment 
Rutherford's Atomic Model (1911) Positively charged nucleus at centre, contains most mass. Atom is spherical and electrons orbit at a definite path . **Limitations:** Leads to instability of atoms due ot spiral inward of electron into nucleus owing to loss of energy. Emission of line spectrum by atoms instead of continuous spectrum	 
Bohr's Atomic Model (1913) Explained the **stability** of the atom and the **line spectra** of elements but was limited to simple atoms like **hydrogen**. Electrons orbit the nucleus in **fixed orbits** without radiating energy. Electrons can jump between orbits by absorbing or emitting specific amounts of energy (quantum of energy). The energy of the orbits is quantised.	

SUB ATOMIC PARTICLES	
ELECRON **Discovered by Sir J.J.Thomson in 1897** **charge** -1.6 x 10^-19 Coulombs **mass** 9.1 x 10^{-31} kg Charge/Mass Ratio**:** $e/m=1.602\times10^{-19}/ 9.109\times10^{-31}$ =1.76×1011C/kg	**PROTON** **Discovered by** Eugen ***Goldstein in 1886***.proton was named by **Rutherford in 1917.** **charge**1.6 x 10^-19 Coulombs **mass** 1.673×10^{-27} Charge/Mass Ratio**:** $e/m=1.602\times10^{-19}/1.673\times10^{-27}$ $=9.58\times10^{7}$C/kg
Neutrons The neutron was discovered by **James Chadwick in 1932,** leading to the discovery of nuclear fission in 1938, the first self-sustaining nuclear reactor (Chicago Pile-1, 1942) and the first nuclear weapon (Trinity, 1945). It is Neutral particle **Mass 1.67492749804 × 10^{-27} kg.**	Extended learning **The cathode ray tube (CRT)** is a vacuum tube, in which electrons are discharged from the cathode and accelerated through a voltage, and thereby gains acceleration of some 600 km/s for every volt. These accelerated electrons collide into the gas inside the tube, thereby allowing it to glow. This enables us to see the path of the beam

Lets glance on quantum mechanical aspects of atomic structure

Hydrogen spectrum

Hydrogen spectrum is a unique pattern of lines in the electromagnetic spectrum resulting from the emission of light by excited hydrogen atoms. These lines correspond to specific wavelengths of light. Wavelengths are given by the Rydberg formula. .

$$\frac{1}{\lambda} = Z^2 R_\infty \left(\frac{1}{n'^2} - \frac{1}{n^2}\right)$$

$R_\infty = 1.09677, \times 10^7\ m^{-1}$ for H atom

n_1 and n_2 are principal quantum numbers

Lyman	Balmer	Paschen	Brackett	Pfund
$n_1 = 1$	$n_1 = 2$	n_1 -3	n_1=4	n_1=5

Bohr's Energy Equation for Hydrogen Atom:

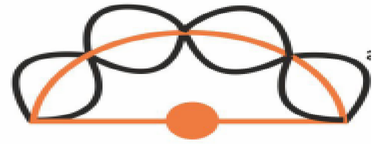
$$E_n = -\frac{13.6}{n^2} eV$$

A sample of excited hydrogen atoms emits a characteristic red light.

When the light emitted by a sample of excited hydrogen atoms is split into its component wavelengths by a prism, four characteristic violet, blue, green, and red emission lines can be observed

Bohr explained line spectrum of H and introduced the concept of quantized energy levels, But model failed for multielectron systems

It also could not explain splitting of spectral lines in electric field(stark effect) and magnetic field (zeeman effect).

Radius of Bohr's Orbit: $r_n = n^2 \times 0.529\ \mathring{A}$	
Key developments leading to the quantum mechanical model	
1.**Limitations of the Bohr model**	couldn't account for the behavior of atoms with multiple electrons or explain the wave-like properties of electrons.
2. Wave-particle duality (1923) **(de Broglie hypothesis)**  **λ = h/mv** ;where h is planck's constant **Heisenberg uncertainty principle** reinforces the concept of wave-particle duality. It implies that a particle's wave-like nature (represented by its wavelength) and its particle-like nature (represented by its position and momentum) are inherently intertwined and not perfectly measurable simultaneously	A moving particle behaves like a wave at times and like a particle at other times.He was first to apply Einstein's famous equation for the relationship between matter and energy:E=mc^2 $\Delta x.\Delta v \geq \frac{h}{4\pi m}$ Where Δx is uncertainity in position and Δv is uncertainity in velocity. And h is planck;s constant and mass of electron.
3. Schrodinger'sequation: **(1925)**Schrodinger derived an equation which described wave motion of an electron. This model describes the electron as a three dimensional wave in the electronic field of positively charged nucleus	$\frac{d^2\Psi}{dx^2}+\frac{d^2\Psi}{dy^2}+\frac{d^2\Psi}{dz^2}+\frac{8\pi^2 m}{h^2}(E-V)\Psi=0$ Ψ is wavefunction for electron whose square gives the probability of finding the electron at any instance in an atom. Solutions to Schrödinger's equation resulted in the concept of quantized energy levels (quantum numbers) clalled orbitals.
4. Quantum numbers and orbitals: Provide the size.shape and orientation of atomic orbital.	Types of Quantum Numbers 1. Principal Quantum Number (n) 2.Azimuthal Quantum Number (l) 3.Magnetic Quantum Number (m) 4.Spin Quantum Number (s)
Principal quantum number (n): Signifies the no. and size of orbit, to large extent the zenergy of the orbital.	

$$E_n = -\frac{Z^2\hbar^2}{2m_0 a_0^2 n^2} = -\frac{Z^2 e^4 m_0}{2\hbar^2 n^2}$$

Azimuthal quantum number (l) :gives the information about subshell (s,p,d,f) in which the electron is located.Its value depends on the value of n.

l = 0 to (n-1)

Magnetic quantum number (m) :gives information about the spatial orientation of orbitals. These different orientations are called orbitals.

m = - l to + l

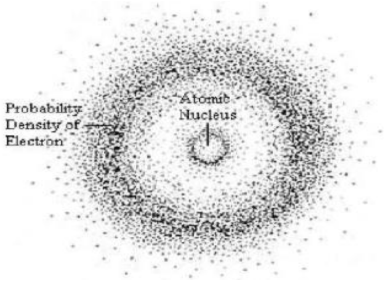
Total number of orbitals = (2l + 1) ; Number of orbital in a shell is n^2.

Spin quantum number (s) : Two electrons that have different s, values ± 1/ 2 and both electrons have opposite spins.

Nodal plane and Nodal surface :- The space where probability of finding an e– is zero. Nodal plane = l ; Nodal surface = n - l – 1

Quantum model of atom : The quantum mechanical model of an atom describes the probability of finding electrons within given orbitals, or three-dimensional regions of space, within an atom. The properties of each electron within the quantum atom can be described using a set of four quantum numbers.

The model views movement of electron in an atom as wave and not as particle.the model does not represents an electron's motion but rather indicates the likelihood of finding an electron within a specific orbital at any given time.



RULES FOR FILLING OF ORBITALS IN AN ATOM

Aufbau's rule:The electrons first occupy the lowest energy orbital avaiable to them and enter into higher energy orbitals only after lower energy orbitals are filled. Exceptions : elements in d- and f- block elements primarily due to increased stability of half filled and fully filled orbitals. Cu, Cr,Ag,Au,Ru etc.	**(n +l) Rule (For multi electron species)** :The subshell with lowest (n + l) value is filled up first, when two or more subshell have same (n + l) value then the subshell with lowest value of n is filled up first.
Hund's rule of maximum multiplicity :orbital available in the subshell are first filled singly with parallel spin electron before they begin to pair.	Extended learning **:**Hund gave three rules: 1. maximum multiplicity 2. spin alignment 3. Total angular momentum
Pauli's exclusion principle : According	The Pauli'sExclusion Principle is a

to this rule no two electron in an atom can have same values of all four quantum numbers.	fundamental concept in quantum mechanics, stating that no two identical fermions (particles with half-integer spin, like electrons) can occupy the same quantum state within a system at the same time
Stability of half filled and fully filled atomic orbitals: Half-filled and fully-filled orbitals exhibit greater symmetry compared to partially filled orbitals. This symmetry minimizes electron-electron repulsion and enhances stability.	

Important links :

1. **Structure of atom**
https://diksha.gov.in/play/content/do_3129505660964208641130?referrer=utm_source%3Dmobile%26utm_campaign%3Dshare_content
2. **Quantum mechanical model.**
https://diksha.gov.in/play/content/do_3129505660964208641130?referrer=utm_source%3Dmobile%26utm_campaign%3Dshare_content
3. **Quantum numbersI**
https://diksha.gov.in/play/content/do_313076031282159616110316?referrer=utm_source%3Dmobile%26utm_campaign%3Dshare_content
4. **Selfevaluation**
https://diksha.gov.in/play/content/do_431321768213896396816475?referrer=utm_source%3Dmobile%26utm_campaign%3Dshare_content
5. **Dual nature of radiation and matter**
https://diksha.gov.in/play/content/do_31337680450440396815554?referrer=utm_source%3Dmobile%26utm_campaign%3Dshare_content
6. **Exchange energy**
https://diksha.gov.in/play/content/do_3129450292118978561409?referrer=utm_source%3Dmobile%26utm_campaign%3Dshare_content

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QUESTION BANK

Section- A (1 Mark)

Q.1) Bohr model can explain :
(a) the solar spectrum
(b) the spectrum of hydrogen molecule
(c) spectrum of any atom or ion containing one electron only
(d) the spectrum of hydrogen atom only

Q.2) Two fast moving particles X and Y are associated with de Broglie wavelengths 1nm and 4 nm respectively. If mass of X in nine times the mass of Y, the ratio of kinetic energies of X and Y would be
(a) 3 : 1 (b) 9 : 1 (c) 5 : 12 (d) 16 : 9

Q.3) An electron has principal quantum number 3. The number of its subshells and orbitals would be respectively
(a) 3 and 5 (b) 3 and 7 (c) 3 and 9 (d) 2 and 5

Q.4)Uncertainty in position of a n electron (mass = 9.1×10^{-28} g) moving with a velocity of 3×10^{4} cm/s accurate upto 0.001% will be (use h/4π) in uncertainty expression where h = 6.626×10^{-27} erg-second).

(a) 1.93 cm (b) 3.84 cm (c) 5.76 cm (d) 7.68 cm

Q.5) Which of the following is responsible to rule out the existence of definite paths or trajectories of electrons?

(a) Pauli's exclusion principle. (b) Heisenberg's uncertainty principle.

(c)Hund's rule of maximum multiplicity. (d) Aufbau principal

Q.6) Rutherford's α-particle dispersion experiment concludes

(a) all positive ions are deposited at small part

(b) all negative ions are deposited at small part

(c) proton moves around the electron(d) neutrons are charged particles.

Q.7) Which of the following is related with both wave nature and particle nature ?

(a) Interference (b) $E = mc^2$ (c) Diffraction (d) $E = h\nu$

Q.8) Which one of the following pairs is not correctly matched ?

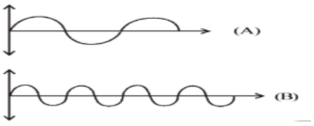
(a) Rutherford-Proton (b) J.J. Thomson-Electron

(c) J.H. Chadwick-Neutron (d) Bohr-Isotopes

Q.9)Maximum number of electrons in a subshell of an atom is determined by the following:

(a) $2l + 1$ (b) $4l - 2$ (c) $2n^2$ (d) $4l + 2$

Q.10)What will be the difference between electromagnetic radiation shown in A and B respectively ?



(a) wavelength only (b) frequency and wavelength

(c) wavelength, frequency and energy (d) energy

ASSERTION-REASON TYPE QUESTIONS:

In the following questions a statement of **Assertion** (A) followed by a statement of Reason (R) is given.

Choose the correct option out of the choices given below each question.

(a) **Assertion** is correct, reason is correct; reason is a correct explanation for **assertion**.

(b) **Assertion** is correct, reason is correct; reason is not a correct explanation for **assertion**

(c) **Assertion** is correct, reason is incorrect

(d) **Assertion** is incorrect, reason is correct.

Q.11)**Assertion** : The (n+l) rule is often used to determine the order of filling orbitals Orbitals with a lower (n+l) value are filled first. If two orbitals have the same (n+l) value, the one with the lower n value is filled first.

Reason : The Aufbau principle helps determine the electronic configuration of an atom, which is a representation of how electrons are arranged in orbitals.

Q.12)**Assertion** : Pauli's exclusion principle is the fundamental principle in quantum mechanics.

Reason : It applies to fermions, particles with half-integer spin like electrons and neutrons. It is not applicable to bosons, particles with integer spin like photons.

Q.13) **Assertion**: Electrons orbit the nucleus in a circular path with a fixed radius and energy.

Reason : Electrons can also radiateenergy while revolving in these orbits.

Q.14) **Assertion**: The effect of the uncertainty principle is significant only for the motion of microscopic particles

Reason : Although the energy of photons can cause significant effect on macroscopic particles too.

Q.15) **Assertion**: Each electron in an atom is described by a unique set of quantum numbers, defining its energy, shape, and spatial orientation.

Reason : Quantum numbers are quantities that characterize the possible states of the system.

knowledge

Fermions:are fundamental particles having half-integer spin (e.g., 1/2, 3/2) and obey the Pauli exclusion principle, like Electrons, quarks, protons, neutrons, and most composite particles.**Bosons** have integer spin values (e.g., 0, 1, 2). like Photons, gluons etc.Bosons can occupy the

ANSWERS:

MULTIPLE CHOICE QUESTIONS

1.c	2.d	3.c	4.a	5.c	6.a
7.d	8.d	9.a	10.c		

ASSERTIONREASON TYPE QUESTIONS

11.a	12.a	13.c	14.c	15.b	

SECTION- B (2 Marks)

Q.1)We don't we see a car moving as a wave on the road why?

(Hint :large mass makes wave character negligible : de Broglie)

Q.2)Why is the energy of 1s electron lower than 2s electron?

(Hint: force of attraction is inversely proportional to square root of distance from nucleus.)

Q.3)Which quantum number determines. (i) energy of electron (ii) Orientation of orbitals.

Ans.) (i) principal quantum number (ii) magnetic quantum number

Q.4 How orbit is different from orbital?

[Hint : orbit is well defined two dimensional path but orbital is not well defined path rather a region around nucleus having maximum probability of finding electron.

Q.5) Which among the following orbitals are degenerate?

$3dxy$, $4dxy$, $3dz^2$, $3dxz$, $4d_{x^2-y^2}$, $4dz^2$

[Hint::similar value of principal quantum number in this case]

SECTION- C (3 Marks)

Q.1)Why do atoms emit a line spectrum instead of a continuous spectrum, based on the concept of quantization?

[Hint : Due to quantization, electrons in an atom can only occupy discrete energy levels.line spectrum is actually discrete wavelengths produced due to difference in energy levels.]

Q.2)Calculate the uncertainty in the velocity of a wagon of mass 4000 kg whose position is known accurately of ±10m.

[Hint : use Heisenberg uncertainityformula ,$\Delta v = 1.3 \times 10^{-39}$ m sec^{-1}]

Q.3)2.36. 2×10^8 atoms of carbon are arranged side by side. Calculate the radius of carbon atom if the length of this arrangement is 2.4 cm.

[Hint :Diameter of each C-atom = (2.4 cm) / (2×10^8) = 1.2×10^{-8} cm

Radius of each C-atom = ½ x 1.2×10^{-8} cm = 6.0×10^{-9} cm = 0.06 nm]

Q.4)What designations are given to the orbitals having

(i) n=2,l=1 (ii) n=2,l=0 (iii) n=4,l=3 (iv) n=4,l=2 (v) n=1,l=1

Q.5**)**What is the wavelength of the light emitted when the electron in a hydrogen atom undergoes transition from the energy level with n = 4 to energy level n = 2? What is the colour corresponding to this wavelength? (Given R_H = 109678 cm^{-1})

[Hint :Use Balmer formula,

Wave number ($\bar{\upsilon}$) = $l/\lambda = R_H[1/n_1^2 - 1/n_2^2]$ cm^{-1}

= $109678[1/2^2 - 1/4^2]$ cm^{-1}

λ= 486 nm]

SECTION – D CASE BASED QUESTIONS (4 MARKS)

Passage - 1.Read the following passage carefully and give answers of the questions

The quantization of atomic energy levels and Niels Bohr’s atomic theory, pivotal in modern chemistry and physics, were rigorously explored in early 20th-century journals. In 1913, Bohr introduced his model in Philosophical Magazine (Series 6, Vol. 26, 1913), building on Planck’s quantum hypothesis (Annalen der Physik, 1900) and Rutherford’s nuclear atom (Philosophical Magazine, 1911). Bohr proposed that electrons orbit the nucleus in discrete, quantized energy levels, with transitions between these levels emitting or absorbing specific quanta of electromagnetic radiation, explaining hydrogen’s spectral lines with remarkable precision. His model integrated classical mechanics with quantum postulates, asserting that angular momentum of electrons in stable orbits is quantized ($L = n\hbar$, where n is an integer).

This was a breakthrough, as it resolved inconsistencies in classical electrodynamics, where orbiting electrons were expected to radiate energy continuously and collapse. Max Planck’s earlier work on blackbody radiation (Annalen der Physik, 1900) laid the foundation for quantization, introducing the concept of energy packets (quanta). Subsequent refinements came with Louis de Broglie’s wave-particle duality (ComptesRendus, 1923) and Erwin Schrödinger’s wave mechanics (Annalen der Physik, 1926), which generalized Bohr’s orbits into probabilistic electron clouds. Despite its limitations for multi-electron atoms, Bohr’s theory, as debated in journals like Zeitschrift für Physik and Physical Review through the 1920s, catalyzed quantum mechanics’ development, providing a framework for understanding atomic stability and spectral phenomena that remains foundational in chemical bonding and spectroscopy.

Q. 1)What experimental evidence did Bohr's model explain, as per the paragraph ?
Hint : spectral lines of Hydrogen
Q.2)How do electrons move according to Bohr's model?
Q.3)Calculate energy if 2mole of photons of radiation whose frequency is 5×10^{14}Hz
Hint : use $E = h\nu$
Q.4) **What is the energy in joules required to shift the electron of the hydrogen atom from the first Bohr orbit to the fifth Bohr orbit ? The ground state electronic energy is – 2.18×10^{-11} ergs.**
Hint : Energy of electron (E_n) = $(- 2.18 \times 10^{-11}\text{ergs}) / n^2 = (- 2.18 \times 10^{-18}\text{ J}) / n^2$
Energy in Bohr's 1st orbit (E_1) = $(- 2.18 \times 10^{-18}\text{ J}) / 1^2$
Energy in Bohr's 5th orbit (E_1) = $(- 2.18 \times 10^{-18}\text{ J}) / 5^2$
now find the difference in energies $E_5 - E_1$(Ans 2.09×10^{-18} J)

PASSAGE 2

Due to the Pauli exclusion principle, two electrons cannot share the same set of quantum numbers within the same system; therefore, there is room for only two electrons in each spatial orbital. One of these electrons must have, (for some chosen direction *z*) $m_s = ½$, and the other must have $m_s = −½$.

Hund's first rule states that the lowest energy atomic state is the one that maximizes the total spin quantum number for the electrons in the open subshell. The orbitals of the subshell are each occupied singly with electrons of parallel spin before double occupation occurs.

Two different physical explanations have been given for the increased stability of high multiplicity states. In the early days of quantum mechanics, it was proposed that electrons in different orbitals are further apart, so that electron–electron repulsion energy is reduced. However, accurate quantum-mechanical calculations (starting in the 1970s) have shown that the reason is that the electrons in singly occupied orbitals are less effectively screened or shielded from the nucleus, so that such orbitals contract and electron–nucleus attraction energy becomes greater in magnitude (or decreases algebraically).

Q.1)How does Hund's rule relates to electron spins and orbital degeneracy?
Q.2) How filling of electrons takes place in degenerate orbitals?
Q.3)Write the electronic configuration of Phosphorous (Z=.15) andsulphur (Z=16)elements.
Q.4)An atomic orbital has n = 3. What are the possible values of **l** and m_l ?

Ans.) For n = 3; l = 0, 1 and 2.
For l = 0 ; m_l = 0
For l = 1; m_l = +1, 0, -1
For l = 2 ; m_l = +2, +1,0, +1, + 2

SECTION - E (5 MARKS)

Q.1) a.) Calculate the total number of angular nodes and radial nodes present in the 3p orbital.

Hint : angular node = azimuthal quantum number

Radial node (n- l -1)

b.)What is the maximum number of emission lines when the excited electron of ahydrogen atom in n = 6 drops to the ground state?

Hint :The maximum no. of emission lines = [n(n–1)] /2

= [6(6–1)] / 2 =3 × 5 = 15

Q.2 a.)In Rutherford experiment, generally the thin foil of heavy atoms like gold, platinum etc. have been used to be bombarded by the α- particles. If a thin foil of light atoms like aluminium etc. is used, what difference would be observed from the above results?

Hint :**the obstruction offered to the path of the fast moving α-particles would be comparatively quite less. As a result, the number of α-particles deflected will be quite less and the particles which are deflected back will be negligible.**

b.)Arrange the following type of radiations in increasing order of wavelength:

(a) Radiation from microwave oven RA (b) Amber light from traffic signal

(c) Radiation from FM radio (d) Cosmic rays from outer space and

(e) X-rays

Hint :Cosmic rays < X-rays < radiation from microwave oven < amber light from traffic signal < radiation from FM radio

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CHAPTER 3

CLASSIFICATION OF ELEMENTS AND PERIODOCITY IN PROPERTIES

SUMMARY:

- **Mandeleev's Periodic Law**:- The properties of the elements are theperiodic function of their atomic masses.
- **Modern Periodic Law**: The physical and chemical properties of elements arethe periodic functions of their atomic numbers.

  Types of Elements: s-, p-, d- and f- blocks.

  MAIN GROUP ELEMENTS/ REPRESENTATIVE ELEMENTS:

  The s- and p- block elements are called main group elements or representative elements.
- **s- block elements:**

  Group-1 (Alkali metals) and Group-2 elements

  (Alkaline earth metals) which respectively have ns^1 and ns^2 outermost electronic configurations.
- **p- Block elements:**

  They belongs to group- 13 to 18.

  The outer most electronicconfiguration is $ns^2\ np^{1-6}$. He ($1s^2$) is a s- block element but is positioned with the group 18 elements ($ns^2\ np^6$) because it has completely filled valence shell and as a result, exhibits properties characteristic of other noble gases.
- **d- block elements (Transition elements) :**Theseare the elements of group 3 to 12having outer electronic configuration $(n-1)\ d^{1-10}\ ns^{1-2}$. Four transition series are 3d, 4d, 5d and 6d. The 6d- series is incomplete. Atomic radius generally decreases across a period and increases as we descend the group.
- f**-Block elements (Inner- transition elements)**

  Lanthanoidscharacterised by the filling of 4f-orbitals, are the elements following lanthanum from $_{58}Ce$ to $_{71}Lu$.

  Actinoids characterised by filling of 5f-orbitals, arethe elements following actinium from $_{70}{}^{Th}$ to $_{103}Lr$. Characteristic outer electronic configuration is $(n-2)\ f^{1-14}\ (n-1)\ d^{0-1}\ ns^2$
- **Noble Gases**: The gaseous elements of group 18 are called noble gases. Thegeneral outermost electronic configuration of noble gases (except He) is $ns^2\ np^6$.

  'He' exceptionally has $1s^2$ configuration. Thus the outermost shell of noble gases is completely filled.
- **PERIODICITY:** The repetition of similar properties after regular intervalsis called periodicity.
- **Cause of Periodicity**: The properties of elements are the periodic repetition ofsimilar electronic configuration of elements as the atomic number increases.
- **ATOMIC PROPERTIES**: The physical characteristics of the atom of anelement are called atomic properties. The properties such as atomic radius, ionic radius, ionisation energy, electro-negativity, electron affinity and valence etc., called atomic properties.
- **ATOMIC RADIUS-** The distance from the centre of the nucleus to theoutermost shell of the electrons in the atom of any element is called its atomic radius.
- **Periodicity**- (a) **In period-**Atomic radius of elements decreases from left toright in a period.

  In Group- Atomic radius of elements increases on moving top to bottom in a group.

- **COVALENT RADIUS-** Half the inter-nuclear distance between twosimilar atoms of any element which are covalently bonded to each other by a single covalent bond is called covalent radius.
- **VAN DER WAALS' RADIUS:** Half the inter-nuclear separation between twosimilar adjacent atoms belonging to the two neighbouring molecules of the same substance in the solid state is called the van der waals'radius of that atom.
- **METALLIC RADIUS:** Half the distance between the nuclei of the two adjacentmetal atoms in a close packed lattice of the metal is called its metallic radius.

  Van der Waals'radius > Metallic radius > Covalent radius
- **IONIC RADIUS:** The effective distance from the centre of the nucleus of anion up to which it has an influence on its electron cloud is called its ionic radius.
  A cation is smaller but the anion is larger than the parent atom. In case of iso-electronic species, the cation with greater positive charge has smaller radius but anion with greater negative charge has the larger radii.
- **IONISATION ENTHALPY:** The ionisation enthalpy is the molar enthalpychange accompanying the removal of an electron from a gaseous phase atom or
  ion in its ground state. Thus enthalpy change for the reaction; $M_{(g)} \rightarrow M^{+}_{(g)} + e^{-}$

  is the ionisation enthalpy of the element M. Like ionisation energies for successive ionisation, the successive ionisation enthalpy may also be named as
  2nd ionisation enthalpy ($\Delta_r H_2$), third ionisation enthalpy ($\Delta_r H_3$) etc. The term ionisation enthalpy is taken for the first ionisation enthalpy, ($\Delta_r H_1$) is expressed in kg mol^{-1} or in eV.
- **Periodicity:**
  Generally the ionisation enthalpies follow the order (there are few exceptions):
  ($\Delta_r H_1$) < ($\Delta_r H_2$) < ($\Delta_r H_3$)
  The ionisation enthalpy decreases on moving top to bottom in a group.
  The ionisation enthalpy increases on moving from left to right in a period.
- **ELECTRON GAIN ENTHALPY:** The electron gain enthalpy (($\Delta_{eg}H$) is themolar enthalpy change when an isolated gaseous atom or ion in its ground state adds an electron to form the corresponding anion thus the enthalpy change forthe reaction;

  $$X_{(g)} + e^{-} \rightarrow X^{-}_{(g)}$$

  is called the electron gain enthalpy (Δ_{eg} H) of the element X. The Δ_{eg} H may be positive or negative.
  The successive values for the addition of second, third etc. Electron, these are called second, third etc. electron gain enthalpies.
- **Periodicity:**
  In period- The electron gain enthalpy increases from left to right in a period.
  In group- The electron gain enthalpy decreases from top to bottom in a group.
- **ELECTRONEGATIVITY:** "The relative tendency of an atom in a moleculeto attract the shared pair of electrons towards itself is termed as its electro-negativity."
- **Periodicity:**
  In period- The electro-negativity increases from left to right in a period.
  In group- The electro-negativity decreases from top to bottom in a group.

- **VALENCE ELECTRONS:** The electrons present in outermost shell arecalled as valence electron. Because the electrons in the outermost shell determine the valency of an element.
- **VALENCY OF AN ELEMENT:** The number of hydrogen or halogen atom ordouble the number of oxygen atom, which combines with one atom of the element is taken as its valency. According to the electronic concept of valency,

  "The number of electrons which an atom loses or gains or shares with other atom to attain the noble gas configuration is termed as its valency."
- **Periodicity:**
  In period- The valency first increases then decreases from left to right in a period.
  In group- The valency remains constant from top to bottom in a group.
- **ELECTROPOSITIVE OR METALLIC CHARACTER:** The tendency ofan element to lose electrons and forms positive ions (cations) is called electropositive or metallic character. The elements having lower ionisation energies have higher tendency to lose electrons, thus they are electropositive or metallic in their behaviour.
  Alkali metals are the most highly electropositive elements.
- **Periodicity:** In period- The electropositive or metallic characters decreasesfrom left to right in a period.
  In group- The electropositive or metallic characters increases from top to bottom in a group.
- **ELECTRO-NEGATIVE OR NON- METALLIC CHARACTERS:** thetendency of an element to accept electrons to form an anion is called its non metallic or electronegative character. The elements having high electro-negativity have higher tendency to gain electrons and forms anion. So, the elements in the upper right hand portion of the periodic table are electro-negative or non-metallic in nature.
- **Periodicity:**
  In period- The electro-negative or non- metallic characters increases from left to right in a period.
  In group- The electro-negative or non-metallic characters decreases from top to bottom in a group.
- **REACTIVITY OF METALS:**
- **Periodicity:**
  In period- The tendency of an element to lose electrons decreases in a period. So the reactivityof metals decreases from left to right in a period.
  In group- The tendency of an element to lose electrons increases in a period. So the reactivityof metals increases from top to bottom in a group.
- **REACTIVITY OF NON- METALS:**
  In period- The tendency of an element to gain electrons increases in a period. So the reactivityof non-metals increases from left to right in a period.
  In group- The tendency of an element to gain electrons decreases in a group. So the reactivityof non-metals increases from top to bottom in a group.
- **SOLUBILITY OF ALKALI METALS CARBONATES AND BICARBONATES:**
  PERIODICITY IN GROUP: The solubility of alkali metal carbonates andbicarbonates in water increases down the group (From Lithium to Caesium).

- **SOLUBILITY OF ALKALINE EARTH METAL HYDROXIDES AND SULPHATES:**
  PERIODICITY IN GROUP: The solubility of alkaline earth metal hydroxideand sulphates in water increases down the group (From Beryllium to Barium).
- **BASIC STRENGTH OF ALKALINE EARTH METAL HYDROXIDES:**
  PERIODICITY IN GROUP: The basic strength of alkaline earth metalhydroxide in water increases down the group (From Beryllium to Barium), i.e.,

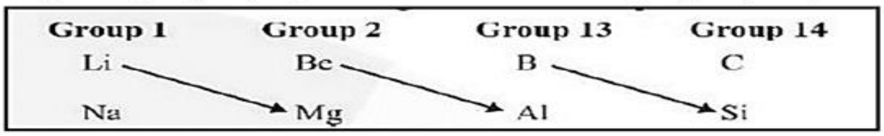
  $Be(OH)_2 < Mg(OH)_2 < Ca(OH)_2 < Sr(OH)_2 < Ba(OH)_2$

  $\longrightarrow$

  Basic strength increases
- **THERMAL STABILITY OF CARBONATES OF ALKALI AND ALKALINE EARTH METALS:**
  Except lithium carbonate, ($LiCO_3$), the carbonates of all other alkali metals are stable towards heat, i.e., carbonates of alkali metals (except $LiCO_3$) do not decompose on heating. $LiCO_3$ decomposes on heating to give lithium oxide .

  The carbonates of alkaline earth metals are relatively less stable. On heating, they decompose to give corresponding oxide and CO_2 gas. The decomposition temperature for alkaline earth metal carbonates increases as we go down the group.
- **Anomalous Properties of Second Period Elements**
  Their anomalous behaviour is attributed to their small size, large charge/radius ratio, high electro negativity, non- availability of d- orbitals in their valence shell. The first member of each group of p-Block elements displays greater ability to form pp-pp multiple bonds to itself (e.g. C=C, C≡C O=O, N≡N) and to other second period elements (e.g. C=O, C≡N, N=O) compared to subsequent member of the group.
  - ***DIAGONAL RELATIONSHIP***
    - It has been observed that some elements of the second period show similarities in properties with the elements of the third period placed diagonally to each other, though belonging to different groups. This similarity in properties of elements placed diagonally to each other is called diagonal relationship. • This is because diagonally situated elements have almost same size, ionization enthalpy, electronegativity etc.

    For example- lithium (of group 1) resembles magnesium (of group 2) and beryllium (of group 2) resembles aluminium (of group 13) and so as.



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Quesiton Bank

Section- A (1 Mark)

1. Set representing correct order of Ionisation potential will be :

(a) $Na^+ > Mg^{+2} > Ne$ (b) $Na^+ > Ne > Mg^{+2}$

(c) $Mg^{+2} > Na^+ > Ne$ (d) $Ne > Na^+ > Mg^{+2}$

2. As per the IUPAC element with atomic no 119 would be named as :

(a) Ununseptium (b) Ununennium (c) unniloctium(d) unnilseptium

3. . Electronic configuration $Ar[4s^2 3d^7]$ Element will belong to:

(a) Group 7 period 3 (b) Group 9 period 3

(c) Group 7 period 4 (d) Group 9 period 4

4. Periodicity in the properties of the elements depend on :

(a) No of electrons in neutral atom (b) No. of neutrons

(c) Sum of no. of protons and neutrons (d) Ratio of no. of neutrons to no of protons

5. Elements known as Eka Aluminium and Eka Silicon would be :

(a) Aluminium and Boron (b) Germanium and Gallium

(c) Gallium and Germanium (d) Boron and Aluminium

6. Second ionization enthalpy is always greater than the first ionisation enthalpy because of :

(a) Increase in no of electrons (b) Decrease in effective nuclear charge (c) Increase in size (d) Increase in effective nuclear charge

7. As per the Modern Periodic table reason for the periodicity is:

(a) Similar electronic configuration (b) Similar ionic size

(c) Same no of neutrons (d) Same neutron/proton ratio

8.Element with the following electronic configurations of an atom has the lowest ionisation enthalpy?

(a) $1s^2\ 2s^2\ 2p^3$(b) $1s^2\ 2s^2\ 2p^6\ 3s^1$

(c) $1s^2\ 2s^2\ 2p^6$(d) $1s^2\ 2s^2\ 2p^5$

9. Elements in the same group have:

(a) Same no. of protons (b) Same no. of valence electrons

(c) Same atomic no. (d) Same physical state

10.Element with the most metallic character will be :

(a) Na (b)Mg (c) Al (d) K

ASSERTION AND REASON TYPE QUESTIONS

In the following questions a statement of **Assertion** (A) followed by a statement of Reason (R) is given.

Choose the correct option out of the choices given below each question.

(a) **Assertion** is correct, reason is correct; reason is a correct explanation for **assertion**.

(b) **Assertion** is correct, reason is correct; reason is not a correct explanation for **assertion**

(c) **Assertion** is correct, reason is incorrect

(d) **Assertion** is incorrect, reason is correct.

11) **Assertion**- Electron gain enthalpy of Fluorine is more negative than that of Chlorine
Reason- Size of Fluorine atom is very small.

12) **Assertion**- He has highest ionization potential in the periodic table
Reason- He is the smallest element in the periodic table.
13) **Assertion**- A cation is always smaller than the parent atom.
Reason- Cation is formed by the loss of electron/s.
14) **Assertion** – Phosphorus belongs to 15th group and 3rd period in the modern periodic table.
Reason- Group no is decided by the no of shells and the period no. is decided by the no. of valence electrons.
15) **Assertion**- Fluorine shows -1 oxidation state .
Reason- Fluorine is the most electronegative element and it does not have d subshell.

KEY for MCQ

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
C	B	D	A	C	D	A	B	B	D	D	C	A	C	A

Section- B[02 Marks]

1. In terms of period and group where would you locate the element with Z=114
[Hint: Period 7th and Group 14th]
2. The species having same no. of electrons are known as ? Name the Noble gas species which are isoelectronic with the following ionic species: (i) F- (ii) K+
[Hint: (i) Ne (ii)Ar]
3. Account the reason that Cations are smaller and anions are larger in radii than their parent atoms.
[Hint: Cation having higher effective nuclear charge , Anions having lesser effective nuclear charge]
4. Element having more negative electron gain enthalpy would be :
(i)O or F (ii) F or Cl
[Hint: (i) F (ii) Cl
5. Predict the elements which have been named by:
(i) Lawrence Barkley laboratory (ii) Seaborg’s group
[Hint; Lr &Bk ,Sg]

Section- C [03 Marks]

1. Compare the Electron gain enthalpy and Electronegativity, Name the element with highest electron gain enthalpy and highest electronegativity.
[Hint: highest electron gain enthalpy element=Cl, Highest Electronegativity element=F]
2. How would you expect the first ionization enthalpies for two isotopes of the same element to be the same or different. Justify your answer
[Hint: First ionization enthalpy should be same as isotopes have same no,. of electrons]
3. Accounts for the following:
(i) F is more reactive than Cl though having less negative electron gain enthalpy

[Hint: low bond dissociation enthalpy of Fluorine make it more reactive]

(ii) First ionisation enthalpy of Na is lower but second ionisation enthalpy is higher as compared to the case of Mg. [Hint: based on electronic configuration in first case it has $3S^1$ but in second case more stable $2P^6$]

(iii) d block elements are called Transitional elements.

[Hint; elements are present in between s- block and p- block elements and they have partially filled d orbital in which electronic transitions may take place]

4. Predict the formula of the stable binary compounds that would be formed by the combination of the following pairs of elements.

(a) Lithium and oxygen (b) Magnisiumnd Nitrogen(c) Aluminium and iodine

(d) Silicon and Oxygen (e) Phosphorus and fluorine

(f) Element with atomic no. 71 and atomic no. 9

[Hint: (a) Li_2O (b) Mg_3N_2 (c) AlI_3 (d) SiO_2 (e) PF_3 or PF_5 (b) Magnesium and nitrogen (d) Silicon and oxygen (f) Element 71 and fluorine (f) The element with the atomic number 71 is Lutetium (Lu). It has valency 3. Hence LuF_3]

5. Give the name of property in which Li resemble with Mg, Also assign the reason [Hint: as per the text]

Section- D CASE BASED STUDY QUESTION [04 marks]

1. Read the passage carefully and answer the questions followed.

The s-Block Elements The elements of Group 1 (alkali metals) and Group 2 (alkaline earth metals) which have ns1and ns^2 outermost electronic configuration belong to the s-Block Elements. They are all reactive metals with low ionization enthalpies. They lose the outermost electron(s) readily to form 1+ ion (in the case of alkali metals) or 2+ ion (in the case of alkaline earth metals). The metallic character and the reactivity increase as we go down the group. Because of high reactivity they are never found pure in nature. The noble gases thus exhibit very low chemical reactivity. Preceding the noble gas family are two chemically important groups of non-metals. They are the halogens (Group 17) and the chalcogens (Group 16).The non-metallic character increases as we move from left to right across a period and metallic character increases as we go down. And the Basic strength of hydroxides also increases .

Account the reason for the following:

(i) group 1 elements known as Alkali metals and group 2 elements Alkaline earth metals . [Hint: Their oxides and hydroxides are basic in nature]

(ii) 16th elements are known as as Chalcogens and group 17th elements as Halogens. [Hint: Chalcogens means ore forming, Halogen means Sea salt producers]

(iii) Nature of chlorides of Group one elements is ionic

[Hint:due to their lower ionisation enthalpy they form cations easily]

(iv) Most basic Hydroxide of alkaline earth metals is $Ba(OH)_2$

[Hint: down the group atomic radius increases so bond dissociation enthalpy decreases]

Long Answer type questions [05 Marks]

1. The first ($\Delta_i H1$) and the second ($\Delta_i H$) ionization enthalpies (in kJ mol^{-1}) andthe ($\Delta_{eg}H$) electron gain enthalpy (in kJ mol^{-1}) of a few elements are given below:

Elements	$_iH$	$_iH$eg$H$
I	520	7300–60
II	419	3051–48
III	1681	3374–328
IV	1008	1846–295
V	2372	5251+48
VI	738	1451–40

Name the above elements likely to be :

(a) the least reactive element. (b) the most reactive metal.

(c) the most reactive non-metal. (d) the least reactive non-metal.

(e) the metal which can form a stable binary halide of the formula MX_2, (X=halogen).

[**Hint**:

(a) Element V is likely to be the least reactive element. This is because it has thehighest first ionization enthalpy ($\Delta_i H_1$) and a positive electron gain enthalpy (Δ_{eg}H).

(**b**) Element II is likely to be the most reactive metal as it has the lowest first ionization enthalpy ($\Delta_i H_1$) and a low negative electron gain enthalpy (Δ_{eg}H).

(**c**) Element III is likely to be the most reactive non–metal as it has a high first ionization enthalpy ($\Delta_i H_1$) and the highest negative electron gain enthalpy (Δ_{eg}H).

(d) Element V is likely to be the least reactive non–metal since it has a very high first ionization enthalpy ($\Delta_i H_2$) and a positive electron gain enthalpy (Δ_{eg}H).

(**e**) Element VI has a low negative electron gain enthalpy (Δ_{eg}H). Thus, it is a metal. Further, it has the lowest second ionization enthalpy ($\Delta_i H_2$). Hence, it can form a stable binary halide of the formula MX_2(X=halogen).

2.(a) What could be the reason for not considering Zn, Cd and Hg as transitional elements. [Hint; parent atom or their cations having fully filled d -orbital]

(b) Predict the first element and group no. for the following as per the periodic able

i. Identify the element with five electrons in the outer sub-shell.

ii. Identify an element that would tend to lose two electrons.

iii. Identify an element that would tend to gain two electrons

[**Hin**t: Cl(17th group),Mg(2nd group), O (16th group)

****

CHEMICAL BONDING AND MOLECULAR STRUCTURE

SOME BASIC CONCEPTS-

Chemical bonding refers to the attractive force that holds various constituents together in a molecule. There are three types of chemical bonds:

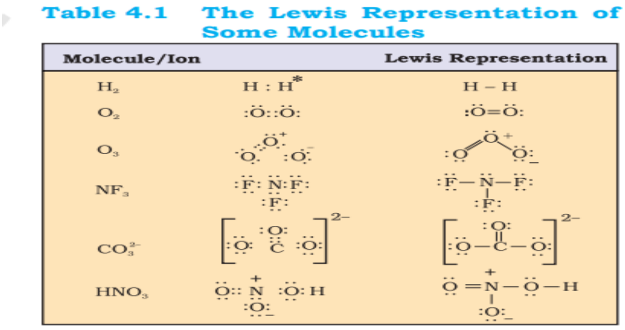
Ionic Bond: Involves a transfer of electrons from one atom to another.

Covalent Bond: Indicates the sharing of electrons between atoms.

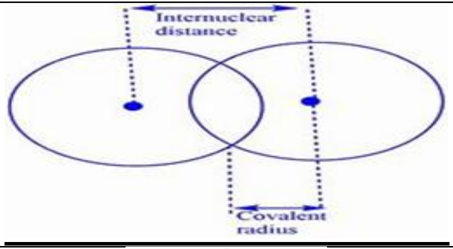
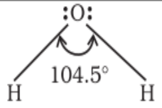
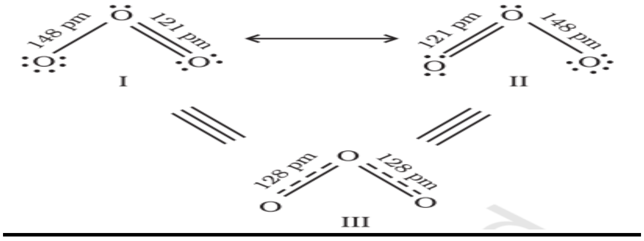
Coordinate Bond: Formed when one or more electrons are completely transferred from one atom to another.

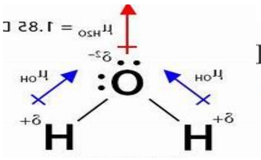
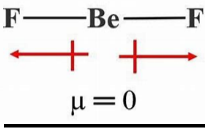
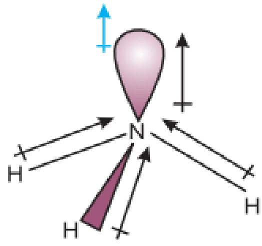
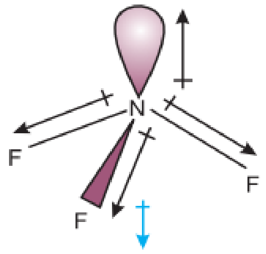
- Octet Rule- atoms can combine either by transfer of valence electrons from one atom to another (gaining or losing) or by sharing of valence electrons in order to have an octet in their valence shells.

Table 4.1 The Lewis Representation of Some Molecules



Bond Parameters

Bond Length- The covalent radius is measured approximately as the radius of an atom’s core which is in contact with the core of an adjacent atom in a bonded situation	
Bond Angle- The angle between the orbitals containing bonding electron pairs around the central atom in a molecule/complex ion.	
Bond Order- the number of bonds between the two atoms in a molecule.Isoelectronic molecules and ions have identical bond orders; for example, F_2 and O_2^{2-} have bond order 1. N_2, CO and NO^+ have bond order 3.	
Resonance-, a number of structures with similar energy, positions of nuclei, bonding and non- bonding pairs of electrons are taken as the canonical structures of the hybrid which describes the molecule accurately	

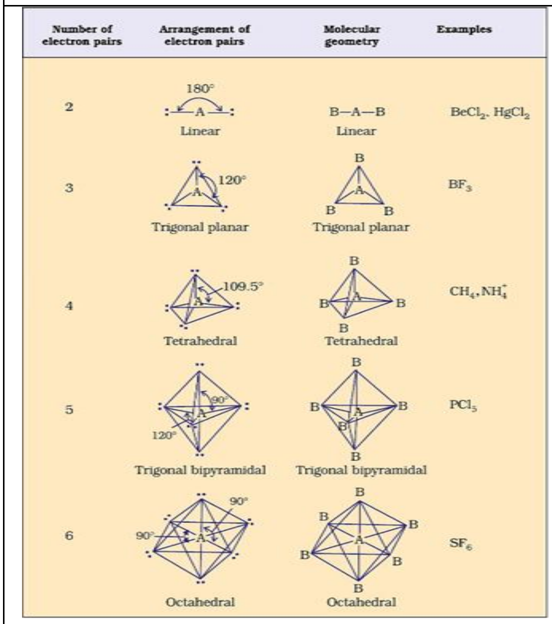
Dipole moment (μ) = charge (q) × distance of separation (d) Unit: Debye units (D).	• **For water-** **For BeF_2**   **For NH_3 and NF_3**  Resultant dipole moment in $NH_3 = 4.90 \times 10^{-30}$ C m  Resultant dipole moment in $NF_3 = 0.80 \times 10^{-30}$ C m
	•

THE VALENCE SHELL ELECTRON PAIR REPULSION (VSEPR) THEORY-

- The exact shape of molecule depends upon the number of electron pairs (bonded or non-bonded) around the central atoms.
- The electron pairs have a tendency to repel each other since they exist around the central atom and the electron clouds are negatively charged. Electron pairs try to take such position which can minimize the repulsion between them.
- The valence shell is taken as a sphere with the electron pairs placed at maximum distance.
- A multiple bond is treated as if it is a single electron pair and the electron pairs which constitute the bond as single pairs.
- Where two or more resonance structures can represent a molecule, the VSEPR theory is applicable to any such structure.
- The repulsive interaction of electron pairs decreases in the order: Lone pair (lp)-Lone pair (lp) > Lone pair (lp) – bond pair (bp) > Bond pair (bp) – Bond pair (bp)

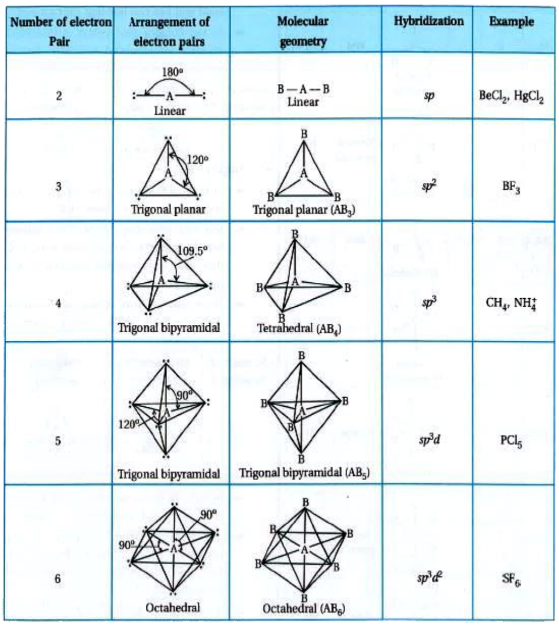
The Valence Shell Electron Pair Repulsion (VSEPR) Theory

Geometry of Molecules in which the Central Atom has No Lone Pair of Electrons



Number of electron pairs	Arrangement of electron pairs	Molecular geometry	Examples
2	Linear	B—A—B Linear	$BeCl_2$, $HgCl_2$
3	Trigonal planar	Trigonal planar	BF_3
4	Tetrahedral	Tetrahedral	CH_4, NH_4^+
5	Trigonal bipyramidal	Trigonal bipyramidal	PCl_5
6	Octahedral	Octahedral	SF_6

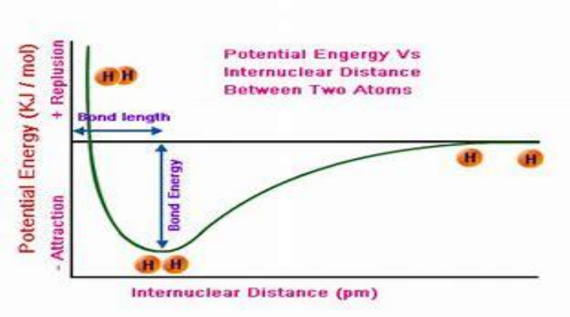
Shape (geometry) of Some Simple Molecules/Ions with Central Ions having One or More Lone Pairs of Electrons(E)



Number of electron Pair	Arrangement of electron pairs	Molecular geometry	Hybridization	Example
2	Linear	B—A—B Linear	sp	$BeCl_2$, $HgCl_2$
3	Trigonal planar	Trigonal planar (AB_3)	sp^2	BF_3
4	Trigonal bipyramidal	Tetrahedral (AB_4)	sp^3	CH_4, NH_4^+
5	Trigonal bipyramidal	Trigonal bipyramidal (AB_5)	sp^3d	PCl_5
6	Octahedral	Octahedral (AB_6)	sp^3d^2	SF_6

.

VALENCE BOND THEORY



- Consider two hydrogen atoms A and B approaching each other having nuclei NA andNB and electrons present in them are represented by eA and eB

PARTICIPANTS:Each hydrogen atom has:1 proton (in the nucleus)1 electronSo, when two hydrogen atoms approach each other, these are the main interactions:

1. Attractive Forces: Electron-Proton Attraction (between different atoms):
(i) The electron of one atom is attracted to the proton (nucleus) of the other atom.
(ii)This is the key attractive force that leads to bond formation.

2. Repulsive Forces:
Electron-Electron Repulsion:
(i) The electrons of the two atoms repel each other because they are both negatively charged.
(ii) Proton-Proton Repulsion:
The nuclei (protons) of the two atoms repel each other due to their positive charges.

Net Result: Balance of Forces-

- At larger distances, attractive forces dominate, pulling the atoms together.As the atoms get closer, repulsive forces become significantAt a certain optimal distance (~0.74 Å), the attraction and repulsion balance, forming a stable covalent bond.
- This is the bond length of H_2.
- The system reaches minimum potential energy, making the molecule stable

Types of Overlapping and Nature of Covalent Bonds

(i) Sigma (σ bond):	(ii) pi (π bond):
(a) Sigma bond is formed by the end to end (head-on) overlap of bonding orbitals along the inter-nuclear axis (b)The extent of overlap is more so, sigma bond is a strong bond. (c) It is the strongest covalent bond	(a) π bond is formed by the atomic orbitals when they overlap in such a way that their axes remain parallel to each other and perpendicular to the inter-nuclear axis. (b) The orbital formed is due to lateral overlapping or side wise overlapping. The extent of overlap is less, so pi bond is a weak bond. (c) It is weaker than a sigma bond

HYBRIDIZATION

The process of intermixing of the orbitals of slightly different energies so as to redistribute their energies, resulting in the formation of new set of orbitals of equivalent energies and shape.

Conditions for Hybridization:

- Orbitals should have almost equal energy.
- Promotion of electron may occur to achieve hybridization.
- Number of hybrid orbitals = number of atomic orbitals mixed.
- It involves only valence shell orbitals.

Important Notes:

- Only sigma bonds are considered for hybridization (π-bonds are not).
- d-orbital participation occurs only in elements of period 3 or higher.
- Hybridization helps explain molecular shape (VSEPR theory).

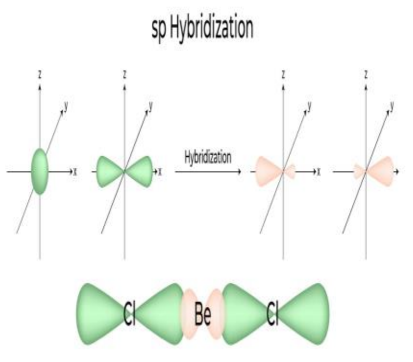
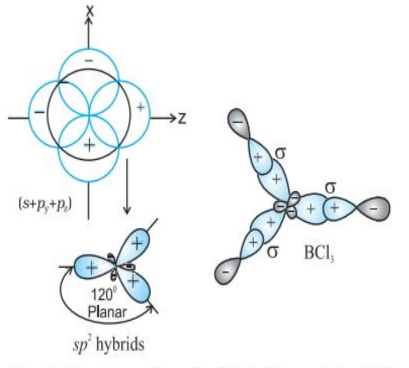
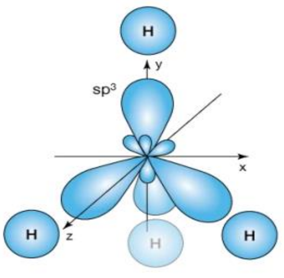
Steps to Determine Hybridization:

1.Count sigma bonds formed by the atom.

2. Add lone pairs on the atom.

3. Total = Number of hybrid orbitals = Type of hybridization.

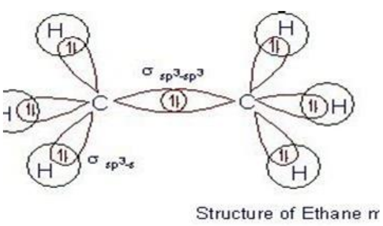
Example: In NH_3
Sigma bonds = 3 (with H)
Lone pairs = 1
Total = 4 → sp^3 hybridization

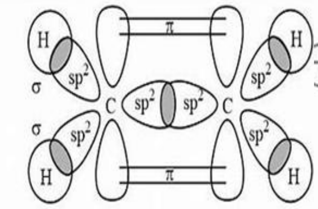
SP HYBRIDIZATION	SP^2 HYBRIDISATION	SP^3 HYBRIDISATION:
		

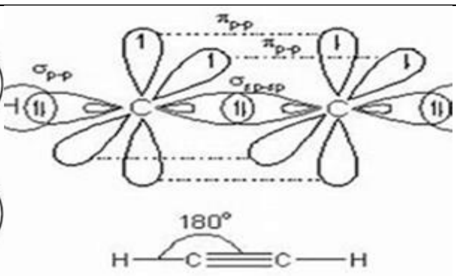
➢ Each of the hybrid orbitals formed has 50% s-character and 50%, p-character. ➢ This type of hybridisation is also known as diagonal hybridisation having linear structure & bond angle = 180° ➢ Example: $BeCl_2$, BeF_2, C_2H_2etc	➢ In this type, one s and two p-orbitals hybridise to form three equivalent sp2 hybrid orbitals in the same plane making an angle of 120° & trigonal planar shape. ➢ Each of the hybrid orbitals formed has 33.3 % s-character and 66.7 %, p-character.	➢ Each orbital has 25% s-character and 75% p-character. With tetrahedral structure & bond angle 109.5° The four sp3 orbitals are directed towards four corners of the tetrahedron. ➢ A compound having sp3 hybridisation is CH_4, CCl_4, NH_4+ etc.

EXAMPLES –(HYBRIDIZATION)

sp^3Hybridisation in C_2H_6 molecule sp^2Hybridisation in C_2H_4spHybridisationin C_2H_2



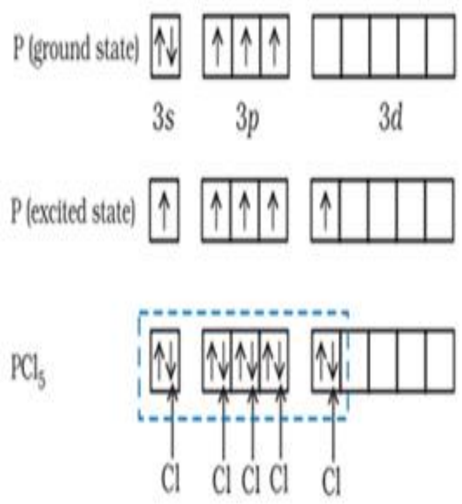


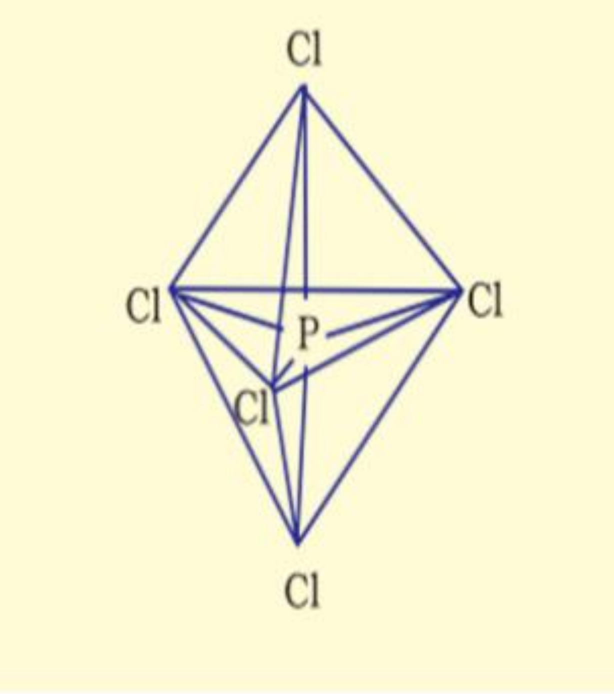


Hybridisation of Elements involving d Orbitals

Hybridization	Orbitals Involved	Geometry	No. of Electron Domains / Regions	Example Compounds
sp^3d	1s, 3p, 1d	Trigonalbipyramidal	5	PCl_5, SF_4
sp^3d^2	1s, 3p, 2d	Octahedral	6	SF_6, $[Fe(CN)_6]^{3-}$
dsp^2	1d, 1s, 2p	Square planar	4	$[Ni(CN)_4]^{2-}$, $PtCl_4^{2-}$
d^2sp^3	2d, 1s, 3p	Octahedral (inner orbital)	6	$[Co(NH_3)_6]^{3+}$, $[Fe(CN)_6]^{4-}$

Formation of PCl_5 (sp^3d hybridisation)





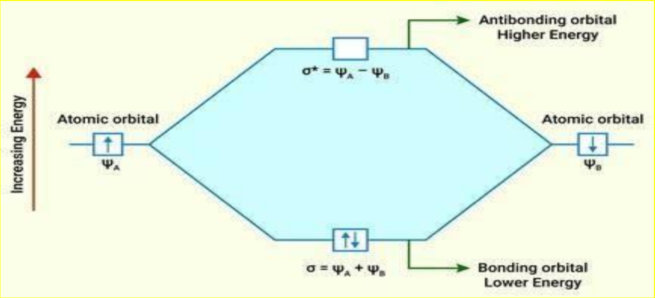
Molecular Orbital Theory-Molecular orbitals exist around the nuclei of molecules, just as atomic orbitals exist around the Nucleus of an atom

- The molecular orbitals are not the same as the atomic orbitals from which they are created.
- In the molecular orbital, the constituent atoms' valence electrons are thought to be moving under the effect of the nuclei of participating atoms.
- Like atomic orbitals in an isolated atom, molecule orbitals have varying energy levels.
- The shape of molecular orbitals is determined by the forms of the atomic orbitals that they are created from.
- Molecular orbitals, like atomic orbitals, are arranged in ascending energy order.In bond formation, the number of molecular orbitals formed equals the number of atomic orbitals merging.
- The Aufbau principle, Hund's rule, and Pauli's exclusion principle govern the filling of electrons in molecular orbitals, just as they do in atomic orbitals.

Formation of Molecular Orbitals Linear Combination of Atomic Orbitals (LCAO)-

The molecular orbitals are formed by LCAO (Linear combination of atomic orbitals) method, i.e., by addition or subtraction of wave functions of individual atoms,

- Mathematically, the formation of molecular orbitals -$\psi MO = \psi A + \psi B$,Therefore, the two molecular orbitalsσ and σ* are formed as :$\sigma = \psi A + \Psi b$, $\sigma^* = \psi A - \psi B$



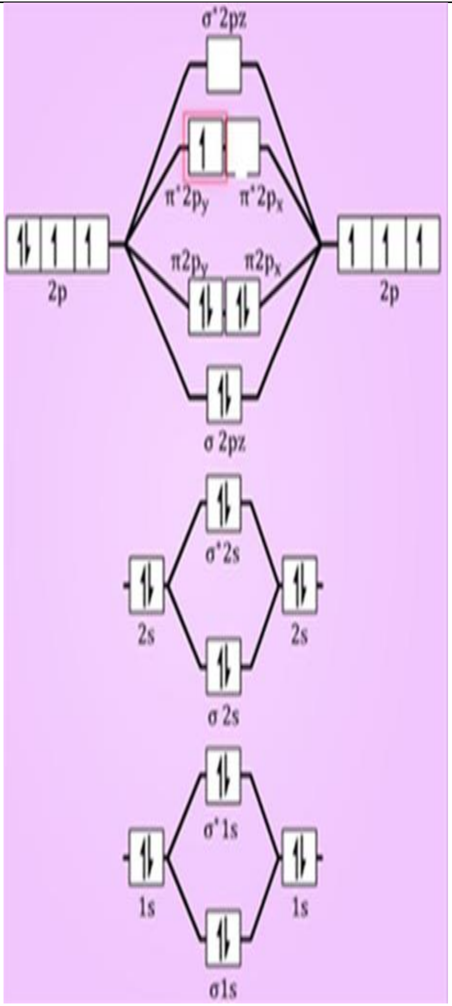
- Molecular orbital of lower energy is known as bonding molecular orbital and that of higher energy is known as anti-bonding molecular orbital.
- Aufbau rule, Pauli’s exclusion principle and Hund’s rule are all applicable for molecular orbitals.

Types of Molecular Orbital		
Bonding Molecular Orbitals (σ and π)	**Antibonding Molecular Orbitals (σ and π)****	**Non-Bonding Molecular Orbitals**
➢ Definition: Formed by constructive interference (in-phase combination) of atomic orbitals. ➢ Properties: Lower energy than the original atomic orbitals. Electron density is concentrated between the nuclei. Stabilizes the molecule. ➢ Types: σ (sigma) bond: Head-on overlap (e.g., s-s, s-p, or p-p along the inter-nuclear axis). π (pi) bond: Side-on overlap of p orbitals perpendicular to the inter-nuclear axis.	➢ Definition: Formed by destructive interference (out-of-phase combination) of atomic orbitals. ➢ Properties: Higher energy than the original atomic orbitals. Has a node between nuclei (zero electron density). Destabilizes the molecule. ➢ Types: σ* (sigma star): From out-of-phase head-on overlap. π* (pi star): From out-of-phase side-on overlap.	➢ Definition: Orbitals that do not overlap with other atomic orbitals. ➢ Properties: No bonding or antibonding character. Energy is similar to that of the original atomic orbital. Often associated with lone pairs (e.g., in H_2O, NH_3).

- The increasing order of energies of various molecular orbitals for O2 and F2 is given below: σ 1s <σ* 1s <σ 2s < σ* 2s <σ 2pz < (π 2px =π 2py) < (π∗2px = π∗ 2py) <σ* $2p_z$
- for molecules such as B2, C2, N2, etc. the increasing order of energies of various molecular orbitals is σ 1s <σ* 1s <σ 2s < σ* 2s < (π 2 px = π 2 py) <σ 2pz < (π∗2px =π∗2py) <σ* 2p
- Electronic Configuration and Molecular Behaviour-

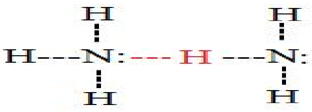
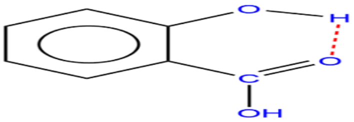
Stability of Molecules: If Nb is the number of electrons occupying bonding orbitals and Na the number occupying the antibonding orbitals, then

(i) the molecule is stable if Nb is greater than Na, and
(ii) the molecule is unstable if Nb is less than Na.

Bond order	**Nature of the bond**	
-Bond order (b.o.) = ½ (Nb–Na) -A positive bond order (i.e., Nb> Na) means a stable molecule while a negative (i.e., Nb= Na) bond order means an unstablemolecule.	➢ Integral bond order values of 1, 2 or 3correspond to single, double or triple bonds respectively **Bond-length** ➢ The bond lengthdecreases as bond order increases. **Magnetic nature** ➢ If all the molecular orbitals in a molecule are doubly occupied, the substance is diamagnetic (repelled by magnetic field). ➢ However if one ormore molecular orbitals are singly occupied it is paramagnetic (attracted by magnetic field)	

BONDING IN SOME HOMONUCLEAR DIATOMIC MOLECULES			
Hydrogen Molecule H_2) Atomic configuration: $1s^1$ for each H atom. Bonding: Combination of two 1s atomic orbitals forms: One bonding molecular orbital ($\sigma 1s$) One antibonding molecular orbital ($\sigma^* 1s$) Electron configuration: $(\sigma 1s)^2$ Bond order = ½ (2 - 0) =1 Bond type: Single covalent bond	**Helium (He)** Atomic number of He = 2 → $1s^2$ Total electrons in He_2 = 2 × 2 = 4 electrons Molecular orbital (MO) configuration: $(\sigma 1s)^2 (\sigma 1s^*)^2$ Bonding electrons = 2 ($\sigma 1s$) Antibonding electrons = 2 ($\sigma 1s^*$) Bond order = (Bonding - Antibonding)/2 = (2 - 2)/2 = 0 Conclusion: He_2 does not exist (unstable), because bond order is zero	**Carbon (C_2)** Atomic number of C = 6 → $1s^2 2s^2 2p^2$ Total electrons in C_2 = 2 × 6 = 12 electrons MO configuration (for $Z \leq 7$): $(\sigma 1s)^2 (\sigma 1s^*)^2 (\sigma 2s)^2 (\sigma 2s^*)^2 (\pi 2p\_x = \pi 2p\_y)^4$ Bonding electrons: 2 ($\sigma 2s$), 4 ($\pi 2p$) = 6 Antibonding electrons: 2 ($\sigma 2s^*$) = 2 Bond order = (6 - 2)/2 = 2 Conclusion: C_2 has a double bond, and it's diamagnetic due to all paired electrons.	**Oxygen Molecule (O_2)** Atomic configuration: $1s^2 2s^2 2p^4$ for each O atom MO diagram order (from O_2 onward): $\sigma 1s < \sigma 1s < \sigma 2s < \sigma 2s < \sigma 2p < \pi 2p < \pi 2p < \sigma 2p$ Electron configuration (total 16 e^-): $(\sigma 1s)^2 (\sigma 1s)^2 (\sigma 2s)^2 (\sigma 2s)^2 (\sigma 2p)^2 (\pi 2p)^4 (\pi^* 2p)^2$ Bond order = ½ (10 bonding - 6 antibonding) = 2 Bond type: Double bond Special feature: Paramagnetic due to two unpaired electrons in π* orbitals.

HYDROGEN BONDING:

Hydrogen bonding is a type of attractive interaction between a hydrogen atom covalently bonded to a highly electronegative atom (like F, O, or N) and another electronegative atom.	
Intermolecular Hydrogen Bonding: Occurs between molecules. Common in water (H_2O), where hydrogen bonds form between different water molecules. Responsible for properties like high boiling point and surface tension of water. Example: Water (H_2O), ethanol (C_2H_5OH), ammonia (NH_3). 	**Intramolecular Hydrogen Bonding:** Occurs within the same molecule between two functional groups. Often seen in organic compounds like ortho-nitrophenol. Can affect the physical and chemical properties such as boiling point and solubility. Example: Ortho-nitrophenol, salicylic acid.  Salicylic acid

QUESITON BANK

SECTION-A (1 MARKS)

Q1**.** The outer orbitals of C in ethene molecule can be considered to be hybridized to give three equivalent sp^2 orbitals. The total number of sigma (s) and pi (p) bonds in ethene molecule is

(a) 1 sigma (s) and 2 pi (p) bonds
(b) 3 sigma (s) and 2 pi (p) bonds
(c) 4 sigma (s) and 1 pi (p) bonds
(d) 5 sigma (s) and 1 pi (p) bonds.

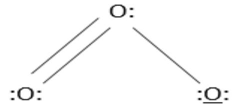
Q2.The correct order of hybridization of the central atom in the following species: NH_3, $[PtCl_4]^{2-}$, PCl_5 and BCl_3 is

(a) dsp^2, dsp^3, sp^2 and sp^3
(b) sp^3, dsp^2, sp^3d, sp^2
(c) dsp^2, sp^2, sp^3, dsp^3
(d) dsp^2, sp^3, sp^2, dsp^3

Q3.Which one of the following arrangements of molecules is correct on the basis of their dipole moments?

(a) $BF_3 > NF_3 > NH_3$ (b) $NF_3 > BF_3 > NH_3$(c) $NH_3 > BF_3 > NF_3$
(d) $NH_3 > NF_3 > BF_3$

Q4.Calculate the formal charge of the middle atom in the ozone molecule.



(a) 1 (b) -1 (c) 0 (d) -2

Q5.Which of the following statements is not correct?

(a) NaCl being an ionic compound is a good conductor of electricity in the solid state.
(b) In canonical structures there is a difference in the arrangement of atoms.
(c) Hybrid orbitals form stronger bonds than pure orbitals.
(d) VSEPR Theory can explain the square planar geometry of XeF_4.

Q6.Which of the following statements is incorrect in relation to ionization enthalpy?

(a)ionization enthalpy increases for each successive electron.
(b)The greatest increase in ionization enthalpy is experienced on removal of electrons from core noble gas configuration.
(c)End of valence electrons is marked by a big jump in ionization enthalpy.
(d)Removal of electron from orbitals bearing lower n value is easier than from outer orbital

Q7.Using VSEPR theory, predict the species which has square pyramidal shape

(a) $SnCl_2$ (b) CCl_4 (c) SO_3 (d) BrF_5

Q8. Sp^3d^2 hybridization is present in $[Co(NH_3)_6]^{3+}$, Find its geometry.

(a) tetrahedral geometry
(b)square planar geometry
(c)tetragonal geometry
(d)octahedral geometry

Q9.The charge/size ratio of a cation determines its polarizing power. Which one of the following sequences represents the increasing order of the polarizing order of the polarizing power of the cationic species, K^+, Ca^{++}, Mg^{2+}, Be^{2+}?

(a) $Ca^{2+} < Mg^{2+} < Be^+ < K^+$
(b) $Mg^{2+} < Be^{2+} < K^+ < Ca^{2+}$
(c) $Be^{2+} < K^+ < Ca^{2+} < Mg^{2+}$
(d) $K^+ < Ca^{2+} < Mg^{2+} < Be^2$

Q10.Which of the following statements explains why silicon dioxide has a high melting point?

(a) It has a giant ionic structure with strong electrostatic attraction between ions.
(b)It has a giant covalent structure with strong covalent bonds between atoms.

(c)It has a simple molecular structure with weak forces between molecules.

(d) It has a giant metallic structure with a strong attraction between positive ions and the sea of electron

In these questions (Q11-Q15), a statement of assertion followed by a statement of reason is given. Choose the correct answer out of the following choices.

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

Q11. Assertion (A): A molecule of ammonia has a pyramidal shape**.**

Reason (R): The nitrogen atom in ammonia is sp^3 hybridized and has a lone pair of electrons.

Q12.Assertion (A): CO_2 is a linear molecule.

Reason (R**):** The central atom in CO_2 undergoes sp^3 hybridization.

Q13. Assertion : Lone pair-lone pair repulsive interactions are greater than lone pair - bond pair and bond pair-bond pair interactions.

Reason : The space occupied by lone pair electrons is more as compared to bond pair electrons.

Q14.Assertion : The lesser the lattice enthalpy more stable is the ionic compound.

Reason : The lattice enthalpy is greater, for ions of highest charge and smaller radii

Q15.Assertion: The dipole moment helps to predict whether a molecule is polar or non polar.

Reason: The dipole moment helps to predict the geometry of molecules –

QUESTION NO	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	13	Q14	Q15
ANSWER	d	b	d	a	a	d	d	d	a	B	a	c	a	d	b

Answer key

SECTION- B (2 MARKS)

Q1.(a)o-nitrophenol is steam volatile while p-nitrophenol is not. Why?

Hint-hydrogen bonding.

(b)Which out of CH_3F and CH_3Cl has a higher dipole moment and why?

Hint-Dipole Moment (μ) = Charge (Q) × distance of separation (r). so CH_3Cl

Q2.In the molecule NH_3, the bond angles are 107° instead of 109.5°. Analyze this deviation in light of Valence Bond Theory and electron pair repulsion.

Hint-refer valence bond theory and VSEPR theory .

Q3. If a new molecule with the formula AX_2E_3 were discovered, how would you use VSEPR theory to determine its 3D geometry? What challenges might arise in modeling such a molecule?

Hint-refer VSEPR theory

Q4The bond length in HCl is 1.27 Å and its dipole moment is 1.03 D. Calculate the percentage ionic character.

Ans .percentage ionic character= theoretical value of dipole moment / observed dipole moment ×100=16.83%

Q5Can a molecule be polar even if it has only non-polar bonds? Justify your answer with an example or counterexample.

Hint-refer dipole moment

SECTION- C(3 MARKS)

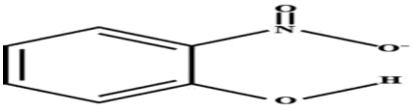
Q1(a) Why are resonance structures necessary to describe the bonding in molecules like benzene, carbonate ion, or nitrate ion?

Hint-a single Lewis structure fails to explain the bonding in a molecule/polyatomic ion due to the presence of partial charges and fractional bonds in it

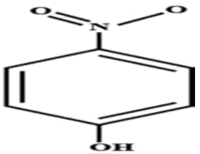
(b) Given two molecules—SF_6 and NH_3—evaluate which one better conforms to the octet rule and justify your answer.

Hint-refer octet rule

(c) Which of the two compounds will have intermolecular hydrogen bonding and which compound is expected to show intramolecular hydrogen bonding



(I)



(II)

Hint-I)IntramolecularII)intermolecular hydrogen bonding.

Q2.Elements X, Y and Z have 4, 5 and 7 valence electrons respectively,

(a) Write the molecular formula of the compounds formed by these elements individually with hydrogen,

HINT-Formula: XH_4,YH_3,ZH,Dipole moment depends on:Polarity of the bond (electronegativity difference)Molecular geometry

(b) Which of these compounds will have the highest dipole moment?

Q3. Give reasons for the following: ‘

(a) Covalent bonds are directional bonds while ionic bonds are non- directional.

HINT-orientation of a covalent bond depend on the direction of the overlapping atomic orbitals

(b) Water molecule has bent structure whereas carbon dioxide molecule is linear.

Hint-refer dipole moment

(c) Ethyne molecule is linear.

Hint-hybridization and overlapping of orbitals

Q4suppose a new compound XY_3 is discovered. It has a trigonal planar structure and all X–Y bond lengths are equal. What can you infer about:

a)The hybridization of X?

Ans -The central atom X is sp^2 hybridized.

b)The presence or absence of lone pairs on X?

ans-X has no lone pairs

c)The bond type and polarity?

Ans-covalent,Bond polarity: Each X–Y bond is polar (if X ≠ Y), but the overall molecule is nonpolar due to symmetry

Q5a)Why does the bond order of O_2^- decrease compared to O_2? What does this imply about the stability and bond length of O_2^-?

Hint: Use Molecular Orbital Theory

b) Can a molecule with an odd number of electrons ever be diamagnetic? Explain why or why not.

Hint- It will always be paramagnetic.

c)If molecular orbitals are created by combining five atomic orbitals from atom A and five atomic orbitals from atom B combine, how many molecular orbitals will result?

Hint-refer Molecular Orbital Theory

SECTION – D CASE STUDY BASED QUESTIONS (4 MARKS)

Read the passage carefully and answer the questions.

Q1.A chemistry lab investigates the physical properties (melting point, solubility in water, and electrical conductivity) of three substances: sodium chloride (NaCl), glucose ($C_6H_{12}O_6$), and magnesium oxide (MgO). They observe that:

- NaCl and MgO conduct electricity in molten form but not as solids.
- Glucose does not conduct electricity in any form.
- NaCl and MgO have high melting points, while glucose melts at a lower temperature.

They conclude that NaCl and MgO are ionic compounds, while glucose is covalent.

i)An ionic bond is formed between ___________

(a) two metal atoms (b) one metal atom and one non-metal atom

(c) two non-metal atoms (d) one metal atom and one metalloid atom

Ans-(b)

ii)Why does glucose not conduct electricity in any state?

Hint-no free ions

iii)Compare the melting points of MgO and NaCl. Why is MgO's melting point higher?

Hint-charge on ions

iv)How does temperature affect the conductivity of ionic and covalent compounds?

Hint-*For ionic compounds: Higher temperature increases ion mobility, thus conductivity increases.*

For covalent compounds: Unless they ionize at higher temperatures, their conductivity remains low.

Q2A group of students is analyzing the bonding in ethene (C_2H_4), ethyne (C_2H_2), and methane (CH_4) using the concept of hybridization. They discover:

- In methane, carbon forms four sigma bonds using sp^3 hybrid orbitals.
- In ethene, carbon forms three sigma bonds using sp^2 hybrid orbitals, and a π bond using unhybridized p-orbitals.
- In ethyne, carbon uses sp hybrid orbitals and forms two π bonds due to two unhybridized p-orbitals.

i)How does hybridization affect the acidity of terminal alkynes?

Hint-percentage s character .

ii)Compare the bond angles in CH_4, C_2H_4, and C_2H_2 and explain the reasons.

Hint-considerhybridization and electron pair repulsion.

iii)Why is ethyne a linear molecule while ethene is planar?

Hint-refer hybridization

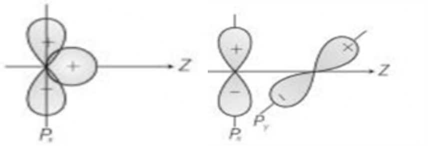
iv)In the compound HCN, identify the hybridization of carbon and explain your reasoning.

Hint-Carbon hybridization in HCN: sp

Reason: Carbon forms two sigma bonds (one with H, one with N) → 2 regions of electron density → sp hybridized.

SECTION - E (5 MARKS)

Q1) a) Why does type of overlap given in the following figure not result in bondformation



Hint-refer VBT and Hybridization

b) Account for the following: (i) Water is a liquid while H_2S is a gas

Hint-hydrogen bonding

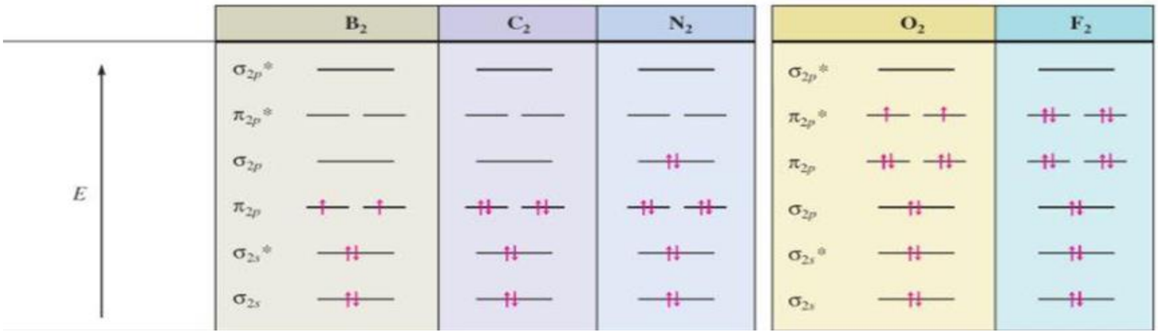
(ii) NH3 has higher boiling point than PH_3.

Hint-hydrogen bonding

c) Why are the axial bonds longer a compared to equatorial bonds?

Hint-Stronger repulsion from equatorial bonds

Q2. Table shows the molecular orbital occupancy and molecular properties for B_2, C_2, N_2, O_2, F_2,.Observe this figure and answer the questions based on this diagram and related studied concepts. MO occupancy and molecular properties for B_2 through N_2



Molecule	MO Configuration (valence electrons only)	Bond Order	Magnetic Behavior
B_2	$(\sigma 2s)^2 (\sigma^* 2s)^2 (\pi 2p)^2$	1	Paramagnetic (2 unpaired e^-)
C_2	$(\sigma 2s)^2 (\sigma^* 2s)^2 (\pi 2p)^4$	2	Diamagnetic (all paired)
N_2	$(\sigma 2s)^2 (\sigma^* 2s)^2 (\pi 2p)^4 (\sigma 2p)^2$	3	Diamagnetic
O_2	$(\sigma 2s)^2 (\sigma 2s)^2 (\sigma 2p)^2 (\pi 2p)^4 (\pi 2p)^2$	2	Paramagnetic (2 unpaired e^-)
F_2	$(\sigma 2s)^2 (\sigma 2s)^2 (\sigma 2p)^2 (\pi 2p)^4 (\pi 2p)^4$	1	Diamagnetic

a)Why is Ne_2 not formed according to M.O. theory?

Hint-bond order

b) Arrange B_2, C_2, N_2, O_2, F_2 in increasing order of bond length.

Hint-bond order

(c) On the basis of fig and table given above ,Why F_2 diamagnetic where as O_2 paramagnetic?

Hint -unpaired electron ,refer molecular orbital theory

d) Consider the table given above and answer ,Why does bond enthalpy of N_2 is higher than O_2?

Hint-triple bond

e) Why is F_2 more reactive than O_2 ?

Hint**-higher electronegativity.**

SOME IMPORTANT LINKS-

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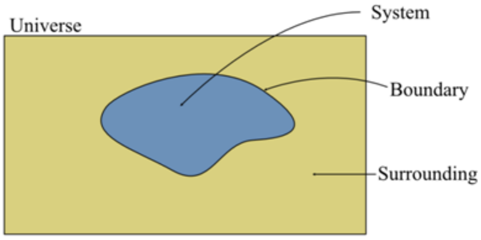
https://diksha.gov.in/play/content/do_31307096763145420811035

https://diksha.gov.in/play/content/do_31307124765334732811346

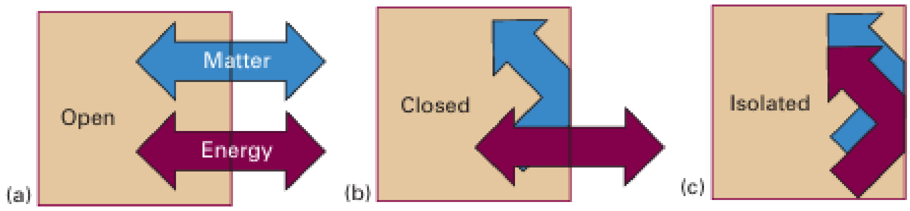
THERMODYNAMIC
SUMMARY

- **System** refers to the specific part of the universe that is under observation or study.
- **Surroundings** include everything in the universe **outside the system**.
- **Boundary** is the real or imaginary surface that separates the **system** from its **surroundings**.
- universe = system + surroundings



TYPES OF THE SYSTEM

(i) Open system: Energy and matter both can be exchanged with the surroundings.
(ii) Closed system: Only energy can be exchanged with the surroundings.
(iii) Isolated system: Neither energy nor matter can be exchanged with the surroundings.



STATE OF SYSTEM

State functions or State variables	Path Functions
(a) Thermodynamic variables whose value depends only on the initial and final states of the system.	(a) Thermodynamic variables whose value depends upon the path followed by system.
(b) Example: Temperature, pressure, volume, density, enthalpy, internal energy, entropy, gibbs free energy etc.	(b) Example: work(w) and heat(q)

THERMODYNAMIC PROPERTIES

Extensive Properties	Intensive Properties
(i) Property whose value depends on the quantity or size of matter present in the system.	(i) Properties which do not depend on the quantity or size of matter present.
(ii) Example: mass, volume, internal energy, enthalpy, heat capacity, etc.	(ii) Example temperature, density, pressure, molar volume, molar heat capacity, molar enthalpy etc.

Note: Molar property like molar volume, molar heat capacity, molar enthalpy is an intensive property because a molar property is an extensive property (like heat capacity or volume) divided by the number of moles, making it independent of the amount of substance present.

THERMODYNAMIC PROCESS

Process	Condition
Isothermal process	Temperature remains constant, i.e. (ΔT=0).
Isochoric process	Volume remains constant, i.e. (ΔV=0).
Isobaric process	Pressure remains constant, i.e. (Δp)= 0.
Adiabatic process	Heat is not exchanged by system with the surroundings, i.e. q=0
Endothermic Process	energy is acquired from its surroundings as heat.
Exothermic process	releases energy as heat into its surroundings.

INTERNAL ENERGY, WORK AND HEAT

- Internal energy(U): (i) The total energy contained within a substance. It is a sum of many types of energies like vibrational energy, translational energy, etc.
- (ii) Absolute internal energy is indeterminable, but its change is measurable, determined by $\Delta U = U_f - U_i$
- Work(w): It is an ordered forces of energy transfer due to the action of macroscopic forces. Unit is Joule
- Heat(q): Exchange of energy, which is a result of temperature difference is called heat. Unit is Joule.

FIRST LAW OF THERMODYNAMICS

- Defination: Energy cannot be created or destroyed, only transformed from one form to another.
- Expression: $\Delta U = q + W$
- Sign Convention:

(i) q is positive = heat is supplied to the system
(ii) q is negative = heat is lost by the system
(iii) W is positive = work done on the system
(iv) W is negative = work done by the system

EXPRESSIONS FOR WORK DONE UNDER VARIOUS CONDITIONS

(a) Work done against constant pressure p under isothermal irreversible change	$w = -p_{ext}(V_f - V_i)$
(b) Work done in reversible expansion under isothermal conditions.	$q = w = -2.303\text{nRTlog}\frac{V_f}{V_i}$
(c) Expansion of a gas in vacuum ($p_{ex} = 0$) is called free expansion.	w = zero, from equation $w = -p_{ext}(V_f - V_i)$; $\Delta U = q$
(d) For adiabatic change,	q = 0 ; $\Delta U = w_{ad}$
(e) Work done at constant volume($\Delta V = 0$)	w = 0 ; $\Delta U = q_v$

ENTHALPY:

- The sum of the energy stored in the system and the ability of the system to do work. Expression: $H = U + pV$
- During a process we can estimate the change in enthalpy as $\Delta H = \Delta U + p\Delta V$

- For ideal gas equation, $p\Delta V = \Delta n_g RT$; $\Delta H = \Delta U + \Delta n_g RT$
- Sign Convention: (i) ΔH is negative for exothermic reactions; (ii) ΔH is positive for endothermic reactions

HEAT CAPACITY

- The amount of heat required to raise the temperature of a system by 1°C.
- Formula: $q = C \times \Delta T$; Here, C is heat capacity.
- Molar Heat Capacity: It is the heat capacity of 1 mole of substance of the system.
- Specific Heat Capacity: (i) It is the heat capacity of 1 g of substance of the system. (ii) Formula: $q = c \times \mathbf{m} \times \Delta T$; Here, c is specific heat of the substance, m is mass of substance, and ΔT is temperature change
- At constant volume, the heat capacity, C is denoted by C_v and at constant pressure, this is denoted by C_p.
-

At constant volume as $q_v = C_v\Delta T = \Delta U$	At constant pressure as $q_p = C_p\Delta T = \Delta H$

- Relationship between C_p and C_v for 1 mol of an Ideal Gas is $Cp – C_v = R$ {Note: The derivation is not provided here, but it is asked in the exam. It can be found on page 145 of the NCERT reprint (2025–2026 edition)}

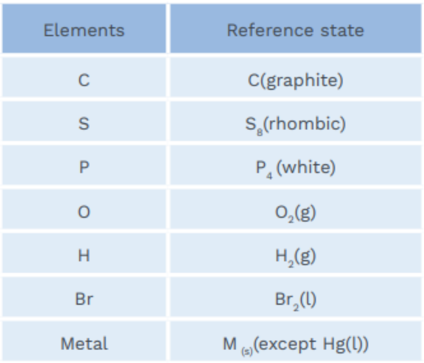
THERMOCHEMISTRY

- Enthalpy Change or Reaction Enthalpy ($\Delta_r H$): The enthalpy change accompanying a reaction is called the reaction enthalpy. The enthalpy change of a chemical reaction is given by:
- $\Delta_r H$ = (sum of enthalpies of products) – (sum of enthalpies of reactants)
- $\Delta_r H = \Sigma a_i H_{products} - \Sigma b_i H_{reactants}$; Here, $\sum$ (sigma) is used for summation and a_i and b_i are the stoichiometric coefficient of balanced chemical equation.
- Standard enthalpy of reaction: The standard enthalpy of reaction is the enthalpy change for a reaction when all the participating substances are in their standard states.
- The standard state of a substance at a specified temperature is its pure form at 1 bar.

Enthalpy Changes during Phase Transformations

Enthalpy of fusion($\Delta_{fu}H^o$)	Standard enthalpy of vaporization ($\Delta_{vap}H^o$)	Standard enthalpy of sublimation, $\Delta_{sub}H^o$
Enthalpy change that accompanies melting of one mole of a solid substance in standard state.	Amount of heat required to vaporize one mole of a liquid at constant temperature and under standard pressure (1bar).	Enthalpy when one mole of a solid substance sublimes at a constant temperature and under standard pressure (1bar).

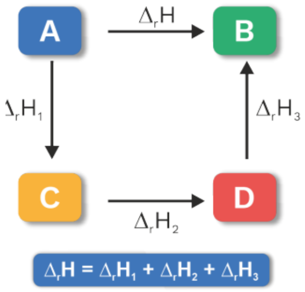
- Standard Enthalpy of Formation($\Delta_f H^o$): The standard enthalpy change for the formation of one mole of a compound from its elements reference states.



Elements	Reference state
C	C(graphite)
S	S_8(rhombic)
P	P_4 (white)
O	O_2(g)
H	H_2(g)
Br	Br_2(l)
Metal	$M_{(s)}$(except Hg(l))

Hess's Law of Constant Heat Summation

- A balanced chemical equation together with the value of its Δr H is called a thermochemical equation. Example: C(graphite,s) + O_2(g) → CO_2(g) $\Delta rH^o = -393.5$ kJ mol^{-1}
- Coefficients in a thermochemical equation represent moles, not molecules, of reactants and products.
- The value of Δ_rH^o corresponds to the moles in the equation and is expressed in kJ mol^{-1}.
- Defination: Enthalpy change for a reaction is the same whether it occurs in one step or in a series of steps.



For example: $C(s) + 1/2O_2\,(g) \rightarrow CO(g)\quad \Delta_rH^0 = -110.5\ kJmol^{-1}$ ......(1)

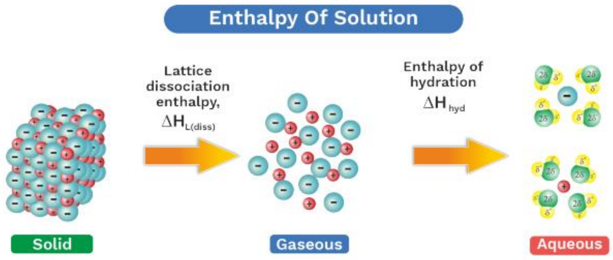
$CO(g) + 1/2O_2\,(g) \rightarrow CO_2(g)\quad \Delta_rH^0 = -283.0\ kJmol^{-1}$ ....(2)

Combine equation 1 and 2

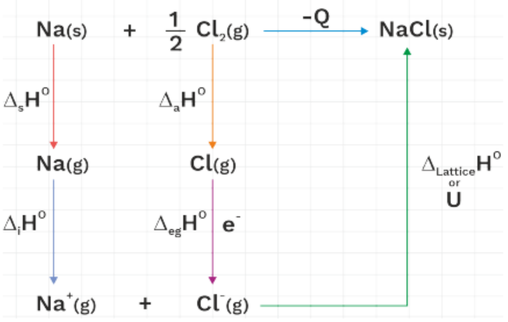
$C(s) + O_2\,(g) \rightarrow CO_2\,(g)\quad \Delta_rH^0 = -393.5\ kJmol^{-1}$

ENTHALPIES FOR DIFFERENT TYPES OF REACTIONS

Enthalpy of Combustion (Δ_cH^o)	Enthalpy of Atomization (Δ_aH^o)	Enthalpy of Solution ($\Delta_{sol}H^o$)
(i) It is the enthalpy change taking place when one mole of a compound undergoes complete combustion in the presence of oxygen. (ii) Exothermic in nature	(i) It is the enthalpy change on breaking one mole of bonds completely to obtain atoms in the gas phase.	(i) It is the enthalpy change when one mole of it dissolves in a specified amount of solvent. (ii) $\Delta_{sol}H^o = \Delta_{lattice}H^o + (\Delta_{hyd}H^o)$



- Enthalpy of dilution: It is the enthalpy change associated with the addition of a specified amount of solute to the specified amount of solvent at a constant temperature and pressure.
- Bond Enthalpy ($\Delta_{bond}H^o$)
  Enthalpy is required to break a bond and energy is released when bond is formed.
  $$\boxed{\Delta_r H = \sum bondenthapies_{reactants} - \sum bondenthapies_{products}}$$
- Lattice Enthalpy:
- Lattice energy of an ionic compound is the amount of energy released when one mole of the compound is formed from its constituent gaseous cations and anions.
- Since it is not possible to determine lattice enthalpies directly through experiments, an indirect method is used by constructing an enthalpy diagram known as the Born-Haber cycle.



Total energies involved in the above five steps

$$= \Delta_s H^o + \frac{1}{2}\Delta_a H^o + \Delta_i H^o - \Delta_{eg} H^o + U$$

SPONTANEOUS PROCESS:

- A process which can take place by itself or has a tendency to take place is called spontaneous process.
- It cannot be reversed.
- All natural processes are spontaneous process.

ENTROPY

- Degree of randomness or disorderness is known as entropy. The unit of entropy is J/mol K.
- Entropy change for a system is given by $\Delta S = \frac{q_{rev}}{T}$
- $$s < l < g$$
  $$\xrightarrow[\text{Entropy}]{} \uparrow$$
- Entropy Criterion Entropy Criterion of Spontaneous Process : The total entropy change (ΔS_{total}) for a spontaneous process is given by $\Delta S_{total} = \Delta S_{system} + \Delta S_{surr} > 0$
- At equilibrium position (ΔS_{total}) is 0.

Note: For isothermal expansion of an ideal gas: **ΔU = 0** for both reversible and irreversible processes.

But ΔS_{total} is not zero for irreversible process. ΔU does not discriminate between reversible and irreversible process, whereas ΔS does.

Entropy and Second Law of Thermodynamics:

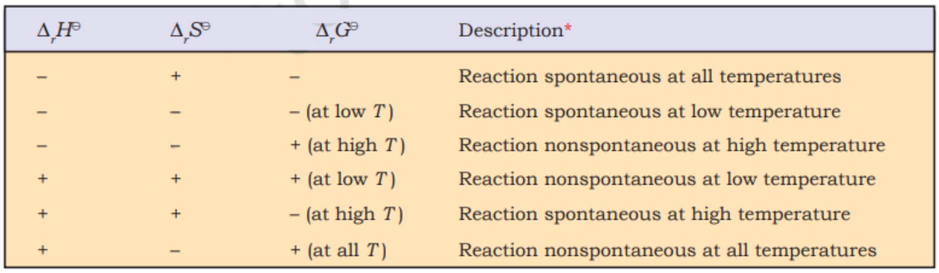
- The entropy of the universe is always increasing in the course of every spontaneous or natural change.

GIBBS ENERGY (G) OR GIBBS FREE ENERGY

- It is the energy available in a system under given conditions that can be used to perform useful work. Gibbs function, G is an extensive property and a state function.
- The formula is $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

Gibbs energy criterion of spontaneity
ΔG > 0, process is non-spontaneous
ΔG< 0, process is spontaneous
ΔG= 0,process is in equilibrium state.

- Effect of Temperature on Spontaneity:



$\Delta_r H^\ominus$	$\Delta_r S^\ominus$	$\Delta_r G^\ominus$	Description*
–	+	–	Reaction spontaneous at all temperatures
–	–	– (at low *T*)	Reaction spontaneous at low temperature
–	–	+ (at high *T*)	Reaction nonspontaneous at high temperature
+	+	+ (at low *T*)	Reaction nonspontaneous at low temperature
+	+	– (at high *T*)	Reaction spontaneous at high temperature
+	–	+ (at all *T*)	Reaction nonspontaneous at all temperatures

GIBBS ENERGY CHANGE AND EQUILIBRIUM

- $\Delta G = \Delta G^\circ + 2.303RT\log Q$
- At equilibrium, ΔG value is zero. The above formula is rewritten as follows: $\Delta G^\circ = -2.303RT\log K$

THIRD LAW OF THERMODYNAMICS

- The entropy of any pure crystalline substance approaches zero as the temperature approaches absolute zero. This is called third law of thermodynamics.

****

SECTION - A (1 MARKS)

1. If the volume of an ideal gas is increased isothermally then its internal energy will be:

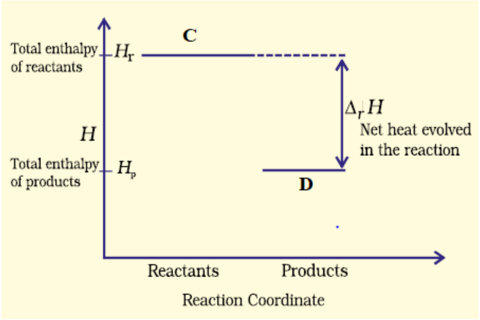
(a) Increases (b) Decreases

(c) Decreases Remains constant (d) Cannot be determined

2. Which of the following options correctly represents the relationship between C_p and C_V for one mole of an ideal gas?

(a) $C_p = RC_v$ (b) $C_v = RC_p$ (c) $C_p + C_v = R$ (d) $C_p - C_v = R$

3. Consider the following diagram for a reaction C → D.



(a) Exothermic (b) Endothermic (c) At Equilibrium (d) None of these

4. The work done when three moles of an ideal gas undergo spontaneous expansion from 2 L to 5 L into a vacuum will be,

(a) 5 Joules (b) zero (c) -6 Joules (d) 9 Joule

5. $N_2 + 3H_2 \rightarrow 2NH_3$; $\Delta_r H^\circ = -94.4$ kJ mol^{-1}. The standard enthalpy of formation of NH_3 gas using the given reaction will be:

(a) -94.4 J mol^{-1} (b) -47.2 kJ mol^{-1} (c) 47.2 kJ mol^{-1} (d) 94.4 J mol^{-1}

6. The lattice energy and enthalpy of the solution of NaCl are 788 kJ mol^{-1} and 4 kJ mol^{-1} , respectively. Calculate the hydration enthalpy of NaCl.

(a) –784 kJ mol^{-1} (b) 784 kJ mol^{-1} (c) -792 kJ mol^{-1} (d) 792 kJ mol^{-1}

7. The entropy change (ΔS) associated with the fusion of one mole of a solid at its melting point of 27°C will be: (Given: Enthalpy of fusion is 2930 J mol^{-1})

(a) 9.77 JK^{-1}mol^{-1} (b) 19.73 JK^{-1}mol^{-1} (c) 2930 JK^{-1}mol^{-1} (d) 108.5 JK^{-1}mol^{-1}

8. Match the terms in List I with their corresponding descriptions in List II:

List I	**List II**
A. Adiabatic process	I. At constant temperature
B. Isolated system	II. No transfer of heat
C. Isothermal change	III. Heat
D. Path function	IV. No exchange of energy and matter

(a) A-II, B-III, C-I, D-IV (b) A-II, B-IV, C-II, D-III

(c) A-IV, B-I, C-II, D-III (d) A-IV, B-III, C-II, D-I

9. Predict which of the following reactions has a negative entropy change:

I: $NH_3(g) + HCl(g) \longrightarrow NH_4Cl(s)$

II: Temperature of a crystalline solid is raised from 0 K to 115 K.

(a). Only (II) (b). Only (I)(c). (I) and (II) (d). None above of these

10. What are the signs of ΔH and ΔS for a reaction that is spontaneous only at low temperatures?

(a) ΔH is positive, ΔS is positive. (b) ΔH is positive, ΔS is negative.

(c) ΔH is negative, ΔS is negative. (d) ΔH is negative, ΔS is positive.

ASSERTION REASON TYPE QUESTIONS(1MARKS)

These questions are based on Assertion-Reason and write the correct option from the following four options given:

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

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

(c) A is correct and R is not correct.
(d) A is not correct but R is correct

11. **Assertion (A):**Variables like P, V, and T are called state functions.
Reason(R): Their values depend solely on the system's state, not its path.

12. Assertion(A): Absolute values of the internal energy of substances cannot be determined.
Reason(R): It is impossible to determine the exact values of constituent energies of the substances.

13. Assertion(A): A reaction with negative enthalpy change ($\Delta H < 0$) and negative entropy change ($\Delta S < 0$) is always spontaneous.
Reason(R): At high temperatures, the value of $T\Delta S$ becomes large enough to make ΔG negative, even if ΔH is positive.

14. Assertion(A): During an adiabatic process, heat energy is not exchanged between the system and its surroundings.
Reason(R): The temperature of a gas increases when it undergoes an adiabatic expansion

15. Assertion (A): The bomb calorimeter is used to measure the energy change of a reaction at constant pressure.
Reason(R): In bomb calorimeter, the heat from the reaction is absorbed by the surrounding water, causing a temperature change.

Answer key-

Question no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Answer	(b)	(d)	(a)	(b)	(b)	(a)	(d)	(b)	(b)	(c)	(a)	(a)	(d)	(c)	(d)

SECTION- B (2MARKS)

1. Consider the reaction given below,
$OF_2 + H_2O \rightarrow O_2 + 2HF$
Calculate the ΔH (enthalpy change) for the reaction
(Given the bond energies of O−F, O−H, H−F and O=O as 44, 111, 135, and 119 kcal mol^{-1}, respectively)
(Hint: -79 kcal)

2. An ideal gas is allowed to expand form 1 L to 10 L against a constant external pressure of 1 bar. Calculate the work done in Joule.
(Hint: -900 J)

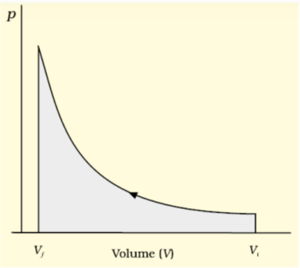
3. Derive the relationship between ΔH and ΔU for an ideal gas.

4. State the third law of thermodynamic.

5. What is meant by enthalpy of atomization and enthalpy of dilution?

SECTION –C (3 MARKS)

1. (a)



Refer to the two P–V graphs in the image:

(i) Does this graph illustrate a reversible process or an irreversible process?

(ii) What does the area under the curve represent?

(b) Change in internal energy is a state function while work is not, why?

2. The standard enthalpy and standard entropy change for the oxidation of NH_3 at 298 K, are -220 kJ mol^{-1} and -150 J Mol^{-1} K^{-1} respectively. Calculate the standard Gibbs energy change for the same reaction at 300 K and also tell reaction is spontaneous or not.

(Hint: Use formula $\Delta G = \Delta H - T\Delta S$; Answer: 175.3 kJ

3. For the reaction at 25 ^oC

$NH_3(g) \rightarrow \frac{1}{2} N_2(g) + \frac{3}{2} H_2(g)$; ΔH^o = 11.04 kcal

Calculate the value of $\Delta U^o$of the reaction at the given temperature.

(Hint: Use formula $\Delta H = \Delta U + \Delta n_g RT$; Answer: 10.44 kcal)

4. (a) Explain why the standard molar enthalpy of formation of $Cl_2(g)$ is zero at 298 K, while that of $H_2O(g)$ is not.

(Hint: Elements in their most stable (standard) states has zero standard molar enthalpy 1of formation)

(b) State the First Law of Thermodynamics and provide its mathematical expression.

5. (a) Calculate the number of kJ of heat necessary to raise the temperature of 60.0 g of aluminium from 35°C to 55°C. Molar heat capacity of Al is 24 J mol^{-1} K^{-1}. S

(Hint: Use formula, $q = c$ **×** m **×** ΔT; Answer: 1.07 kJ)

SECTION – D CASE BASED QUESTIONS (4 MARKS)

1. Read the following passages and answer the questions that follow:

Most chemical reactions occur in open or closed systems, not isolated ones. In such conditions, the **total entropy change** ΔS_{total}helps determine spontaneity, but **enthalpy (ΔH)** also plays a significant role. To combine both entropy and enthalpy considerations, a thermodynamic quantity known as **Gibbs free energy (G)** is defined as: **G = H – TS**. For a process at constant temperature, the change in Gibbs free energy is: **$\Delta G = \Delta H - T\Delta S$.**

This equation helps predict spontaneity: If **$\Delta G < 0$**, the process is **spontaneous**. If **$\Delta G > 0$**, the process is **non-spontaneous**. If **$\Delta G = 0$**, the system is at **equilibrium.**

(i) A reaction has ΔH = +30 kJ/mol and ΔS = +100 J/mol·K. At what minimum temperature will the reaction become spontaneous?

(a) 100 K (b) 200 K (c) 300 K (d) 400 K

(Hint: Use formula **$\Delta G = \Delta H - T\Delta S$ by taking ΔG value zero. Answer:** 400 K)

(ii) State the conditions for the change in internal energy (ΔU) and total entropy change (ΔS_{total}) during an irreversible isothermal expansion of an ideal gas.

(iii) Two reactions have the same ΔH, but one is spontaneous while the other is not. Explain how entropy change and temperature influence this behavior.

(Hint: For spontaneous reaction **$T\Delta S > \Delta H$)**

2. Read the following passages and answer the questions that follow:

In thermodynamics, the change in internal energy (ΔU) and enthalpy (ΔH) are essential concepts for understanding heat flow during chemical reactions. When a reaction occurs at constant volume, the heat absorbed or evolved is equal to the change in internal energy ($\Delta U = q_v$). However, most chemical reactions occur at constant pressure, where the heat absorbed is equal to the enthalpy change ($\Delta H = q_p$). For an ideal gas, the relationship between ΔH and ΔU is given by the equation:

$\Delta H = \Delta U + \Delta n_g RT$; where Δn_g is the change in number of moles of gaseous products and reactants, **R** is the gas constant, and **T** is the temperature in Kelvin.

(i) The maximum value of (ΔH−ΔU) at 27°C among the following reactions is:

(a) $H_2(g)+Cl_2(g) \longrightarrow 2HCl(g)$ (b) $PCl_5(g) \longrightarrow PCl_3(g)+Cl_2(g)$

(c) $N_2O_4(g) \longrightarrow 2NO_2(g)$ (d) $NH_4HS(s) \longrightarrow NH_3(g)+H_2S(g)$

(Hint: Calculate the value of $\Delta n_g RT$; Answer: (d))

(ii) Chemical reactions in industries are often carried out at constant pressure. In such conditions, explain why enthalpy (ΔH) is preferred over internal energy (ΔU) to measure heat changes in reactions.

(iii) A system undergoes a change where ΔU = 1000 J and it expands against a constant external pressure, doing 300 J of work. Calculate the change in enthalpy (ΔH)?

SECTION –E (5 MARKS)

1. (a) Use the information in the table to calculate the enthalpy of this reaction

$C_2H_6(g) + \frac{7}{2}O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

Reactions	ΔH_f^o kJ / mol
$2C(s) + 3H_2(g) \rightarrow C_2H_6(g)$	-84.7
$C(s) + O_2(g) \rightarrow CO_2(g)$	-393.5
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	-285.8

(Hint: Use Hess Law; Answer: -

(b) Will the heat released in the following two reactions be equal? Give reasons in support of your answer.

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

(Hint: The heat released in a reaction depends on the reactants, products and the physical states.)

2. (a)14 g of N_2 gas is expanded reversibly and isothermally at a constant temperature of 300 K from 5 dm^3 to 25 dm^3. Calculate the values of **ΔU**, **ΔH**, **w**, and **q**.

(Hint: w =-2.303nRTlog$\frac{V_f}{V_i}$, andΔU = q + w; Answer: w = −2006.9 J)

(b) Given that the equilibrium constant (K) for a reaction is 20 at a certain temperature, calculate the standard Gibbs free energy change (ΔG°) for the reaction.
(Given: R = 8.314J.$K^{-1}mol^{-1}$ and T = 300K)
(Hint: Use Formula: ∆G°= -2.303RTlogK; Answer: -7.47 kJ/mol)

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CHAPTER 6 (EQUILIBRIUM)

Summary

Equilibrium is defined as the state at which there is no change in concentration, Temperature,Pressure or observable and measurable properties of reactants and products. At equilibrium the rate of forward reaction is equal to the rate of backward reaction.

Type of Equilibrium –

A. **Equilibrium involve in Physical process.**

Process	Conclusion
Liquid ↔Vapour H_2O (l) ↔H_2O (g)	p_{H2O} constant at given temperature
Solid↔Liquid H_2O (s)↔ H_2O (l)	Melting point is fixed at constant pressure
Solute(s) ↔Solute (solution) Sugar(s)↔ Sugar (solution)	Concentration of solute in solution is constantat a given temperature
Gas(g) ↔Gas (aq) CO_2(g) ↔CO_2(aq)	[gas(aq)]/[gas(g)] is constant at a given temperature [CO_2(aq)]/[CO_2(g)] is constant at a given temperature

General Characteristics of Equilibria Involving Physical Processes-

(i) Equilibrium is possible only in a closed system at a given temperature.

(ii) Both the opposing processes occur at the same rate and there is a dynamic but stable condition.

(iii) All measurable properties of the system remain constant.

(iv)When equilibrium is attained for a physical process, it is characterized by constant value of one of its parameters at a given temperature.

(v) The magnitude of such quantities at any stage indicates the extent to which the physical process has proceeded before reaching equilibrium.

B. .**Equilibrium in Chemical Processes -Equilibrium involve in Chemical process.**

1. $H_2(g)+I_2(g) \rightleftharpoons 2HI(g)$

2. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$

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

Characteristics of Equilibria Involving Chemical Processes-

(i) The concentration of each of the reactants and the products becomes constant at equilibrium.

(ii) The rate of forward reaction becomes equal to the rate of backward reaction at equilibrium and hence equilibrium is dynamic in nature.

(iii) None of the products is allowed to escape out or separate out as a solid then only chemical equilibrium can be established.

Law Of Mass Action - Proposed by Guldberg and Waage so also known as Guldberg - Waage Law it statethate:-

The rate of a chemical reaction is directly proportional to the product of the active masses (concentrations) of the reactants, each raised to the power of their stoichiometric coefficients in the balanced chemical equation

Consider a reaction where aA + bB → cC + dD, Where a, b, c, and d are stoichiometric coefficients and A, B, C, and D are the reactants and products. According to the law of mass action.

Rate of reaction = $k[A]^a[B]^b$, where k is the rate constant.

Law of Chemical Equilibrium –

At a constant temperature, the rate of a chemical reaction is directly proportional to the product of the molar concentrations of the reactants each raised to a power equal to the corresponding stoichiometric coefficients as represented by the balanced chemical equation. Let us consider the reaction,

Consider a reaction where aA + bB → cC + dD

$$Kc = [C]^c [D]^d / [A]^a [B]^b$$

Where K_C is the Equilibrium Constant.

Characteristics of Equilibrium Constant:

(i)The value of the equilibrium constant for a particular reaction is always constant depending only upon the temperature of the reaction and is independent of the concentrations of the reactants with which we start or the direction from which the equilibrium approached.

(ii) The value of equilibrium constant in inversed when the reaction is reversed.

(iii) The equilibrium constant for the new equation is square root of K. (i.e, K), when the equation is divided by 2.

(iii) The equilibrium constant for new equation is the square of K (i.e, 2 K), when the equation is multiplied by 2.

(iv) By the addition of catalyst to the reaction will not affect the value of the equilibrium.

Difference between K_p and K_c-

K_p	K_c
This equilibrium constant is for the pressure ratio of products and reactants.	It is defined as the ratio of the concentrations of products and reactants.
This constant is only applicable to gaseous mixtures.	This constant can be applied to both gaseous and liquid reactions.
It is defined by pressure units.	It is defined by concentration units.

Relationship between equilibrium constants K_p and K_c

This relation between Kc and Kp can be defined using the equation:

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

K_p denotes the pressure equilibrium constant, Kc denotes the concentration equilibrium constant, R is the universal gas constant (8.314 Jmol-1K-1), T is the temperature, and n is the difference between total moles of gas products and total moles of gas reactants.

Predicting the direction of reaction in an equilibria :

$Q_c > K_c$	Backward
$Q_c < K_c$	Forward
$Q_c = K_c$	No change

Note :

If $\Delta G^{\ominus} < 0$,then $-\Delta G^{\ominus}/RT$ is positive and e−ΔGϴ/RT>1, making K>1 Reaction is spontaneous in forward direction and products are present predominantly.

If $\Delta G^{\ominus} > 0$,then $-\Delta G^{\ominus}/RT$ is negative and e^−ΔGϴ/RT<1, making K<1 Reaction is non-spontaneous in forward direction and only a very minute quantity of product is formed.

Le Chatelier's principle.

It states that a change in any of the factors that determine the equilibrium conditions of a system will cause the system to change in such a manner so as to reduce or to counteract the effect of the change. This is applicable to all physical and chemical equilibria.

Factors That Affect Equilibrium

Factors	Affect the Equilibrium
a).Temperature	1.Increasing temperature generally favors the endothermic reaction (one that absorbs heat). 2.Decreasing temperature favors the exothermic reaction (one that releases heat).
b). Pressure	1.Increasing pressure generally favors the side of the reaction with fewer moles of gas. 2.Decreasing pressure favors the side with more moles of gas.
c). Concentration	1.Adding more reactants will shift the equilibrium towards the product side. 2.Adding more products will shift the equilibrium towards the reactant side.
d). Catalyst	A catalyst does not affect the position of equilibrium itself. It speeds up both the forward and reverse reactions equally

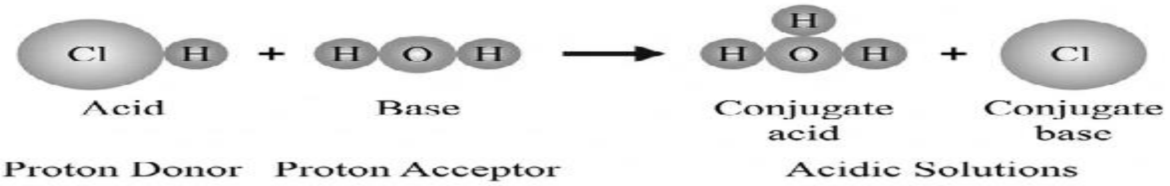
Acid Base theory -

Arrhenius Concept of Acids and Bases:

According to Arrhenius acids give hydrogen ions while bases produce hydroxyl ion in their aqueous solutions.

Bronsted Lowry Theory:

Acid is a chemical substance that donates the proton (H^+).
Base is a chemical substance that accepts the proton (H^+).

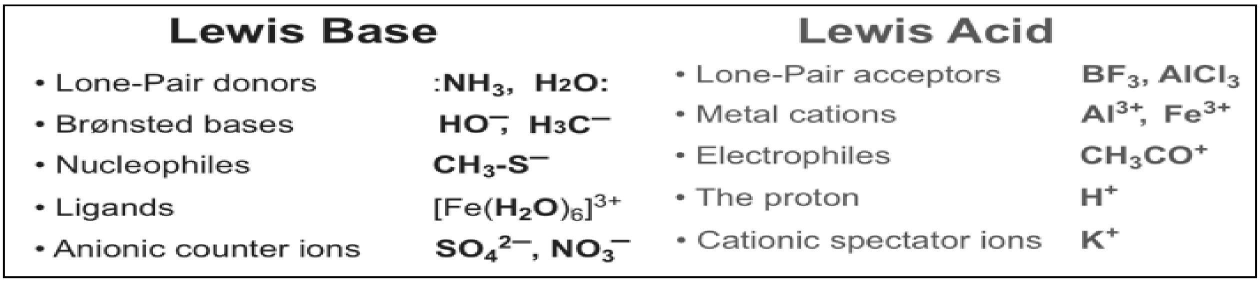


An acid and a base which differ only by the presence or absence of a proton are called a conjugate acid-basepair.

Lewis Theory:

Lewis Acid is a species which accepts electron pair .

Lewis Base is a species which donates an electron pair.



Lewis Base		Lewis Acid	
• Lone-Pair donors	$:NH_3$, $H_2O:$	• Lone-Pair acceptors	BF_3, $AlCl_3$
• Brønsted bases	HO^-, H_3C^-	• Metal cations	Al^{3+}, Fe^{3+}
• Nucleophiles	$CH_3\text{-}S^-$	• Electrophiles	CH_3CO^+
• Ligands	$[Fe(H_2O)_6]^{3+}$	• The proton	H^+
• Anionic counter ions	SO_4^{2-}, NO_3^-	• Cationic spectator ions	K^+

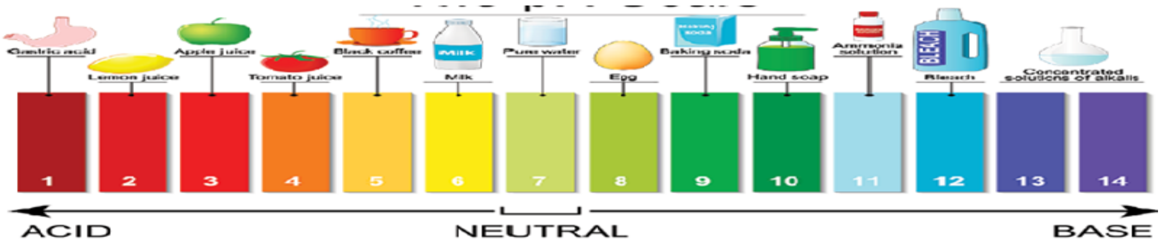
Ionic Equilibrium - An equilibrium involving ions is called ionic equilibrium. This equilibrium between unionized molecules and the ions is represented by ‘reversible arrows’.

For example: $CH_3COOH(l) + H_2O(l) \leftrightharpoons H_3O^+(aq) + CH_3COO^-(aq)$

pH and pH scale:

Hydronium ion concentration in molarity is more conveniently expressed on a logarithmic scale known as the pH scale. The pH of the solution is defined as the negative logarithm to base 10 of the activity of hydrogen ion.

pH= -log [H]$^+$



Acidic: $[H_3O^+] > 10^{-7}$ M. $pH < 7$

Neutral: $[H_3O^+] = 10^{-7}$ M. $pH = 7$

Basic : $[H_3O^+] < 10^{-7}$ M. $pH > 7$

This has been extended to other quantities;

pOH= -log [OH]- pKa= -log [Ka]

pKb= -log [Kb] pKw= -log [Kw]

Ionization of water: Self ionization of water:-

$H_2O(l) + H_2O(l) \longrightarrow H_3O^+(aq) + OH^-(aq)$

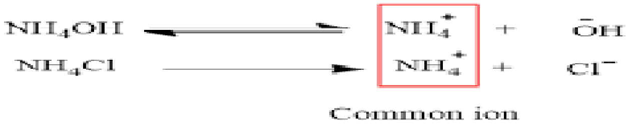
Acid base conjugate acid conjugate base

$Kw = [H_3O^+][OH^-] = (1 \times 10^{-7})^2 = 1 \times 10^{-14}$

For the ionization of water

pH + pOH = pKw equation is always satisfied.

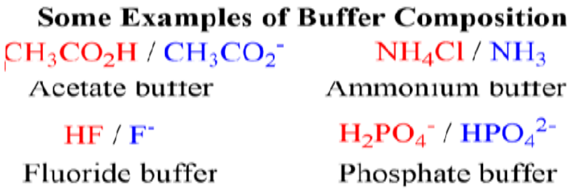
Common ion effect-When a common ion is added to a solution containing a weak electrolyte in equilibrium with its ions, the equilibrium shifts to the left, favoring the undissociated form of the weak electrolyte.



Buffer solution:

The solutions which resist change in pH on dilution or with the addition of small amounts of acid or alkali are called Buffer Solutions.

Two types-Acidic buffer solution and Basic buffer solution



Some Examples of Buffer Composition

CH_3CO_2H / $CH_3CO_2^-$	NH_4Cl / NH_3
Acetate buffer	Ammonium buffer
HF / F^-	$H_2PO_4^-$ / HPO_4^{2-}
Fluoride buffer	Phosphate buffer

Solubility Product-It represents the product of the concentrations of the ions in a saturated solution, each raised to the power of its stoichiometric coefficient in the dissolution equation.It is denoted by K_{sp}.

For the dissolution of AgCl(s) into Ag+(aq) and Cl-(aq):

AgCl(s) $\rightarrow$ Ag+(aq) + Cl-$_{(aq)}$

If the solubility (S) of AgCl is 's',

then [Ag+] = [Cl-] = s.

Ksp = [Ag+][Cl-]

= s $_x$ s = s² Therefore, **S = √Ksp** .

Difference between solubility and solubility product.

Solubility	Solubility Product
1.At a definite temperature solubility is defined as the concentration of asubstance as solute in its saturated solution.	At a definite temperature solubility product of asparingly soluble salt is define as the product of the molar concentrationof its ions each raised to the power equal to the number of ions present in the balanced equation representing the dissociation of molecule of the salt or electrolyte.
2. Applicable to both organics and inorganic solute.	It is applicable in case of electrolyte only.
3.Its magnitude change due to common ion effect or complex formation.	At a given temperature it has a fixed magnitude and dose not affected by common ion effect.

QUESTION BANK

SECTION - A (1 MARK EACH)

1- Le Chatelier’s principle is applicable to:
(a) only homogeneous chemical reversible reactions
(b) only heterogeneous chemical reversible reactions
(c) only physical equilibria
(d) all systems, chemical or physical in equilibrium.

2-When NH_4Cl is added to NH_4OH solution the dissociation of ammonium hydroxide is reduced. It is due to:
(a) common ion effect (b) hydrolysis (c) oxidation (d) reduction

3- The pH of a solution of hydrochloric acid is 4.The molarity of the solution is:
(a) 4.0 (b) 0.4 (c) 0.0001 (d) 0.04

4- What does it indicate having a higher equilibrium constant?
(a) reaction occurs faster
(b) rate of backward reaction is faster
(c) both the backward and forward reactions are equal
(d) reaction may be slower than usual

5- The equilibrium constant of a reaction is 20 units and the equilibrium constant of other reaction is 30 units when both the reactions are added up together then the equilibrium constant of the resultant reaction is given by
(a) 20 units (b) 600 units (c) 50 units (d) 10 units

6- What is the equilibrium constant of the following reaction:

$$\mathbf{4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O}$$

(a) $[NO][H_2O]/[NH_3][O_2]$ (b) $[C]^c[D]^d/[A]^a[B]^b$
(c) $[NO\}^4[H_2]^6/NH_3]4[O_2]^5$ (d) $[NO]^4[H_2O]^6/[NH_3]^4[O_2]^5$

7- Consider the following equilibrium in a closed container **N_2O_4 (g)$\rightarrow$$2NO_2$ (g)**. At a fixed temperature, the volume of the reaction container is halved. For this change, which of the following statements hold true regarding the equilibrium constant (Kp) and degree of dissociation (α)?
(a) Neither Kp nor α changes (b) Both Kp and α change
(c) Kp changes but α does not change (d) Kp does not change but α changes.

8- We know that the relationship between Kc and Kp is $Kp = Kc\ (RT)^{\Delta n}$ What would be the value of Δn for the reaction NH_4Cl (s) $\Leftrightarrow$$NH_3$ (g) + HCl (g)
(a) 1 (b) 0.5 (c)1.5 (d) 2

9- Acidity of BF_3 can be explained on the basis of which of the following concepts?
(a) Arrhenius concept (b) Bronsted Lowry concept
(c) Lewis concept (d) Bronsted Lowry as well as Lewis concept.

10- A reversible reaction, two substances are in equilibrium. If the concentration of each one is doubled the equilibrium constant will be
(a) Reduce to half its original value. (b) Reduced to one fourth of its original value.
(c) Doubled. (d) Constant.

ASSERTION- REASON TYPE QUESTIONS

In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

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

11-Assertion: (A) For any chemical reaction at a particular temperature, the equilibrium constant is fixed and is a characteristic property.
Reason: (R) Equilibrium constant is independent of temperature.

12- Assertion: (A) :Kp can be less than, greater than or equal to Kc.
Reason: (R): Relation between Kp and Kc depends on the change in number of moles of gaseous reactants and products (Δn).

13- Assertion: (A) :The endothermic reactions are favoured at lower temperatures and the exothermic reactions are favoured at a higher temperature.
Reason: (R): when a system in equilibrium is disturbed by changing the temperature, it will tend to adjust itself so as to effect of change.

14- Assertion: (A) :If water is heated to 59°C, the pH will increase.
Reason: (R): K_w increases with an increase in temperature.

15.Assertion: (A) :Buffer system of carbonic acid and sodium bicarbonate is used for the precipitation of hydroxides of third group elements.
Reason: (R):It maintains the pH to a constant value, about 7.4.

ANSWERS KEY

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ans	d	a	c	c	B	d	d	d	c	d	c	a	d	d	d

SECTION – B (2 MARKS)

1. Calculate the hydrogen ion concentration for the following biological fluids which have pH as given below.
(I) For Human saliva, 6.4 (II) For Human stomach fluid, 1.2
Answer Key-(I) For Human saliva, 6.4, pH = 6.4
6.4 = – log [H+] ,[H+] = 3.98 x 10-7
(II) For Human stomach fluid, 1.2, pH =1.2
1.2 = – log [H+],[H+] = 0.063

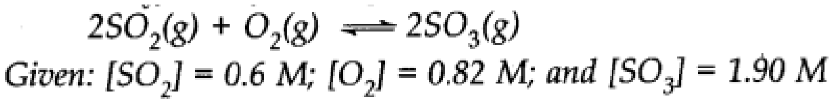
2.On the basis of the given equation pH= – log [H+], the pH of the given 10^{-8} moldm^{-3} solution for HCl should be 8. But, it is observed as less than 7.0. Justify the reason.
Answer Key-The water concentration could not be neglected as the solution is very dilute.
From Acid $[H_3O^+] = 10^{-8} + 10^{-7}$ M,FromWater $[H_3O+] = 10^{-8} (1 + 10)$,
Total = $[H_3O+] = 11 X 10^{-8}$ M
pH = – log $[H_3O+]$
pH = – log ^{11} X 10^{-8} M = pH = 6.96 (pH would be less than 7.0.)

3.For the following equilibrium, Kc = 6.3 × 10^{14} at 1000K .Both the forward and backward reactions in the equilibrium are elementary bimolecular reactions. What is Kc, for the backward reaction?
Answer Key- The value of equilibrium constant in inversed when the reaction is reversed.

4. What will be the effect on equilibrium when Δn is negative and pressure is decreased?

Answer Key – According to Le Chatelier's principle Reaction will shift in backward direction.

5.Find the K_c for the following reaction in state of equilibrium?



$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Given: $[SO_2] = 0.6\ M$; $[O_2] = 0.82\ M$; *and* $[SO_3] = 1.90\ M$

SECTION- C (3 MARKS)

1.The sparingly soluble salt gets precipitated only if the product of the concentration of the ions in the given solution (Ksp) becomes greater than the solubility product. When the solubility of $BaSO_4$ in water is 8 × 10-4 mol dm^{-3}, calculate the solubility in 0.01 mol $dm-^{3}$ of H_2SO_4.

Answer Key - Given that the standard solubility of $BaSO_4$ in water is 8×10^{-4} g/L dissociation of $BaSO_4$ would be- $BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$

(S' is the solubility of the Ba^{2+} in 0.01 of HCl) ,S<<< 0.01, thus it could be neglected and We already know that $K_{sp} = S^2$

Ksp = $(8\times10\text{-}8)^2$ = 64×10^{-8} Then, Ksp= (S') (0.01)

S' = 64.8×10-8/0.01 = 6.4×10^{-5}

Thus, the solubility of $BaSO_4$ in the given 0.01 mol dm^{-3} of H_2SO_4 is 6.4×10^{-5}

2.What is meant by conjugate acid-base pair? Find the conjugate acid/base for the following species: HNO_2, CH^-, $HClO_4$, OH^-, CO_3^{2-}, S^{2-}

Answer key - An acid-base pair which differs by a proton only (HA———> A^- + H^+) is known as conjugate acid-base pair.

3.The compound BF_3 does not have a proton; however, it still acts as an acid and reacts with NH_3. Why is it so? What type of bond can be formed between the two?

4. What happens to the magnitude of the equilibrium constant if the forward response rate is doubled, given $K = k_f/k_r$? What happens if the reverse reaction rate for the total reaction is reduced by a factor of three?

Answer key: $K = k_f/k_r$,

$K' = 2(k_f/k_r) = 2K$.

5. How can you predict the following stages of a reaction by comparing the value of Kc and Qc?

(i) Net reaction proceeds in the forward direction.

(ii) Net reaction proceeds in the backward direction.

(iii)No net reaction occurs.

SECTION- D Case Study Based question (Four marks)

1.Reactants and products coexist at equilibrium, so that the conversion of reactant to products is always less than 100%. Equilibrium reaction may involve the decomposition of a covalent (nonpolar) reactant or ionization of ionic compound into their ions in polar solvents. Ostwald dilution law is the application of the law of mass action to the weak electrolytes in solution. A binary electrolyte AB which dissociates into A+ and B– ions i.e.

$$AB \rightleftharpoons A^+ + B^-$$

for every weak electrolyte, Since α <<1 (1 – α) = 1

$$K = C\,\alpha^2 \Rightarrow \alpha = \sqrt{\frac{K}{C}} \Rightarrow \alpha = \sqrt{KV}.$$

(i) A monobasic weak acid solution has a molarity of 0.005 M and pH of 5. What is its percentage ionization in this solution?

(a) 2.0 (b) 0.2 (c) 0.5 (d) 0.25

(ii) Calculate ionisation constant for pyridinium hydrogen chloride.

(Given that H+ ion concentration is 3.6×10^{-4} M and its concentration is 0.02 M.)

(a) 6.48×10^{-2} (b) 6×10^{-6} (c) 1.5×10^{-9} (d) 12×10^{-3}

(iii)The behaviour of weak electrolytes in aqueous solution has been studied by Ostwald.

Give the law referring this behaviour.

Answer Key- (i) b (ii) c (iii) Ostwald's dilution law.

2 - According to Arrhenius theory, acids are substances that dissociate in water to give hydrogen ions H+ (aq) and bases are substances that produce hydroxyl ions OH– (aq). The ionization of an acid HX (aq) can be represented by the following equations:

HX (aq) → H+ (aq) + X – (aq) or **$HX(aq) + H_2O(l) \rightarrow H_3O^+(aq) + X^-(aq)$**

Similarly, a base molecule like MOH ionizes in aqueous solution according to the equation: **MOH(aq) → M+ (aq) + OH–(aq)**

Bronsted acids are proton donors whereas Bronsted bases are proton acceptors. Acids on donating proton form conjugate bases whereas bases form conjugate acids after accepting proton. Buffer solution is a solution whose pH does not change. By adding small amount of H+ or OH-.The decrease in concentration of the ion by adding other ion as common ion is called common ion effect. Ksp (solubility product) is product of molar concentrations of ions raised to power no. of ions per formula of ions per formula of the compound in sparingly soluble salt.

Precipitation occurs only if ionic product exceeds solubility product. Solubility of salt decreases in presence of common ion. Kw the ionic product of water is $1\text{x}10^{-14}$ at 298 k. K_w increases with increase in temperature.

pH is $-\log[H_3O+]$

where [H3O+]=cα in monoprotic acid, is molar conc., α is degree of ionisation.

(a) What will be the conjugate base of

(i) H_2SO_4 (ii) HCO_3^-?

(b) What will be the conjugate acid of

(i) NH_2^- (ii) NH_3

(c) The conc. of H_3O^+ is $4\text{x}\,10^{-4}$. Find its pH.

(d) Kb for NH3 is$1.80 \text{ x } 10^{-5}$, what will be Ka? [Kw is $1 \text{ x}10^{-14}$]

Answer key- (a) (i)HSO_4^- (ii) $CO_3^{\,2-}$ (b) (i)NH_3 ii) NH_4^+ (c) 3.398 d)$5.5\text{x}10^{-10}$

SECTION-E (5 MARKS)

1. A(i) The ratio of the product of molar concentration of products to the product of molar concentration of reactants at any stage of the reaction**?**

(ii) a mixture containing weak base and its salt with a strong acid is called and give its example**?**

B.Which of the following reactions will get affected by increase in pressure ? Also mention whether the change will cause the reaction to go to the right or left direction.

(i) $CH_4(g) + 2S_2(g) \rightleftharpoons CS_2(g) + 2H_2S(g)$

(ii) $CO_2(g) + C(s) \rightleftharpoons 2CO(g)$

(iii) $4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$

(iv) $C_2H_4(g) + H_2(g) \rightleftharpoons C_2H_6(g)$

(v) $COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$

(vi) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

Answer key – A (i) reaction quotient.

(ii) Basic beffer e.g., $NH_4Cl + NH_4OH$

B. Only those reactions will be affected by increasing the pressure in which the number of moles of the gaseous reactants and products are different ($n_p \neq n_r$) (gaseous).

2(i)Describe a situation where you had to apply the Law of Mass Action to solve a problem in a laboratory or academic setting. What was the challenge, how did you apply the principle, and what was the outcome?

(ii) A solution of NH_4Cl in water shows pH less than 7.why?

(iii)What is the effect of increasing pressure in the given reactions? Give reasons.

(a)$PCl_5(g) \rightarrow PCl_3(g) + Cl_2(g)$

(b)$N_2(g)+O_2(g) \rightarrow 2NO(g)$

(iv) Which of the following are lewis acids?

H_2O, BF_3, H+, NH_4^+

Answer Key-(i) **Situation:** During a chemistry lab in my second year, we were tasked with determining the equilibrium constant (Kc) for the esterification of ethanoic acid with ethanol.

Task: The challenge was that the reaction didn't go to completion, and we needed to apply the Law of Mass Action to calculate Kc using the equilibrium concentrations.

Action: I prepared the solution, allowed the system to reach equilibrium, and used titration to determine the concentration of ethanoic acid remaining. Using initial concentrations and the changes during the reaction, I applied the Law of Mass Action.

Rate of reaction = $k[A]^a[B]^b$, where k is the rate constant

(ii) NH_4Cl is salt of weak base NH_4OH and strong acid HCl, therefore H+ ions are more than OH-ions thus, pH is less than 7.

(iii) (a)The equilibrium will shift in backward reaction because number of moles of products are more than reactants $\Delta n>0$.

(b)No effect because number of moles of reactants and products are equal, i.e., $\Delta n=0$.

(iv) BF_3, H+

****

Redox reaction

Summary

- The chemical changes that occur when electrons are transferred between reactants are called oxidation – reduction reaction.

Oxidation	Reduction
Addition of oxygen or an electronegative elements	Removal of oxygen or an electronegative elements
Removal of hydrogen or an electropositive elements	Addition of hydrogen or an electropositive element
Loss of electron(s) by any species.	Gain of electron(s) by any species.

- **Oxidising agent:** A reagent which can increase the oxidation number of an element in a given substance. These reagents are also called as oxidants .
- **Reducing agent:** A reagent which lowers the oxidation number of an element in a given substance. These reagents are also called as **reductants**.

Types of Redox Reactions

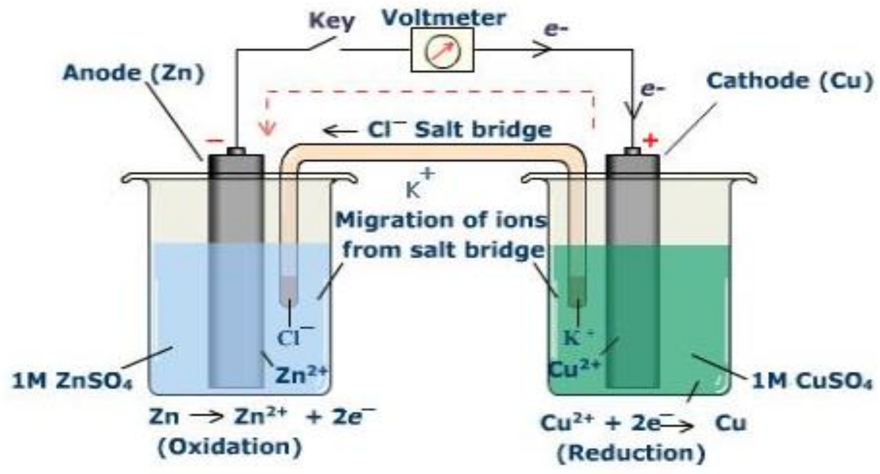
Type	Example
Combination Reactions: Chemical reactions in which two or more substances (elements or compounds) combine to form a single substance	$\overset{0}{C}(s) + \overset{0}{O_2}(g) \xrightarrow{\Delta} \overset{+4\,-2}{CO_2}(g)$
Decomposition Reactions: Chemical reactions in which a compound break up into two or more simple substances	$\overset{+1\,-2}{2H_2O}(l) \xrightarrow{\Delta} \overset{0}{2H_2}(g) + \overset{0}{O_2}(g)$
Displacement Reactions: Reaction in which one ion(or atom)in a compound is replaced by an ion(or atom) of other element	$X + YZ \rightarrow XZ + Y$
Metal Displacement Reactions: Reactions in which a metal in a compound is displaced by another metal in the uncombined state	$\overset{+2\,+6\,-2}{CuSO_4}(aq) + \overset{0}{Zn}(s) \rightarrow \overset{0}{Cu}(s) + \overset{+2\,+6\,-2}{ZnSO_4}(aq)$
Non-metal Displacement Reactions: Such reactions are mainly hydrogen displacement or oxygen displacement reactions	$\overset{0}{2Na}(s) + \overset{+1\,-2}{2H_2O}(l) \rightarrow \overset{+1\,-2\,+1}{2NaOH}(aq) + \overset{0}{H_2}(g)$
Disproportionation Reactions: Reactions in which an element in one oxidation state is simultaneously oxidized and reduced	$\overset{0}{P_4}(s) + 3OH^-(aq) + 3H_2O(l) \rightarrow \overset{-3}{PH_3}(g) + \overset{+1}{3H_2PO_2^-}$

Balancing of Redox Reactions

) Oxidation Number Method:	**(b) Half Reaction Method or Ion – electron method:**
(i) Write the skeletal redox reaction for all reactants and products of the reaction.	(i)Find the elements whose oxidation numbers are changed. Identify the substance that acts as an oxidizing agent and reducing agent.
(ii) Indicate the oxidation number of all the atoms in each compound above the symbol of element.	(ii) Separate the complete equation into oxidation half reaction and reduction half reaction.
(iii) Identify the element/elements which undergo change in oxidation numbers.	(iii) Balance the half equations by following steps.
(iv) Calculate the increase or decrease in oxidation number per atom.	(iv) Add the two balanced equations. Multiply one or both half equations by suitable numbers so that on adding two equations the electrons are balanced.
(v) Equate the increase in oxidation number with decrease in oxidation number on the reactant side by multiplying formula of oxidizing agent and reducing agents with suitable coefficients .	(v)Balance all atoms other than H and O .
(vi) Balance the equation with respect to all other atoms except hydrogen and oxygen.	(vi) Calculate the oxidation number on both sides of equation. Add electrons to whichever side is necessary to make up the difference.
(vii) Finally balance hydrogen and oxygen. For balancing oxygen atoms add water molecules to the side deficient in it. Balancing of hydrogen atoms depend upon the medium .	(vii) Balance the half equation so that both sides get the same charge .
(viii) Finally balance the equation by cancelling common species present on both sides of the equation .	(viii) Add water molecules to complete the balancing of the equation.

- Electrochemical cell is a device that converts chemical energy produced in a redox reaction into electrical energy. These cells are also called Galvanic cells or Voltaic cells .

- **Direct redox reaction:** Redox reactions in which reduction and oxidation occurs in same solution (i.e. same reaction vessel). In these reactions transference of electrons is limited to very small distance.
- **Indirect redox reactions:** Redox reactions in which oxidation and reduction reactions take place in different reactions vessels and thus transfer of electrons from one species to another does not take place directly.



Functions of salt bridge

1. The electrical circuit is completed with a salt bridge.
2. Salt bridge also maintains the electrical neutrality of the two half cells.

- Electrical potential difference developed between the metal and its solution is called electrode potential. It can also be defined as tendency of an electrode in a half cell to gain or lose electrons
- Oxidation potential is the tendency of an electrode to lose electrons or to get oxidized
- Reduction potential is the tendency of an electrode to gain electrons or get reduced
- In an electrochemical cell, by the present convention, the electrode potentials are represented as reduction potential
- The electrode having a higher reduction potential will have a higher tendency to gain electrons.
- By convention, the standard electrode potential of hydrogen electrode is 0.00 volts.
- A redox couple is defined as having together oxidized and reduced forms of a substance taking part in an oxidation or reduction half reaction.
- The difference between the electrode potentials of the two electrodes constituting the electrochemical cell is called EMF (Electromotive force) or the cell potential

  EMF = $E^\ominus$ cathode – $E^\ominus$ anode
- A negative $E^\ominus$ means that the redox couple is a stronger reducing agent than the H^+/H_2 couple
- A positive $E^\ominus$ means that the redox couple is a weaker reducing agent than the H^+/H_2 couple.

SECTION- A (1 mark each)

Q.1The oxidation number of Cr in $Cr(CO)_6$ is ——————

(a) 0 (b) +2 (c) -2 (d) +6

Q.2 Identify the reaction which is not a redox reaction?

(a) $2H_2 + O_2 \rightarrow 2H_2O$ (b) $CaCO_3 \rightarrow CaO + CO_2$

(c) $Na + H_2O \rightarrow NaOH + 1/2H_2$ (d) $MnCl_3 \rightarrow MnCl_2 + 1/2\ Cl_2$

Q.3 A standard hydrogen electrode has zero electrode potential because

(a) hydrogen is easiest to oxidize (b) the electrode potential is assumed to be zero

(c) hydrogen atom has only one electron (d) hydrogen is the lightest element

Q.4 How many electrons are transferred in the redox reaction:

$2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$?

(a) 2 (b) 5 (c) 10 (d) 16

Q.5 "Which of the following rules used to determine the oxidation number of an element in a compound is incorrect?"

(a) The oxidation number of hydrogen is always +1.

(b) The algebraic sum of all the oxidation numbers in a compound is zero.

(c) An element in the free or the uncombine state bears oxidation number zero.

(d) In all its compounds, the oxidation number of fluorine is –1.

Q.6 The most powerful oxidising agent among the following is:

(a) H_2SO_4 (b) H_3BO_3 (c) HPO_3 (d) H_3PO_4

Q.7 Consider the following reaction:

$Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$

With reference to the above, which one of the following is the correct statement?

(a) Zn is reduced to Zn^{2+}ions (b) Zn is oxidised to Zn^{2+}ions

(c) Zn^{2+} ions are oxidised to Zn (d) Cu^{2+}ions are oxidized to Cu

Q.8 In the reaction:

$2Ag + 2H_2SO_4 \rightarrow Ag_2SO_4 + 2H_2O + SO_2$

Sulphuric acid acts as:

(a) Oxidising agent (b) Reducing agent

(c) Catalyst (d) Acid as well as oxidant

Q.9 Reduction never involves:

(a) gain of electrons (b) decrease in oxidation number

(c) loss of electrons (d) decrease in valency of electropositive component

Q.10 Which of the following elements does not show disproportionation tendency?

(a) Br (b) F (c) Cl (d) I

Assertion-Reasoning

Given below are two statements labelled as Assertion (A) and Reason (R) Select the most appropriate answer from the options given below:

(a) Assertion and reason both are correct statements and reason is correct explanation for assertion.

(b) Assertion and reason both are correct statements but reason is not correct explanation for assertion.

(c) Assertion is correct statement but reason is wrong statement.

(d) Assertion is wrong statement but reason is correct statement.

Q.11 **Assertion**: For every oxidation-reduction reaction oxidant and reductant must be different molecules or ions.

Reason: Oxidation and reduction always occur simultaneously.

Q.12 **Assertion (A):** $HgCl_2$ and $SnCl_2$ cannot stay together.

Reason (R): $HgCl_2$ is an oxidising agent but $SnCl_2$ is reducing agent.

Q.13 **Assertion (A)**: Among halogens fluorine is the best oxidant.

Reason (R) : Fluorine is the most electronegative atom.

Q.14 **Assertion(A)**: Zinc liberates hydrogen from a dilute solution of hydrochloric acid.

Reason(R): $E^0$of Zn is higher than that of H_2.

Q.15 **Assertion:** Elements with greater electron affinities are better oxidizing agents.

Reason: Oxidation is the gaining of electrons.

Answer Key:

Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10	Q.11	Q.12	Q.13	Q.14	Q.15
(a)	(b)	(d)	(c)	(a)	(a)	(b)	(d)	(c)	(b)	(d)	(a)	(b)	(c)	(c)

SECTION- B (2 marks each)

Q.1 MnO_4^{2-} undergoes a disproportionation reaction in an acidic medium but MnO_4^- does not. Give a reason.

(Hint: Oxidation number of Mn in MnO_4^{2-} is +6 and inMnO_4^-+7)

Q.2 "A student suggests storing copper sulphate solution in an iron container. Using your knowledge of metals and chemical reactions, explain whether this is appropriate or not."

(Hint: No, because Iron is more reactive than copper)

Q.3 "Using your understanding of redox reactions in an electrochemical cell, explain the direction in which electrons flow between the anode and cathode."

(Hint: Anode to cathode because electron density is more at anode due to loss of electron)

Q.4 Calculate the oxidation numbers of each sulphur atom in the following compounds:

(a) $Na_2S_2O_3$ (b) Na_2SO_4

(Hint: (a) +2 and (b) +6

Q.5 **Show that F cannot undergo disproportionation reaction?**

(Hint : F cannot show three different oxidation states)

SECTION –C (3 marks each)

Q.1 Depict the galvanic cell in which the reaction

$Zn_{(s)} + 2Ag^+_{(aq)}$ -----------> $Zn^{2+}_{(aq)} + 2Ag_{(s)}$ takes place. Further show :

(i) Which electrode is negatively charged.

(ii) The carriers of the current in the cell.

(iii) Individual reaction at each electrode**.**

(Hint : (i) Zn (ii) Ag to Zn electrode (iii) oxidation half reaction and reduction half reaction)

Q.2 **Consider the elements: Cs, Ne, I and F**

(a) Identify the element that exhibits only negative oxidation state.

(b) Identify the element that exhibits only positive oxidation state.

(c) Identify the element that exhibits both positive and negative oxidation states.

(d) Identify the element which exhibits neither the negative nor does the positive oxidation state.

(Hint :a –F b - Cs c- I d-Ne)

Q.3 Write the balanced chemical equation corresponding to the reaction. (In acidic medium)

$Cr_2O_7^{2-}{}_{(aq)} + Fe^{2+}{}_{(aq)} \rightarrow Cr^{3+}{}_{(aq)} + Fe^{3+}{}_{(aq)}$

(Hint : Balance the equation by following the steps)

Q.4 Balance the equation

$MnO_4^- + I^- \rightarrow Mn^{2+} + I_2 + H_2O$ by ion electron method in acidic medium

(Hint : Balance the equation by following the steps)

Q.5 "Why is a salt bridge used in an electrochemical cell? Explain its role and significance."

(Hint : To complete the circuitand to maintain the electrical neutrality of the solutions in the two half cells.)

SECTION – D CASE STUDY BASED QUESTIONS (4 MARKS)

Q.1 The idea of oxidation number has been invariably applied to define oxidation, reduction, oxidising agent (oxidant), reducing agent (reductant) and the redox reaction. To summarise, we may say that:

Oxidation: An increase in the oxidation number of the element in the given substance.

Reduction: A decrease in the oxidation number of the element in the given substance.

Oxidising agent: A reagent which can increase the oxidation number of an element in a given substance. These reagents are called as oxidants also.

Reducing agent: A reagent which lowers the oxidation number of an element in a given substance. These reagents are also called as reductants.

Redox reactions: Reactions which involve change in oxidation number of the interacting species.

1) In … an ion (or an atom) in a compound is replaced by an ion (or an atom) of another element.

(a) displacement reaction (b) decomposition reaction
(c) disproportionation reaction (d) combination reaction

2) … leads to the breakdown of a compound into two or more components at least one of which must be in the elemental state.

(a) displacement reaction (b) decomposition reaction
(c) disproportionation reaction (d) combination reaction

3) In …. an element in one oxidation state is simultaneously oxidised and reduced.

(a) displacement reaction (b) decomposition reaction
(c) disproportionation reaction (d) combination reaction

4) Reactions which involve change in oxidation number of the interacting species…

(a) Exothermic reaction (b) Endothermic reaction
(c) Neutralization reaction (d) Redox reaction

(Hint: (1) (a) , (2) (b) , (3) (c) , (4) (d))

Q.2Jiya conducted an experiment to study redox reactions. She placed a clean iron nail into a beaker containing blue copper(II) sulfate solution. After a few minutes, she noticed a reddish-brown coating forming on the nail and the blue color of the solution fading gradually. Curious, she decided to analyze the changes using her understanding of redox chemistry.

(a) Identify the type of chemical reaction occurred between iron and copper(II) sulfate?

(b) Identify which species is oxidized and which is reduced in this reaction.

(c) Write the balanced chemical equation for the reaction.

(d) Predict and justify what will happen if a copper strip is placed in iron(II) sulfate solutioninstead.

(Hint: (a) redox reaction and also a displacement reaction.

(b) Iron (Fe) is oxidized and Copper ions (Cu^{2+}) are reduced:

(c) $Fe_{(s)} + CuSO_{4\,(aq)} \rightarrow FeSO_{4\,(aq)} + Cu_{(s)}$

(d) Copper is **less reactive** than iron and cannot displace iron from iron(II) sulfate solution. Therefore, no reaction occurs when a copper strip is placed in $FeSO_4$)

SECTION – E (5 marks each)

Q.1 Identify the redox reactions out of the following reactions and identify the oxidising and reducing agents in them.

(i) $3\,HCl_{(aq)} + HNO_{3(aq)} \rightarrow Cl_{2(g)} + NOCl_{(g)} + 2H_2O_{(l)}$

(ii) $HgCl_{2(aq)} + 2KI_{\,(aq)} \rightarrow HgI_{2(s)} + 2KCl_{\,(aq)}$

(iii) $Fe_2O_{3(s)} + 3CO_{(g)} \rightarrow 2Fe_{(s)} + 3CO_{2(g)}$

(iv) $PCl_{3(l)} + 3H_2O_{(l)} \rightarrow 3HCl(aq) + H_3PO_{4\,(aq)}$

(v) $4NH_3 + 3O_{2(g)} \rightarrow 2N_{2(g)} + 6H_2O_{(g)}$

(Hint: (i) HNO_3 (O.A.), HCl (R.A.),(ii)Not a redox reaction

(iii) Fe_2O_3(O.A.), CO(R.A.), (iv) not a redox reaction (v) O_2 (O.A.) ,NH_3(R.A.))

Q.2 (a)Why are redox reactions important in everyday life and industrial processes?

(b)On the basis of standard electrode potential values, suggest which of the following reactions would take place? (Consult the book for E^0 value).

(i) $Cu_{(s)} + Zn^{2+}_{(aq)} \longrightarrow Cu^{2+}_{\,(aq)} + Zn_{(s)}$

(ii) $Mg_{(s)} + Fe^{2+}_{(aq)} \longrightarrow Fe_{(s)} + Mg^{2+}_{(aq)}$

(iii) $Cd_{(s)} + Fe^{2+}_{(aq)} \longrightarrow Fe(s) + Cd^{2+}_{(aq)}$

(Hint: (a) In electrochemistry , (b) (i) and (iii) reaction is not feasible , (ii) is feasible)

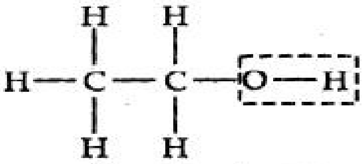
****

8.ORGANIC CHEMISTRY-SOME BASIC PRINCIPLES AND TECHNIQUES
SUMMARY

Organic Chemistry

Organic chemistry is the branch of chemistry that deals with the study of hydrocarbons and their derivatives.

- **The Shapes of Carbon Compounds:** In organic or carbon compounds, s and p orbitals are involved in hybridisation. This leads to three types of hybridisation which are sp^3(in alkanes) – Tetrahedral in shape sp^2(in alkenes) – Planar structure sp(in alkynes) – Linear molecule
- **Functional Group:** The functional group are atom or group of atoms joined in a specific manner which determines the chemical properties of the organic compound. The examples are hydroxyl group (—OH), aldehyde group (—CHO) and carboxylic acid group (—COOH) etc.

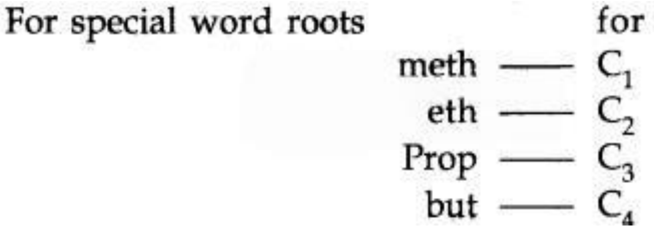


Functional group

- **Homologous Series -** A homologous series may be defined as a family of organic compounds having the same functional group, similar chemical properties and the successive members differ from each other in molecular formula by —CH_2 units. The members of a homologous series can be represented by same general molecular for.
- **IUPAC (International Union of Pure and Applied Chemistry) -**

According to IUPAC system, the name of an organic compound contains three parts: (i) word root, (ii) suffix, (iii) prefix.

(i) Word root: Word root represents the number of carbon atoms present in the principal chain, which is the longest possible chain of carbon atoms.



For special word roots for

meth —— C_1

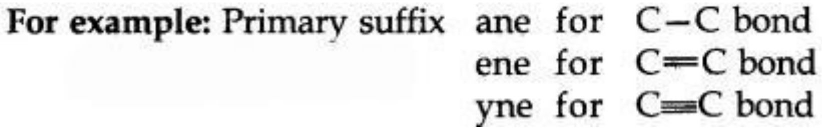
eth —— C_2

Prop —— C_3

but —— C_4

(ii) Suffix: Suffix are of two types, primary suffix, secondary suffix.

(a) Primary Suffix: It indicates the type of bond in the carbon atoms.



For example: Primary suffix ane for C−C bond

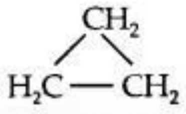
ene for C=C bond

yne for C≡C bond

(b) Secondary Suffix: Secondary suffix is used to represent the functional group.

(iii) Prefix: Prefix is a part of IUPAC name which appears before the word root. Prefix are of two types:

(a) Primary prefix: For example, primary prefix cyclo is used to differentiate cyclic compounds.



cyclopropane

(b) Secondary prefix: Some functional groups are considered as substituents and denoted by secondary prefixes.

For example:

Substituted Group	Secondary prefix.
— F	Fluoro
— Cl	Chloro
— Br	Bromo
— NO	Nitroso
— NO_2	Nitro
— CH_3	Methyl
— OCH_3	Methoxy

- **Naming of Compounds Containing Functional Groups:** The longest chain of carbon atoms containing the functional group is numbered in such a manner that the functional group is attached at the carbon atoms possessing lowest possible number in the chain.

  In case of polyfunctional compounds, one of the functional group is selected as principal functional group and the compound is named on that basis. The choice of principal functional group is made on the basis of order of preference. The order of decreasing priority for the functional group is

$$-COOH,\ -SO_3H,\ -COOR\ (R = \text{alkyl group})\ COCl,\ -CONH_2,\ COCl,$$
$$-CONH_2,\ -CN,\ -C{=}O, > -C{=}O,\ -OH,\ -NH_2 > C{=}C<,\ -C{\equiv}C-$$

- **Isomerism :**When there are two or more compounds possessing the same molecular formula but different structural formula and different physical and chemical properties, the phenomenon is called isomerism. Such compounds are called isomers.

  It is of two types:

  (1) Structural Isomerism

  (2) Stereoisomerism

  (1) Structural Isomerism: Structural isomerism is shown by compounds having the same molecular formula but different structural formulae differing in the arrangement of atoms

  It is of following types-chain,functional,position,metamerism,tautamerism.

  (2) Stereoisomerism: When isomerism is caused by the different arrangements of atoms or groups in space, the phenomenon is called stereoisomerism. The steroeoisomers have same structural formula but differ in arrangement of atoms in space.

- **Fundamental Concepts in Organic Reaction Mechanism**

  Fission of a covalent bond: A covalent bond can undergo Fission in two ways:

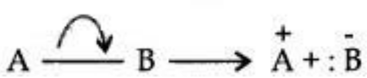
  (i) By Homolytic Fission or Homolysis

  (ii) By Heterolytic Fission or Heterolysis

Homolytic Fission: In this process each of the atoms acquires one of the bonding electrons.

- A-A → A^*+A^*

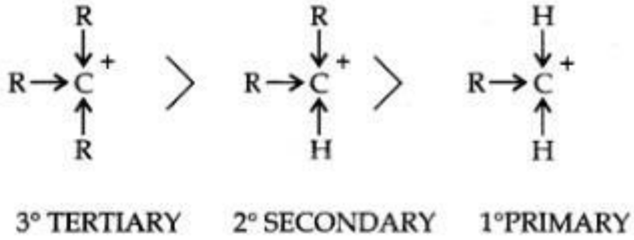
- **Heterolytic Fission:** In this process one of atoms aquires both of the bonding electrons
when the bond is broken.
If B is more electronegative than A which thereby aquires both the bonding electrons and becomes negatively charged.



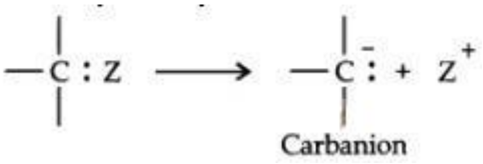
The products of heterolytic fission are ions.
Reaction Intermediates: Heterolytic and homolytic bond fission results in the formation of short-lived fragments called reaction intermediates. Among the important reaction intermediates are carbonium ions, carbanions, carbon free radicals and carbenes.

- Carbocations: Organic ions which contain a positively charged carbon atom are called carbonium ions or carbocations. They are formed by heterolytic bond fission.

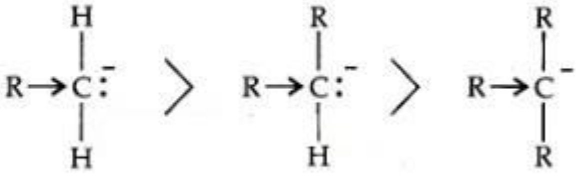
where Z is more electronegative than carbon.
Tertiary carbonium ion is more stable than a secondary, which in turn is more stable than a primary because of +I effect associated with alkyl group.



***Carbanion:** Organic ion which contains a negatively charged carbon atom are called carbanions. They are also formed by hterolytic bond fission.

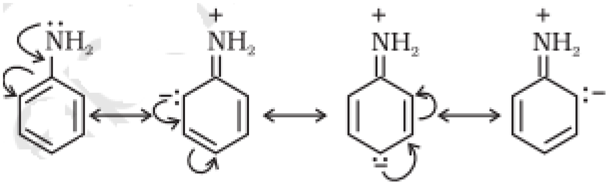


Where Z is less electronegative than carbon. A primary carbanion is more stable than a secondary, which in turn is more stable than a tertiary, because of +I effect associated with alkyl group.



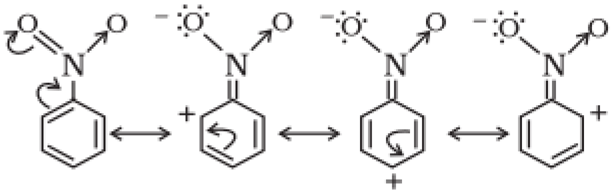
- **Electrophile:** It is positively charged or neutral species which is electron deficient, e.g.,
  He^-, H_20^+, CH_3 , NH_4^+, $AlCl_3$, $S0_3$, $CHCl_2$,CCl_3.
- **Nucleophile**: It is negatively charged or neutral species with lone pair of electrons e.g., (HO^-), Cyanide (C = N), H_20: R_3N, R_2NH etc.
- **Electron Displacement Effects in Covalent Bonds:** Electronic displacements in covalent bonds occurs due to the presence of an atom or group of different electronegativity or under the influence of some outside attaching group.
  These lead to a number of effects which are as follows:
  (i) Inductive effect (ii) Elecromeric effect
  (iii) Resonance or Mesomeric effect (iv) Hyperconjugation effect.
- **Inductive Effect:** It involues c electron. The a electrons which form a covalent bond are seldom shared equally between the two atoms. Due to different electronegatively electrons are displaced towards the more electronegative atom.
  This introduces a certain degree of polarity in the bond

- Atoms or groups which donate electrons towards a carbon atom are said to have a **+I effect**.eg- alkyl group
- Those atoms or groups which draw electrons away from a carbon atom are said to have a **-I Effect**.eg-Cl^-,-OH,-NO_2
- **Resonance Effect:** The polarity produced in the molecule by the interaction of two π-bonds or between a π-bond and a lone pair of electrons present on an adjacent atom. There are two types of resonance or mesomeric effects designated as R or M effect.
  Positive Resonance Effect (+R effect):
  Those atoms which lose electrons towards a carbon atom are said to have a +M effect or +R effect. For example**:**



—Cl, —Br, —I, —NH_2, —NR_2, —OH, —OCH_3

Negative Resonance Effect (-R effect): Those atoms or groups which draw electrons away from a carbon atom are said to have a -M effect or -R effect.



For example:-COOH,-CHO,-CN

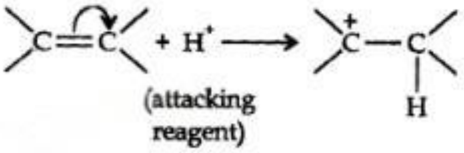
Electromeric Effect (E Effect):

The electromeric effect refers to the polarity produced in a multiple bonded compound when it is attacked by a reagent when a double or a triple bond is exposed to an attack by an electrophile E^+ (a reagent) the two π electrons which from the π bond are completely transferred to one atom or the other. The electromeric effect is represented as:

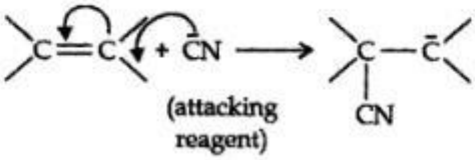
.

It is represented by E and the shifting of the electrons is shown by a curved arrow (↷). There are two distinct types of electromeric effect.

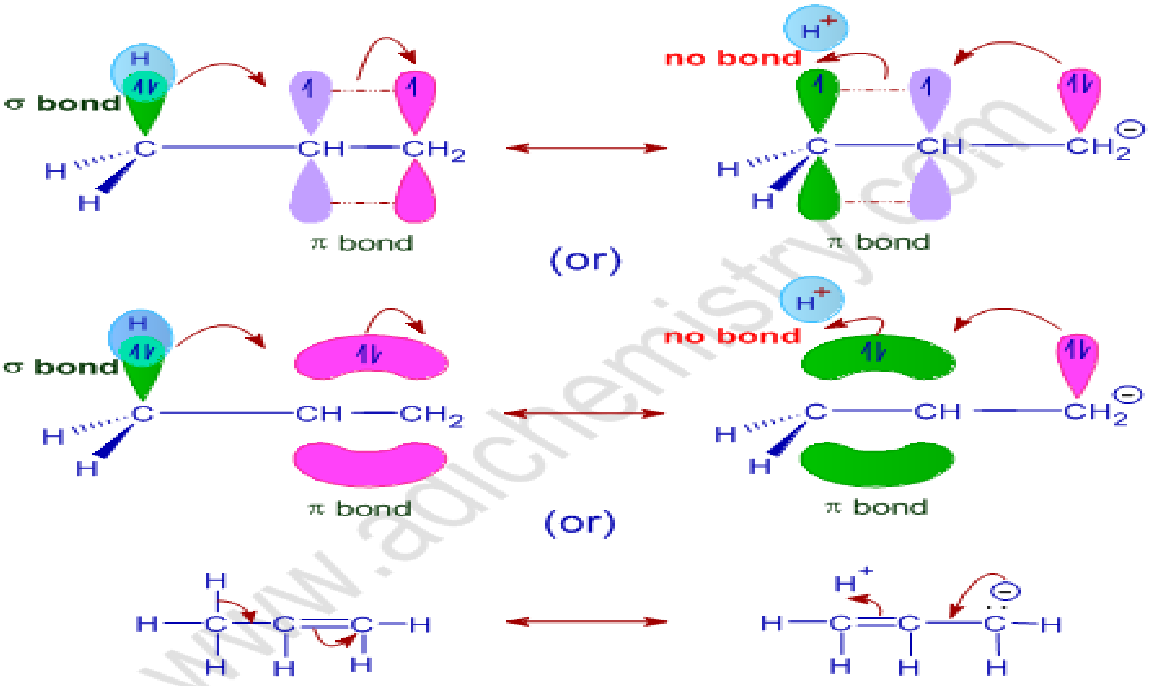
(*i*) **Positive Electromeric Effect (+E effect):** In this effect the π electrons of the multiple bond are transferred to that atom to which the reagent gets attached.



(*ii*) **Negative Electromeric Effect (–E effect):** In this effect the π electrons of the multiple bond are shifted to that atom to which the attacking reagent does not get attached.



- **Hyperconjugation or No Bond Resonance:** Hyperconjugation is a stabilizing interaction that involves the delocalization of electrons from a sigma (σ) bond (usually C – H or C – C) to an adjacent empty or partially filled p-orbital or π -orbital. It's often used to explain the stability of carbocations, alkenes, and radicals.:. This way of electron release by assuming no bond character in the adjacent C—H bond is called No-Bond Resonance or Hyperconjugation



Hyperconjugation in propene

.**METHODS OF PURIFICATION OF ORGANIC COMPOUNDS:**

1. Crystallization

- **Principle**: Based on differences in solubility of the compound and impurities in a suitable solvent.
- **Use**: Purification of solid organic compounds.

2. Sublimation

- **Principle**: Some solids can directly change to gas without becoming liquid (sublime).
- **Use**: For purifying solids that sublime (e.g., camphor, naphthalene).

3-Distillation

- **Principle**: Based on different boiling points.
- **Use**:
  - For liquid-liquid mixtures.
  - For separating volatile liquids from non-volatile impurities.
- **Types**:
- **Simple distillation** – large difference in boiling points (> 25°C).
- Fractional distillation – Small difference in boiling points (e.g., in petroleum refining)

4. Distillation under Reduced Pressure (Vacuum Distillation)

- **Use**: For compounds that decompose on heating.
- **Principle**: Boiling point of a liquid decreases under reduced pressure.

5. Steam Distillation

- **Use**: For temperature-sensitive organic compounds that are immiscible with water.
- **Principle**: Volatile compounds co-distill with steam at a lower temperature.
- **Example**: Extraction of essential oils

7. Chromatography

- **Principle**: Based on differential adsorption of compounds on an adsorbent.
- **Use**: For separation and purification of mixtures of compounds (especially colored compounds).
- **Types**:
- **Paper Chromatography**
- **Column Chromatography**
- **Thin Layer Chromatography (TLC)**
- **Formula to calculate R_f value:**
- **R_f =distance traveled by the compound/distance traveled by the solvent**

Qualitative analysis

Preparation of Lassaigne's Extract:

- **Fusion:**
  - A small piece of **dry sodium metal** is taken in a fusion tube.
  - The **organic compound** (dry, powdered form) is added.
  - The tube is heated strongly until the mixture melts and fuses. This helps sodium react with N, S, and halogens in the compound.
- **Quenching:**
  - The hot tube is plunged into **distilled water** in a beaker and broken.
  - The solution is **boiled for a few minutes** to ensure complete extraction of the ionic compounds.
- **Filtration** The mixture is filtered.

The clear filtrate is called the **Lassaigne's extract**.

Quantitative Analysis

Element	Estimation Method	Formula
Carbon	Carius Method	%C = (Mass of CO_2 × 12× 100) / (44 × Mass of sample)

Hydrogen	Carius Method	%H = (Mass of H_2O × 2 × 100) / (18 × Mass of sample)
Nitrogen	Kjeldahl Method	%N = (1.4 × Volume of acid × Normality) / Mass of sample
Nitrogen	Dumas method	%N=28×V(volume of N_2 at STP)×100/22.4×mass of sample
Sulphur	Carius Method	%S = (Mass of $BaSO_4$ × 32 × 100) / (233 × Mass of sample)
Chlorine	Carius Method	%Cl = (Mass of AgCl × 35.5 × 100) / (143.5 × Mass of sample

SECTION - A (1 mark question)

Q1. Select the compound that behaves as a nucleophile.
(a) BF_3 (b) NH_3(c) $AlCl_3$ (d) H^+

Q2. Out of the following which one is the correct order of stability of carbocations?
(a) 1° > 2° > 3° (b) 3° > 2° > 1°
(c) 2° > 3° > 1° (d) 1° > 3° > 2°

Q3. Hyperconjugation involves interaction of:
(a) σ and π bonds (b) σ and p orbitals
(c) π and π orbitals (d) lone pair and π bond

Q4. Homolytic fission of a covalent bond results in:
(a) Carbocation and carbanion (b) Free radicals
(c)Two ions (d) Nucleophile and electrophile

Q5. The strongest acid among the following is:
(a) CH_3CH_2OH (b) CH_3COOH
(c) HCOOH (d) $C_2H_5NH_2$

Q6. The hybridization of carbon in ethyne (C_2H_2) is:
(a)sp (b) sp^2
(c) sp^3 (d) dsp^2

Q7. The IUPAC name of CH_3CH_2COOH is:
(a) Propanoic acid (b)Ethanoic acid
(c) Butanoic acid (d) Acetic acid

Q8. Identify the true statement about mesomericeffect .
(a) It is a temporary effect (b) It operates through sigma bonds
(c) It involves delocalization of π electrons (d) It is due to electronegativity

Q9. Which is a planar molecule?
(a) Ethane (b) Ethene
(c) Cyclohexane (d) Propane

Q10. Which one of the following reactions does not belong to Lassaign'stest

(a) $Na + X \xrightarrow[\Delta]{} +NaX$ (b) $2CuO + C \xrightarrow[\Delta]{} 2Cu + CO_2$

(c) $Na + C + N \xrightarrow[\Delta]{} NaCN$ (d) $2Na + S \xrightarrow[\Delta]{} Na_2 S$

Assertion and reason type question

(a) Assertion and reason both are correct statements and reason is the correct explanation for assertion.

(b) Assertion and reason both are correct statements but the reason is not a correct explanation for assertion.

(c) Assertion is a correct statement but the reason is the wrong statement.

(d) Assertion is a wrong statement but the reason is a correct statement

Q11.**Assertion (A):**Carbocations are electron-deficient species.

Reason (R): Carbocations have a sextet of electrons in the valence shell of the positively charged carbon.

Q12. Assertion (A): Resonance structures differ in the position of atoms.

Reason (R): Resonance involves delocalization of electrons.

Q13. Assertion (A): Electrophiles are electron-deficient species.

Reason (R): Electrophiles donate a pair of electrons to form a new bond.

Q14.**Assertion (A):** The angle between bonds in methane (CH_4) is 109.5°.

Reason (R): Methane has sp^2 hybridized carbon atom.

Q15.**Assertion (A):**Functional groups determine the chemical properties of organic compounds.

Reason (R): All organic compounds with the same functional group behave similarly.

Ans.:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B	B	B	B	C	A	A	C	B	B	A	D	C	C	A

SECTION - B (2 MARKS)

Q1. Can you explain what a carbocation is? Explain its stability order.

Hint: Stability order: tertiary (3°) > secondary (2°) > primary (1°) > methyl.

Q2. State a technique commonly employed for purification of

a)A liquid that decomposes at its boiling point

b) Kerosene containing water.

Hint:a)Distillation under reduced pressure.

b)Separating funnel

Q3. 0.45 of an organic compound when analysed by combustion method, gave 1.10 g carbon dioxide and 0.30 g water. Calculate the percentage of carbon and hydrogen in it.

Hint:C%=12×mass of CO2/44×mass of organic compound

H%=2×mass of water/18×mass of organic compound

C%=66.67;H%=7.41%

Q4.. Which electron displacement effect explain the following correct orders of acidity of the carboxylic acids?

(a) $Cl_3CCOOH > Cl_2CHCOOH > ClCH_2\,COOH$

(b) $CH_3CH_2COOH > (CH_3)_2\,CHCOOH > (CH_3)_3CCOOH$

Hint:Inductive effect (-I and +I)

Q5.Identify the hybridized state of each C atom in the following compound

$CH_2 = CH – CN$

Hint: SP^2,SP^2,SP

SECTION – C (3 MARKS)

Q1. Explain the term 'reaction intermediates' and describe any two types along with examples.

Hint:Carbanion/ carbocation and free radical

Q2.Draw structures for the following IUPAC name

a)2-chloro 2-phenyl butane

b) 1,2 dibromo ethane

c)Propane 1,2,3carboxylic acid

Hint: a) CH3-CH(Cl)-C(C6H5)-CH3

b)Br-CH_2-CH_2-Br

c) COOH-CH_2-CH(COOH)-CH_2-COOH

Q3. 0.3 g of urea (NH_2CONH_2) was analyzed according to Kjeldahls method. After digestion, the released ammonia was absorbed in 40 mL of 0.1 MHCl.The excess of acid required 15 mL of 0.1 M NaOH solution for complete netralization. Calculate % nitrogen.

Hint: $M_1V_1=M_2V_2$ N%=1.4×volume of acid used×M/mass of organic compound N%=11.67%

Q4. Account for the following:

a) Methyl amine is more basic than ammonia.

b) NH_4^+ is not considered an electrophile.

c) Benzene is more stable than expected from its structure.

Hint. a) +I effect

b) Absence of vacant orbitals.

c) Resonance energy

Q5. a) On what principle does chromatography work?

b) In a TLC experiment, a compound has an Rf value of 0.70 and the solvent front moved 9.0 cm. How far did the compound travel?

Hint:a) Refer summary

- b) **R_f =distance traveled by the compound/distance traveled by the solvent ;6.3cm**

SECTION - D(CASE BASED STUDY QUESTIONS)

Q1 Raj, a Class 11 student, is studying organic chemistry and learning how carbon compounds form different structures. He comes across three compounds in his chemistry lab:

1. **Methane (CH_4)**
2. **Ethene (C_2H_4)**
3. **Ethyne(C_2H_2)**

He notices that all three compounds contain carbon and hydrogen, but their bonding Sand reactivity are different. He is curious to learn how their structures influence their proper

a) What is the hybridization of the carbon atoms in methane, ethane?

b) Classify each compound as saturated or unsaturated.

c) Identify the type of bonds present in , ethene, and ethyne. How many sigma (σ) and pi (π) bonds are there in each compound?

Hint:a)SP^3,SP^2 b)methane(saturated), ethene and ethyne (unsaturated)

- c**)Ethene (C_2H_4):** 5 σ bonds, 1 π bond
- **Ethyne (C_2H_2):** 3 σ bonds, 2 π bonds

Q2. Nisha is studying the chapter "Organic Chemistry – Some Basic Principles and Techniques." Her teacher gives her a chart with the following compounds:

- **Compound A:** CH_3CH_2OH
- **Compound B:** CH_3COOH
- **Compound C:**CH_3Cl
- **Compound D:** CH_3CHO
- **Compound E:** $CH_3CH(OH)CH_3$

She is asked to identify the functional groups and understand their naming and properties

a) Identify the functional group in compound B and D
b) Write the IUPAC name of compound E
c) Which compounds among A–E belong to the same homologous series? Name the series..

Hint: a) Carboxylic acid ,aldehyde b)Propan -2-ol c)A and E(alcohol)

SECTION - E(5 MARKS)

Q1Consider structures 1 to 7 and answer the questions a to e

1.$CH_3CH_2CH_2CH_2OH$
2.$CH_3CH_2CH(OH)CH_3$
3.$CH_3CH_2OCH_2CH_3$
4.$CH_3CH_2COCH_2CH_3$
5.$CH_3COCH_2CH_2CH_3$
6.$CH_3\text{-}CH_2CH_2CH_2CH_3$
7.$(CH_3)_2CHCH_2CH_3$

(a) Point out the pair of compounds that are metamers.
(b) From the compounds mentioned, which ones form a pair of functional group isomers.
(c) Which of the listed compounds exhibit position isomerism?
(d) Identify the pairs of compounds that represents chain isomerism.
(e) Give a definition of stereoisomerism..

Hint: a)4&5 b)1&3,2&3 c)1&2 d)6&7

Q2(i).Give IUPAC names for following compounds:

a.$HO–CH_2–CH_2–COOH$ b.$CH_3–CHBr–CH_2–CH_3$ C. $CH_3–CH=CH–COOH$

(ii) Account for the following:

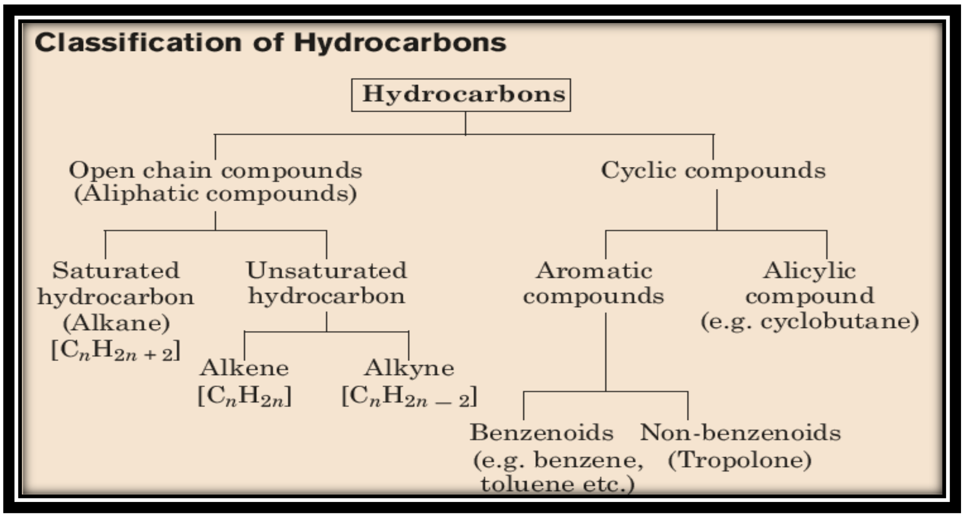
a) Toluene is o,p directing. b. Propene is more stable than ethene.

Hint (i) a)2-Hydroxypropanoic acidb) 2-Bromobutane

b) But-2-enoic acid(ii)a) hyperconjugationb)hyperconjugation

9. HYDROCARBONS
SUMMARY

The term ‘hydrocarbons’means compounds of carbon and hydrogen only.



ALKANES-Hydrocarbons containing carbon-carbon single bonds.The general formula for alkane is C_nH_{2n+2}.

Preparation of Alkanes

i. **From unsaturated hydrocarbons:**

This process of addition of dihydrogen is known as **hydrogenation** process.

$CH_2{=}CH_2 + H_2 \longrightarrow CH_3\text{-}CH_3$

$CH{\equiv}CH + 2H_2 \longrightarrow CH_3\text{-}CH_3$

ii. **From alkyl halides**

a) **Reduction:**$CH_3\text{-}Cl \xrightarrow{Zn/HCl} CH_4$

b) **Wurtz reaction:**$CH_3Br + 2Na + BrCH_3 \xrightarrow{Dry\ ether} CH_3\text{-}CH_3 + 2NaBr$

iii. **From carboxylic acids**

a) **By decarboxylation of carboxylic acids:**

$CH_3COONa + NaOH \xrightarrow{CaO,\ \Delta} CH_4 + Na_2CO_3$

b) **Kolbe’s electrolytic method:**

$CH_3COONa + 2H_2O \longrightarrow CH_3\text{-}CH_3 + 2CO_2 + H_2 + NaOH$

Properties of Alkanes

Physical Properties

- C1 to C4 are gases, C5 to C17 are liquids and C18 or more are solids at 298 K.
- They all are colourless and odourless.
- Alkanes are generally insoluble in water or in polar solvents, but they are soluble in non-polar solvents like, ether, benzene, carbon tetrachloride etc.
- The boiling points of straight chain alkanes increase regularly with the increase of number of carbon atoms.

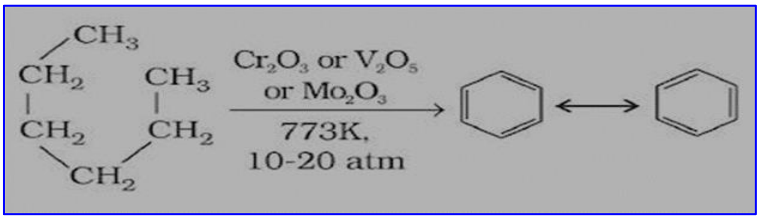
Chemical Properties

i. Halogenation reaction:$CH_4 + Cl_2 \xrightarrow{UV\ or\ high\ Temp} CH_3Cl + HCl$

ii. Combustion: $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

iii. Controlled oxidation: $2CH_4 + O_2 \longrightarrow \xrightarrow{Cu, 523K/100atm} 2CH_3OH$

iv. Aromatization:



v. Reaction with steam: $CH_4 + H_2O \longrightarrow CO + 3H_2$

Conformations of ethane:

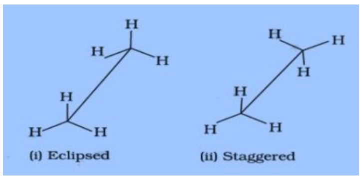
Eclipsed conformation: - conformation in which hydrogen atoms attached to two carbons are as closed together as possible is called eclipsed conformation and

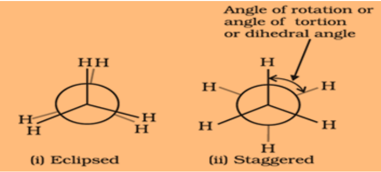
Staggered conformation: - conformation in which hydrogens are as far apart as possible is known as the staggered conformation.

Skew conformation:-Any other intermediate conformation is called a skew.

Projection of Eclipsed and Staggered Conformations of Ethane

Sawhorse Projection **Newman projections**





Relative stability of conformations

Staggered conformation is more stable than the eclipsed conformation.

Order of stability:-

Staggered conformation > skew conformation > eclipsed conformation

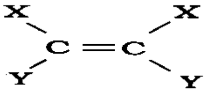
ALKENES

Alkenes are unsaturated hydrocarbons containing at least one carbon-carbon double bond with general formula C_nH_{2n}.

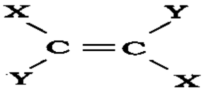
Conditions for Geometrical isomerism in Alkenes

Each double bonded carbon atom should be attached with two different atoms or groups.

The geometrical isomers are also known as cis-trans isomers.



cis-isomer

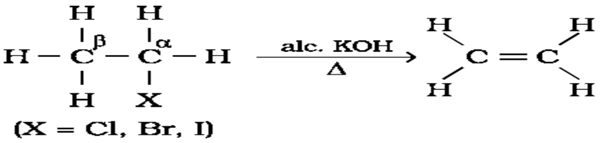


trans-isomer

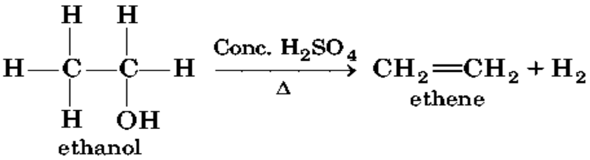
Preparation

i. From alkynes: $CH\equiv CH + H_2 \longrightarrow \xrightarrow{Pd/C} CH_2=CH_2$

ii. From alkyl halides:



(iii) From alcohols by acidic dehydration:



Properties of Alkenes

Physical properties

- The first three members of alkenes are gases, the next fourteen are liquids and the higher ones are solids.
- Alkenes are colourless and odourless, insoluble in water but fairly soluble in non-polar solvents like benzene, petroleum ether.
- They show a regular increase in boiling point with increase in size.

Chemical properties

i. **Addition of dihydrogen:** $CH_2=CH_2 + H\text{-}H \xrightarrow{Ni\ or\ Pt\ or\ Pd} CH_3\text{-}CH_3$

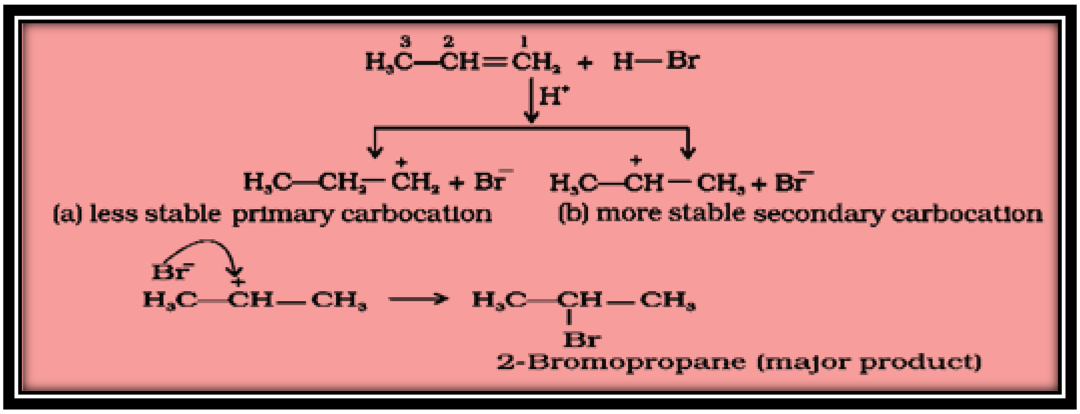
ii. **Addition of halogens:** $CH_2=CH_2 + Br\text{-}Br \xrightarrow{CCl4} Br\text{-}CH_2\text{-}CH_2\text{-}Br$

iii. **Addition of hydrogen halides:**

Markovnikov rule: According to the rule, the negative part of the addendum (adding molecule) adds to that carbon atom of the unsymmetrical alkene which is maximum substituted or which possesses lesser number of hydrogen atoms.

$CH_3CH=CH_2 + HBr \longrightarrow CH_3\text{-}CH(Br)\text{-}CH_3$

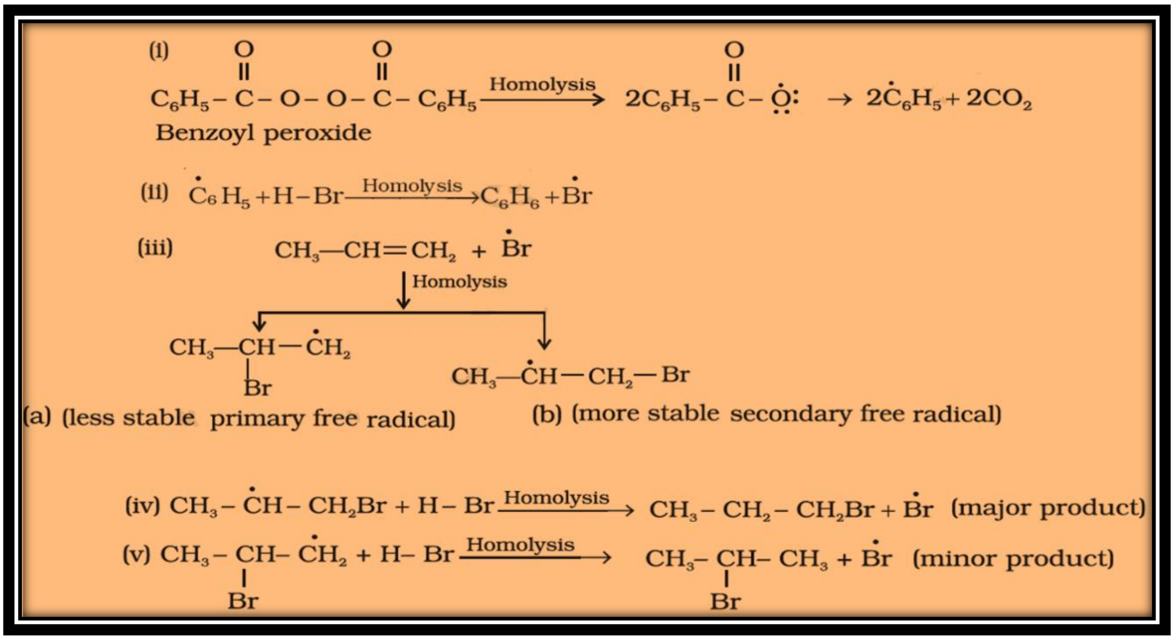
Mechanism of Addition according to Markovnikov Rule



Anti Markovnikov addition or Peroxide effect or Kharash effect: In the presence of peroxide, addition of HBr to unsymmetrical alkenes like propene takes place contrary to the Markovnikov rule. This happens only with HBr but not with HCl or HI. This reaction is known as peroxide or Kharash effect or addition reaction anti to Markovnikov rule.

$CH_3CH=CH_2 + HBr \longrightarrow CH_3\text{-}CH_2\text{-}CH_2\text{-}Br$

Mechanism of Addition according to AntiMarkovnikov Rule



(i) $C_6H_5-\overset{O}{\overset{\|}{C}}-O-O-\overset{O}{\overset{\|}{C}}-C_6H_5 \xrightarrow{\text{Homolysis}} 2C_6H_5-\overset{O}{\overset{\|}{C}}-\dot{\ddot{O}}: \rightarrow 2\dot{C}_6H_5+2CO_2$

Benzoyl peroxide

(ii) $\dot{C}_6H_5+H-Br \xrightarrow{\text{Homolysis}} C_6H_6+\dot{Br}$

(iii) $CH_3-CH=CH_2+\dot{Br} \xrightarrow{\text{Homolysis}}$

$CH_3-\underset{Br}{\underset{|}{CH}}-\dot{C}H_2$ (a) (less stable primary free radical)

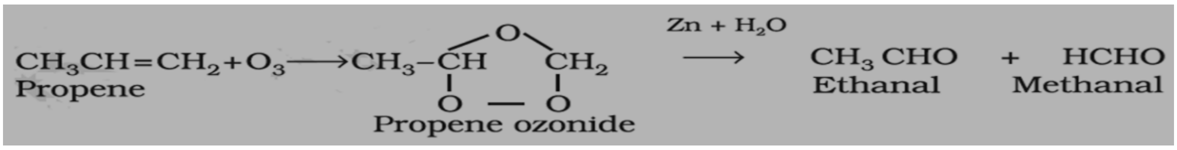
$CH_3-\dot{C}H-CH_2-Br$ (b) (more stable secondary free radical)

(iv) $CH_3-\dot{C}H-CH_2Br+H-Br \xrightarrow{\text{Homolysis}} CH_3-CH_2-CH_2Br+\dot{Br}$ (major product)

(v) $CH_3-\underset{Br}{\underset{|}{CH}}-\dot{C}H_2+H-Br \xrightarrow{\text{Homolysis}} CH_3-\underset{Br}{\underset{|}{CH}}-CH_3+\dot{Br}$ (minor product)

Ozonolysis :

Products are carbonyl compounds (aldehyde and /or ketone)



$CH_3CH=CH_2+O_3 \longrightarrow$ Propene ozonide $\xrightarrow{Zn\ +\ H_2O} CH_3CHO + HCHO$

iv. Polymerisation:

$$n(CH_2=CH_2) \xrightarrow[\text{Catalyst}]{\text{High temp./pressure}} -\!\!(CH_2-CH_2)\!\!-$$

Polythene

Alkynes

Alkynes are also unsaturated hydrocarbons with general formula C_nH_{2n-2}.

Nomenclature

Preparation

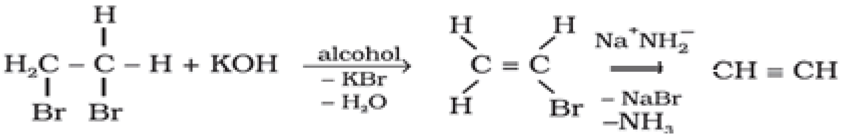
i. From calcium carbide:

$CaCO_3 \longrightarrow CaO + CO_2$

$CaO + 3C \longrightarrow CaC_2 + CO$

$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$

ii. From vicinal dihalides:



$H_2\underset{Br}{\underset{|}{C}}-\overset{H}{\overset{|}{\underset{Br}{\underset{|}{C}}}}-H + KOH \xrightarrow[-KBr,\ -H_2O]{\text{alcohol}} \begin{matrix}H & & H\\ & C=C & \\ H & & Br\end{matrix} \xrightarrow[-NaBr,\ -NH_3]{Na^+NH_2^-} CH \equiv CH$

Properties of Alkynes

Physical properties

- The first three members (acetylene, propyne and butynes) are gases, the next eight are liquids and higher ones are solids.
- Alkynes are weakly polar in nature and nearly insoluble in water. They are quite soluble in organic solvents like ethers, carbon tetrachloride and benzene.
- Their melting point, boiling point and density increase with increase in molar mass.

Chemical properties

Acidic character of alkynes

$$HC \equiv CH + Na \rightarrow HC \equiv C^{-}Na^{+} + \tfrac{1}{2}H_2$$

Monosodium ethynide

$$HC \equiv C^{-}Na^{+} + Na \rightarrow Na^{+}C^{-} \equiv C^{-}Na^{+} + \tfrac{1}{2}H_2$$

Disodium ethynide

Order of acidic strength

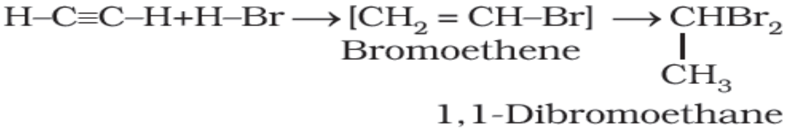
i) $HC{\equiv}CH > H_2C{=}CH_2 > CH_3{-}CH_3$

ii) $HC{\equiv}CH > CH_3{-}C{\equiv}CH >> CH_3{-}C{\equiv}C{-}CH_3$

i. **Addition of dihydrogen:** $CH{\equiv}CH + H_2 \longrightarrow CH_2{=}CH_2 \longrightarrow CH_3{-}CH_3$

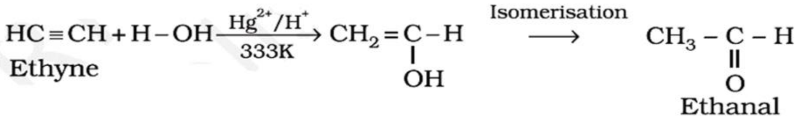
ii. **Addition of halogens:** $CH{\equiv}CH + Cl_2 \longrightarrow CH(Cl){=}CH(Cl) \longrightarrow CH(Cl)_2{-}CH(Cl)_2$

iii. **Addition of hydrogen halides:**



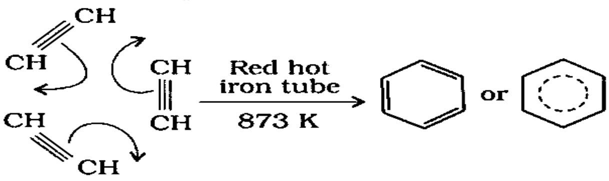
$$H{-}C{\equiv}C{-}H + H{-}Br \longrightarrow \underset{\text{Bromoethene}}{[CH_2 = CH{-}Br]} \longrightarrow \underset{\text{1,1-Dibromoethane}}{CHBr_2{-}CH_3}$$

iv. **Addition of water:**



$$\underset{\text{Ethyne}}{HC{\equiv}CH} + H{-}OH \xrightarrow[333K]{Hg^{2+}/H^{+}} CH_2{=}C(OH){-}H \xrightarrow{\text{Isomerisation}} \underset{\text{Ethanal}}{CH_3{-}C(=O){-}H}$$

v. **Polymerisation:**



vi. **Combustion:** $2C_2H_2 + 5O_2 \longrightarrow 4CO_2 + 2H_2O$

Aromatic Hydrocarbon

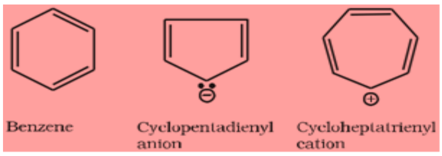
Aromatic hydrocarbons are also known as ‘arenes‘. Since most of them possess pleasant odour (Greek; aroma meaning pleasant smelling), the class of compounds are known as ‘aromatic compounds’.

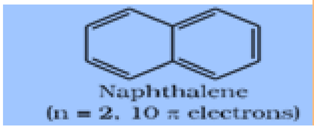
Conditions of Aromaticity

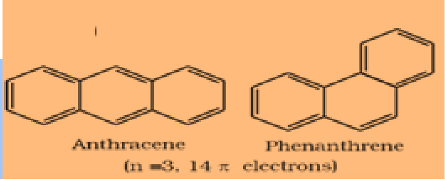
(i) Planarity

(ii) Complete delocalisation of the π electrons in the ring

(iii) Presence of (4n + 2) π electrons in the ring where n is an integer (n = 0, 1, 2 . . .). This is often referred to as **HückelRule**.Some examples of aromatic compounds are given below:

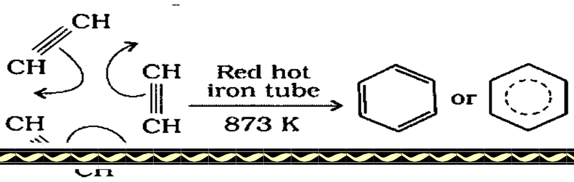




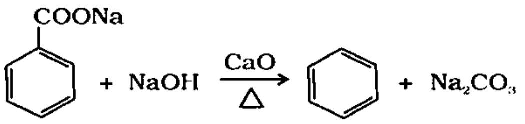


Preparation of Benzene

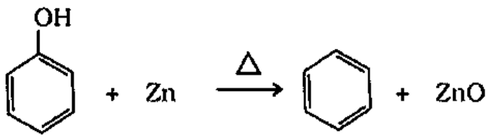
i. **Cyclic polymerisation of ethyne:**



ii. Decarboxylation of aromatic acids:



iii. Reduction of phenol:



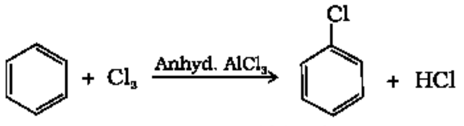
Properties of Benzene

Physical Properties

- Aromatic hydrocarbons are non-polar molecules and are usually colourless liquids or solids with a characteristic aroma. They burn with sooty flame.
- Aromatic compounds are insoluble in water but soluble in organic solvents such as alcohol and ether.

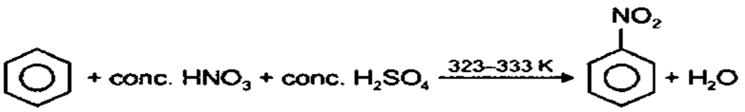
Chemical properties

i.Halogenation:

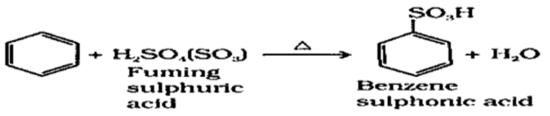


Chlorobenzene

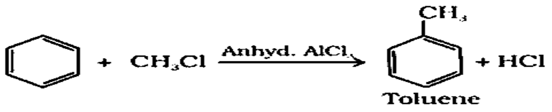
ii. Nitration:



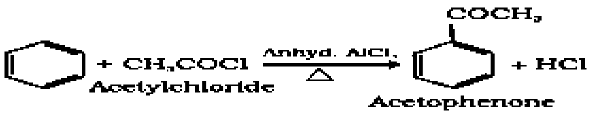
iii.Sulphonation:



iv. Friedel-Crafts alkylation reaction:



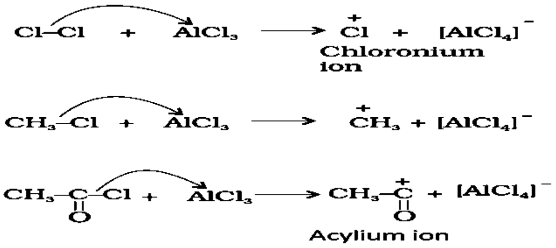
v.Friedel-Crafts acylation reaction:



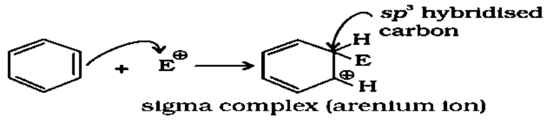
Mechanism of electrophilic substitution reactions:

These reactions are supposed to proceed via the following three steps:

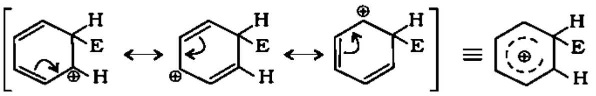
(a) Generation of electrophile E⊕:



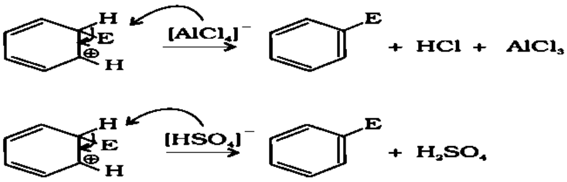
(b) Formation of carbocation intermediate (arenium ion)



The arenium ion gets stabilised by resonance:



(c) Removal of proton from the carbocation intermediate



Directive influence of a functional group in monosubstituted benzene

Ortho and para directing groups: (activating Groups)

- The groups which direct the incoming group to *ortho*and*para*positions are called *ortho*and*para*directinggroups.Examples are $-\mathrm{OH}$, $-\mathrm{NH_2}$, $-\mathrm{NHR}$, $-\mathrm{NHCOCH_3}$, $-\mathrm{OCH_3}$, $-\mathrm{CH_3}$, $-\mathrm{C_2H_5}$ etc.
- In the case of aryl halides, halogens are moderately deactivating.

Meta directing group:-(Deactivating groups)

The groups which direct the incoming group to meta position are called meta directing groups. Some examples of meta directing groups are $-NO_2$, $-CN$, $-CHO$, $-COR$, $-COOH$, $-COOR$, $-SO_3H$ etc.

CARCINOGENICITY AND TOXICITY: Benzene and polynuclear hydrocarbons containing more than two benzene rings fused together are toxic and said to possess cancer producing (carcinogenic) property. They enter into human body and undergo various biochemical reactions and finally damage DNA and cause cancer.

QUESTION BANK

SECTION – A (01 mark)

Q1. Which of the following hydrocarbon has highest boiling point?

(a) Isobutane (b) Butane (c) Neopentane (d) n-Hexane

Q2. Reaction of ethyne with Br_2 in CCl_4 gives:

(a) Bromoethane (b) 1, 2-Dibromoethane

(c) 1, 1-Dibromoethane(d) 1, 1, 2, 2-Tetrabromoethane

Q3. Ozonolysis of benzene followed its reaction with Zn/H_2O gives:

(a) HCHO (b) CHO-CHO (c) CH_3CHO (d) None of these

Q4. Phenol when distilled with zinc dust gives:

(a) Benzoic acid (b) Benzene (c) o– Nitrophenol (d) p – Nitrophenol

Q5. Which branched chain isomer of the hydrocarbon with molecular mass 72u gives only one isomer of monosubstituted alkyl halide?

(a) Tertiary butyl chloride (b) Neohexane (c) Neopentane (d) Isohexane

Q.6 The catalyst used in Friedel–Crafts reaction is

(a) Zn/HCl (b) Anhydrous Aluminium Chloride (c) Methyl Chloride (d) Copper

Q7.Isomerization of n-hexane on heating with anhydrous $AlCl_3$ and HCl gas gives

a) 2-methylpentane b) 3-methylpentane c) 2-methylhexane

d) Mixture of 2-methylpentane and 3-methylpentane

Q8. Which of the following is an example of meta directing group?

a) -CHO b) $-NH_2$ c) $-OCH_3$ d) -NHR

Q9. Chlorination of alkanes in presence of diffused sunlight is an example of

(a) Free radical addition reaction (b) Free radical substitution reaction

(c) Nucleophilic substitution reaction (d) Nucleophilic addition reaction.

Q10. Which of the following statements is not correct?

(a) An aromatic molecule must be cyclic (b) An aromatic ring must be planar

(c) An aromatic ring must involve cyclic delocalization of $(4n + 2)$ π-electrons

(d) An aromatic ring must involve cyclic delocalization of $4n$ π-electrons

Assertion-Reason questions (01 Mark)

These questions are based on Assertion-Reason and write the correct option from the following four options given:

Option (A) if Both A and R are correct and R is the correct explanation of A.

Option (B) if Both A and R are correct but R is not the correct explanation of A.

Option(C) if A is correct and R is not correct.

Option (D) if A is not correct but R is correct

Q.11. Assertion: Acetylene is acidic in nature.

Reason: In Acetylene carbon is sphybridised.

Q.12. Assertion: Boiling point of alkanes increases with increase in molecular mass.

Reason: Van der Waal's forces increase with increase in molecular mass.

Q.13. Assertion: Benzene on heating with conc. H_2SO_4 and Conc HNO_3 gives nitrobenzene.

Reason: .Mixture of Conc H_2SO_4 and Conc HNO_3 produces electrophile SO_3

Q.14. Assertion: .Boiling point of Cis-But-2-ene is higher than Trans But-2-ene

Reason: Trans-But-2-ene is polar but Cis-but-2-ene is non-polar.

Q.15. Assertion (A): Addition of HBr to propene in presence of benzoyl peroxide produces 1- bromopropane as the major product.

Reason(R): Addition of HBr to propene in the presence of peroxide follows free radical chain mechanism.

ANSWERS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
d)	d)	b)	b)	c)	b)	d)	a)	b)	d)	a)	a)	c)	c)	a)

Short Answer Type Questions (2 Marks)

Q1. Draw cis and trans isomers of hex-2-ene. Which isomer will have higher boiling point and why?

(Hint: Cis isomer has higher boiling point because it is more polar.)

Q2. Draw the possible chain isomers of alkane with Molecular Formula C_5H_{12} and write their IUPAC names.

(Hint: IUPAC Names-Pentane, 2-Methyl Butane and 2,2- Dimethyl Propane)

Q3. Draw Newman projections of ethane for the eclipsed and staggered conformations of ethane. Which of these conformations is more stable and why?

(Hint: The staggered conformation is most stable because the hydrogens and bonding pairs of electrons are at maximum distance, thus causing minimum repulsion.)

Q4. An alkene 'A' on ozonolysis gives a mixture of ethanal and pentan-3- one. Write structure and IUPAC name of 'A'.

(Hint: 3-Ethyl Pent-2-ene)

Q5.Sodium salt of which acid is needed for the preparation of methane? Write chemical equation involved.

(Hint: Sodium Acetate CH_3COONa)

Short Answer Type Questions (3 Marks)

Q1. a) Out of benzene, m–dinitrobenzene and toluene which will undergo nitration most easily and why?

b) Draw resonating structures of chlorobenzene using arrow to show Resonance effect in it.

(Hint: Toluene will undergo nitration easily due to +R effect of Methyl group attached to benzene ring which increases electron density.)

Q2. Convert the following

a) Benzoic acid to benzene b) Ethane to butane c) Ethyne to acetaldehyde

(Hint: a) First reaction with NaOH and then use soda-lime decarboxylation
b) First Chlorination of ethane and then apply wurtz reaction
c) Addition of water in the presence of H_2SO_4 and $HgSO_4$)

Q3. a) How Huckel's rule is applied?

b) Out of cyclopentadiene and cyclopentadienyl anion which one is aromatic and why?

c) Which conditions are essentially required for a compound to be aromatic

(Hint: a) Huckel's Rule states that a Cyclic, Planar molecule is considered to be Aromatic if it has $(4n + 2)$ πElectrons
b) Cyclopentadienyl anion is aromatic because it has $(4n + 2)$ πElectrons, planarity and complete delocalisation of πElectrons
c) The molecule should follow Huckel rule, there should be Complete delocalization of π electrons, Molecule should be Planar)

Q4. Use the following terms by taking an example.

a) Markovnikov's Rule b) Wurtz Reaction c)Decarboxylation reaction

(Hint: a)Negative part of the addendum is attached to that double bonded carbon atom which has the least number of hydrogen atoms.

b) $CH_3Br + 2Na + BrCH_3 \xrightarrow{Dry\ ether} CH_3\text{-}CH_3 + 2NaBr$

c) $CH_3COONa + NaOH \xrightarrow{CaO,\ \Delta} CH_4 + Na_2CO_3$)

Q.5.Addition of HBr to propene yields 2-bromopropane, while in the presence of benzoyl peroxide, the same reaction yields 1-bromopropane. Explain and give mechanism

(Hint: Addition of HBr to propene yields 2-bromopropane because the addition take place according to Markovnikov's rule through electrophilic addition, while in the presence of benzoyl peroxide, the addition take place against Markovnikov's rule through free radical addition)

Case Based Questions (04 Marks)

The following questions are case-based questions. Each question has an internal choice and carries 4 marks each.

Read the passage carefully and answer the questions that follow

Q1. Hydrocarbons are compounds of carbon and hydrogen only, obtained from coal and petroleum mainly which are major sources of energy. Hydrocarbons are classified as open chain, saturated (alkanes), unsaturated (alkenes and alkynes), cyclic (alicyclic) and aromatic based on structure. Alkanes show conformational isomerism due to free rotation along C-C bond leading to staggered and eclipsed conformations of ethane.

The repulsive interaction between the electron clouds, which affects stability of a conformation, is called torsional strain. Magnitude of torsional strain depends upon the angle of rotation about C–C bond. This angle is also called dihedral angle or torsional angle. Of all the conformations of ethane, the staggered form has the least torsional strain and the eclipsed form, the maximum torsional strain.

Alkenes show geometrical (cis-trans) isomerism due to restricted rotation around carbon-carbon double bond.

(a) Name the angle between hydrogens of different carbons of ethane (1 mark)

(b) Alkanes show conformational isomerism but alkenes do not .Why? (1 mark)

(c) Which conformation of ethane has less torsional strain and why? (2 marks)

OR

Why is trans but-2-ene has higher melting point than cis but-2-ene?

(Hint: a) dihedral angle

b) In alkenes there is no free rotation in Carbon-Carbon bond.

c) Staggered due to maximum dihedral angle.

OR

The molecule is symmetrical and hence packed well in the crystal lattice.)

Q2. Benzene is a key compound in organic chemistry and serves as a starting material for synthesizing various derivatives used in industries, such as dyes, plastics, and pharmaceuticals. Due to its aromatic nature, benzene undergoes electrophilic substitution reactions like nitration, sulphonation, halogenation, and Friedel-Crafts alkylation/acylation. These reactions involve the replacement of a hydrogen atom on the benzene ring with a functional group. The reactivity of benzene is influenced by the electron density in its pi system, which makes it susceptible to attack by electrophiles.

a) Name one electrophilic substitution reaction that benzene undergoes.(1 mark)

b) What is the role of a catalyst in the Friedel-Crafts alkylation of benzene?(1 mark)

c) Describe the mechanism of nitration of benzene.(2 marks)

Or

Benzene undergoes electrophilic substitution reactions easily and nucleophilic substitutions with difficulty. Why?

(Hint: a) Nitration, sulphonation, halogenation, and Friedel-Crafts alkylation/acylation (any one)

(b) The catalyst generates the electrophile.

(c) The generation of the nitronium ion (NO_2^+) as the electrophile, followed by its attack on the benzene ring forming a sigma complex (arenium ion).A proton is then lost from the sigma complex, restoring the aromatic ring and forming nitrobenzene ($C_6H_5NO_2$).

Or

Benzene is a planar molecule having delocalized electrons above and below the plane of the ring. Hence, it is electron-rich. As a result, it is highly attractive to electron-deficient species i.e., electrophiles but repels Nucleophiles (Electron rich species). Therefore, it undergoes electrophilic substitution reactions very easily.)

Long Answer Questions (05 Marks)

Q1. (i)Write chemical equation for lab preparation of ethene.

(ii) What happens (Give chemical equation involved in each case.)

a) whenethene is passed through Br_2 water

b) Propene reacts with HBr in the presence of peroxide

(iii) Convert : a. Ethyne to Benzene b. Benzene to Acetophenone

(Hint: (i) $CH_3\text{-}CH_2OH \xrightarrow{ConcH2SO4\ /Heat} C_2H_4 + H_2O$

(ii) a) Form colourless 1,2-dibromoethane.

b) Apply antiMarkownikov's rule

(iii) (a) $3C_2H_2 \xrightarrow{redhot\ iron\ tube\ /873K} C_6H_6$

(b) $C_6H_6 + CH_3COCl \xrightarrow{AnhydAlCl3} C_6H_5COCH_3 + HCl$)

Q2. (i) Give reason for following

a) Ethyne is more acidic than ethene

b) Nitration of Toluene give ortho and para nitro toluene but not m-Nitro toluene

(ii) Complete the following equation

$CH_3CH(Cl)\text{-}CH_2\text{-}CH_3 \xrightarrow{AlcKOH}$

(iii) Give a chemical test to distinguish the following pairs

(a)Ethene and Ethyne (b)Ethene and Ethane .

(H nt: (i) a) Inethyne, the hybridization of each carbon is sp which has 50 % s character.

(b) In Toluene, $-CH_3$ group causes +R effect and activates the benzene ring.

(ii) $CH_3CH=CH\text{-}CH_3$ (Major product) + HCl

(iii) (a) When ammonical Silver Nitrate ($AgNO_3$) is added to Ethyne then it gives white precipitate.

(a) Ethene will react with bromine water and will decolourise bromine water.

SESSION ENDING EXAMINATION PRACTICE PAPER- 01

CLASS – XICHEMISTRY(043)

Max.Marks:70 **Time:3Hours**

ReadthefollowingInstructionscarefully.

(a) There are **33** questions in this question paper with internal choice.
(b) SECTION A consists of 16 multiple -choice questions carrying 1 mark each.
(c) SECTION B consists of 5 short answer questions carrying 2 marks each.
(d) SECTION C consists of 7 short answer questions carrying 3 marks each.
(e) SECTION D consists of 2 case - based questions carrying 4 marks each.
(f) SECTION E consists of 3 long answer questions carrying 5 marks each.
(g) All questions are compulsory.
(h) Use of log tables and calculators is not allowed.

SECTION-A

The following questions are multiple -choice questions with one correct answer. Each question carries 1 mark. There is no internal choice in this section.

1	The prefix 10^9 is ———— (a) giga (b) exa (c) 4 (c) kilo (d) mega	**[1]**
2	Iso electronic species are : (a) Mg, Na ((b) Al, Be (c) Ca^{2}+, Ar (d) Cl, Ar	**[1]**
3	IUPAC name of an element with atomic no 118 is : (a) Ununseptium (b) Ununoctium (c) unniloctiumd() unnilseptium	**[1]**
4	Principal, Azimuthal and magnetic quantum numbers are respectively related to: (a) Size, shape and orientation (b) Size, orientation and shape(c) Shape, size and orientation (d) None of the above	**[1]**
5	Which of the following is not permissible? (a) n= 4, l = 3, m= 0 (b) n= 4, l = 2, m= 1 (c) n= 4, l = 0, m= 0 (d) n= 4, l = 4, m= 1	**[1]**
6	Which of the following molecule has two or more than two polar bond and still the molecule is non-polar: (a) BF_3(b) H_2O (c)ClF_3(d) NH_3	**[1]**
7	the reaction C(s) + O2(g) → CO2(g) : $\Delta H > \Delta U$ (b) $\Delta H = \Delta U$ (c) $\Delta H < \Delta U$ (d) None of these	**[1]**
8	For an ideal gas, CV and CP are related as : (a) CV – CP = R (b) CV + CP = R (c) CP –Cv =nRT(d) CP –Cv = R	**[1]**
9	If the pH of a solution of Hydrochloric acid is 4 then the molarity of the solution is: (a) 4.0 (b) 0.4 (c) 0.0001 (d) 0.04	**[1]**
10	When NH_4Cl is added to NH_4OH solution the dissociation of ammonium hydroxide is reduced. It is due to: (a) common ion effect (b) hydrolysis (c) oxidation (d) reduction	**[1]**
11	Which of the following is not a redox reaction: (a) Burning of candle (b) Dissolving salt in water (c) Rusting of iron (d) Dissolving Zinc in dil. H_2SO_4	**[1]**
12	IUPAC name of Neopentane is: (a) 2,2-dimethylpropane (b) 2-methylpropane (c) 2,2-dimethylbutane (d) None of the above	**[1]**
	SERTION REASON TYPE QUESTIONS The question given below consist of an Assertion and the Reason. Use the following key to choose the appropriate answer. a. If assertion and reason both are correct statements and reason is correct explanation for assertion. b. If assertion and reason both are correct statements but reason is not correct explanation for assertion c. If assertion is correct statement but reason is wrong statement. d. If assertion is wrong statement but reason is correct statement	
13	Assertion :Significant figures for 0.2000 is 4 whereas for 2000 it is 1. Reason : Zero at the end or right of a number are significant provided they are not on the right side of the decimal point.	**[1]**
14	Assertion- Fluorine always shows -1 oxidation state . Reason- Fluorine is the most electronegative element and it does not have d subshell.	**[1]**
15	Assertion: He_2 does not exists. Reason: Bond order in He_2 is zero.	**[1]**
16	Assertion: The reaction: $CaCO_3$(s) → CaO(s) + CO_2 (g) is an example of decomposition reaction. Reason: Above reaction is not a redox reaction.	**[1]**

	SECTION B **This section contains 5 questions with internal choice in one question. The following questions are very short answer type and carry 2 marks each.**	
17	Calculate the percentage composition of H and O in water molecule.	**[2]**
18	If Yellow light emitted from a sodium lamp has a wavelength of 580 nm. Then Calculate the frequency and wave number of yellow light**.**	**[2]**
19	**What is K_c for the following reaction in state of equilibrium?** $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ *Given:* $[SO_2] = 0.6\ M;\ [O_2] = 0.82\ M;$ *and* $[SO_3] = 1.90\ M$	**[2]**
20	Balance the following equation by the ion-electron method. $Zn(s) + NO_3^- \rightarrow Zn^{2+}(aq) + NH_4^+(aq) + H_2O(l)$ (In acid medium)	**[2]**
21	Out of Ethylene and Acetylene which is more acidic and why? OR Give the structure and name of the alkene (C_4H_8) which adds on HBr in the presence and in the absence of peroxide to give the same product C_4H_9Br.	**[2]**
	SECTION C This section contains 7 questions with internal choice in one question. The following questions are short answer type and carry 3 marks each.	
22	What is the difference between empirical and molecular formula? A compound contains 4.07 % hydrogen, 24.27 % carbon and 71.65 % chlorine. Its molar mass is98.96 g. Find it's empirical and molecular formulas?	**[3]**
23	Give reason: electron gain enthalpy of fluorine is less negative than that of chlorine. Group 1 elements are called Alkali metals First ionisation enthalpy of Nitrogen is higher than that of Oxygen	**[3]**
24	For the reaction, $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$ at 25^0C enthalpy change $\Delta H = 177$ kJ/mol and Enthalpy change $\Delta S = 285\ JK^{-1}\ mol^{-1}$. Calculate free energy change ΔG at 25^0C and predict whether the reaction is spontaneous or not. OR What is Hess's Law? Write it's two applications	**[3]**
25	**(a)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.** **$N_2(g) + 3H_2(g)$ ⍰$2NH_3(g)$ $\Delta_rH = -92.38\ kJ\ mol^{-1}$** **(b) What will be the effect of addition of argon to the above reaction mixture at constantvolume?**	**[2]** **[1]**
26	Suggest a method to separate the constituents from the following mixture: (i) A mixture of solid benzoic acid and sodium chloride (ii) A mixture of oil and water(iii) A mixture of plant pigments	**[3]**
27	Define Isomerism. Explain Position Isomerism and Functional Group Isomerism with examples.	**[3]**
28	Write the reactions to prepare Benzene from: (i) Ethyne (ii) Phenol (iii) Sodium benzoate	**[3]**
	SECTION D **The following questions are case -based questions. Each question has an internal choice and carries 4 (1+1+2) marks each. Read the passage carefully and answer the questions that follow.**	
29	**CASE BASED QUESTION** We can measure the transfer of heat from one system to another which cause change in temperature. The magnitude of change in temperature depends upon heat capacity of the substance.In chemical thermodynamics, the type of work involved is mostly pressure-volume work that is the work done when a system (gas) expands or contracts against an external opposing pressure. Hence, work is also defined as the transfer of energy that can be used to change the height of a mass in the surroundings. **Now answer the following**" **(i)** Which of the following statement is correct? (a) ΔU = Wadiabatic (b) Wad = + ve, when work is done on the system (c) Wad = – ve, when work is done by the system (d) All of the above.	1

	(ii) A process in which the system does not exchange heat and matter with the surroundings is known as (a) isothermal (b) adiabatic. (c) isochoric (d) isobaric. **(iii)** State Second and Third law of Thermodynamic	1 2
30	**CASE BASED QUESTION** Alkanes are generally inert towards acids, bases, oxidising and reducing agents. However, they undergo the following reactions under certain conditions. 1) Substitution reactions One or more hydrogen atoms of alkanes can be replaced by halogens, nitro group and sulphonic acid group. Halogenation takes place either at higher temperature (573 773 K) or in the presence of diffused sunlight or ultraviolet light. Lower alkanes do not undergo nitration and sulphonation reactions. These reactions in which hydrogen atoms of alkanes are substituted are known as substitution reactions. As an example, chlorination of methane. 2) Combustion- Alkanes on heating in the presence of air or dioxygen are completely oxidized to carbon dioxide and water with the evolution of large amount of heat. Due to the evolution of large amount of heat during combustion, alkanes are used as fuels. During incomplete combustion of alkanes with insufficient amount of air or dioxygen, carbon black is formed which is used in the manufacture of ink, printer ink, black pigments and as filters. 3 Controlled oxidation- Alkanes on heating with a regulated supply of dioxygen or air at high pressure and in the presence of suitable catalysts give a variety of oxidation products.**Now answer the following questions**: **1**. what is called when a decomposition reaction causing smaller fragments of hydrocarbon by the application of heat . **2**. Name the reaction in which alkanes on heating in the presence of air or dioxygen are completely oxidized to carbon dioxide and water. **3**. Explain controlled oxidation reaction taking two examples	**[4]**
	SECTION E **The following questions are long answer type and carry 5 marks each. All questions have an internal choice.**	
31	**(a)** State the following(with example) : (i)Hund's Rule of maximum Multiplicity (ii) Aufbau Principle (iii) Pauli exclusion principle **(b)** State HeisenbergUncertainty principle and write it's mathematical form OR An atom of an element contains 29 electrons and 35 neutrons. Now deduce the following: **(i)**the number of protons and**(ii)** the electronic configuration of theelement (**iii**) Identify the element . **(b)** (i) The energy associated with the first orbit in the Hydrogen atom is -2.18 x10^{-18}J/atom What is the energy associated with the fifth orbit (ii) Calculate the radius of Bohr's fifth orbit for Hydrogen atom.	**[3]** [2] [3] [2]
32	**(a)**Distinguish between a sigma bond and a pi bond. **(b)**Account for the following: (i) Water is a liquid while H_2S is a gas (ii) NH_3 has higher polarity than NF_3. (iii)Why the bond angle in water molecule is less as compared to methane though both are SP3 hybridized **OR** **1.** Draw diagrams showing the formation of a double bond and a triple bond between carbon atoms in $C_2 H_4$ and $C_2 H_2$ molecules. Also predict theirHybridization **2**(i) Write molecular orbital configuration and draw molecular orbital diagram of O_2 molecule. (ii) Calculate bond order of O_2 and write its magnetic nature.	**[2+3]**
33	(a)Draw the cis- and trans-structures for hex-2-ene. Which iosmer will have higher b.p. and why? (b) What are the necessary conditions for any system to be aromatic? Why is benzene extra-ordinarily stable though it contains three double bonds? OR (a) Find the products obtained by the ozonolysis of the following compounds: (i) Pent-2-ene (ii) 1-Phenylbut-l-ene. (b) Explain the following(with reaction): (i) Wurtz reaction (ii) Saytzef rule (iii) Friedal craft alkylation of benzene	**[3+2]**

SESSION ENDING EXAMINATION PRACTICE PAPER- 02
CLASS – XI- CHEMISTRY

Time:3:00HRs. **MM.: 7**

Read the following instructions carefully.
(a) There are 33 questions in this question paper with internal choice.
(b) SECTION A consists of 16 multiple -choice questions carrying 1 mark each.
(c) SECTION B consists of 5 short answer questions carrying 2 marks each.
(d) SECTION C consists of 7 short answer questions carrying 3 marks each.
(e) SECTION D consists of 2 case - based questions carrying 4 marks each.
(f) SECTION E consists of 3 long answer questions carrying 5 marks each.
(g) All questions are compulsory.
(h) Use of log tables and calculators is not allowed.

Q. NO.	QUESTION	MARKS
	Section A	
1.	Ratio of empirical formula mass to molecular formula mass of benzene will be (a) 1:6 (b) 2:3 (c) 6:1 (d) 3:2	**1**
2.	**For which of the following sets of quantum numbers, an electron will have the highest energy?** **(a) 3, 2, +1, +1/2 (b) 4, 2, -1, +1/2 (c) 4,1,0, -1/2** **(d) 5,0,0, +1/2**	**1**
3.	The element with atomic number 25 will be found in group : (a) 2 (b) 7 (c) 6 (d) 10	**1**
4.	**Find the molecule with the highest bond angle** **(a) BeF_2 (b) CH_4 (c) NH_3 (d) H_2O**	**1**
5.	**Which of the following is an extensive property?** **(a) volume (b) temperature (c) enthalpy (d)all of these**	**1**
6.	The enthalpies of all elements in their standard states are: (a) Unity (b) zero (c) > 0 (d) different for each element	**1**
7.	Which of the following pairs can form a buffer solution? (a) HCl and NaCl (b) NH_3 and NH_4Cl (c) NaOH and NaCl (d) H_2SO_4 and $KHSO_4$	**1**
8.	The solubility product expression for $BaSO_4$ is: (a) Ksp = $[BaSO_4]$ (b) Ksp = $[Ba^{2+}][SO_4{}^{2-}]$ (c) Ksp = $[Ba^{2+}][SO_4{}^{2-}]/[BaSO_4]$ (d) Ksp = $[Ba^{2+}]^2 [SO_4{}^{2-}]^2$	**1**
9.	Oxidation number of P in PO_4 3- , of S in $SO_4{}^{2-}$ and that of Cr in $Cr_2O_7{}^{2-}$ are respectively: (a) +3, +6 and +5 (b) +5, +3 and +6 (c) +3, +6 and +6 (d) +5, +6 and +6	**1**
10	A miscible mixture of benzene and chloroform can be separated by: (a) Sublimation (b) distillation (c) filtration (d) crystallisation	**1**
11.	Find the correct order for relative energies of the ethane conformations. (a) staggered < skewed < eclipsed (b) skewed < staggered < eclipsed (c) skewed < eclipsed < staggered (d) staggered < eclipsed < skewed	**1**
12.	Which among the following has the highest boiling point? (a) Pentane (b) Hexane (c) Heptane (d) Octane	**1**
	Assertion and Reasons Given below are two statements labelled as Assertion (A) and Reason (R) A. Both A and R are true and R is the correct explanation of A	

13.	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 .Assertion (A): CO_2 is a linear molecule. Reason (R**):** The central atom in CO_2 undergoes sp^3 hybridization.	**1**
14.	**Assertion**: Boiling point of alkanes increases with increase in molecular weight. **Reason**: van der Waal's forces increase with increase in molecular weight	**1**
15.	**Assertion :** The sum of q + w is a state function. **Reason :** Work and heat are state functions.	**1**
16.	**Assertion:** 1.231 has three significant figures. **Reason :** All numbers right to the decimal point are significant	**1**
	SECTION B	
17.	Chlorine is prepared in the laboratory by treating manganese dioxide (MnO_2) with aqueous hydrochloric acid according to the reaction 4 HCl (aq) + MnO_2(s) $\rightarrow$ $2H_2O$ (l) + $MnCl_2$(aq) + Cl_2 (g) How many grams of HCl react with 5.0 g of manganese dioxide	**2**
18.	Define electronegativity and electron gain enthalpy.	**2**
19.	For the reaction at 298 K, $2A + B \rightarrow C$; $\Delta H = 400$ kJ mol^{-1} and $\Delta S = 0.2$ kJ K^{-1} mol^{-1} At what temperature will the reaction become spontaneous considering ΔH and ΔS to be constant over the temperature range	**2**
20.	Write the conjugate acid and base for the following : H_2O , NH_3	**2**
21.	(a) How many σ and π bonds are present in $CH_2{=}CH\text{-}CH_2CH_3$ molecule? (b) Draw the structure of pent-4-en-1-ol	**2**
	SECTION C	
22.	In a reaction $A + B_2 \rightarrow AB_2$ Identify the limiting reagent, if any, in the following reaction mixtures. (i) 300 atoms of A + 200 molecules of B (ii) 2 mol A + 3 mol B (iii) 100 atoms of A + 100 molecules of B	**3**
23.	(a) What is the lowest value of n that allows g orbitals to exist? (b) Write the electronic configuration of Cr^+ ion. (c) An electron is in one of the 3d orbital. Give the possible values of n, l and ml for this electron	**3**
24.	What do you understand by Ionization enthalpy? 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**
25.	(i) Write the expression for the equilibrium constant, Kc for the following reaction: (i) $2Cu(NO_3)_2$ (s) $\Leftrightarrow$ 2CuO (s) +$4NO_2$(g) + O_2(g) (ii) Describe the effect of: (a) addition of H_2 (b) addition of CH_3OH (c) removal of CO (d) removal of CH_3OH on the equilibrium of the reaction: $2H_2$(g) + CO $\rightarrow$(g) CH_3OH (g)	**3**
26.	Balance the following redox reactions by ion – electron method : (a) MnO_4^- (aq) + I^- (aq) $\rightarrow$ MnO_2 (s) + I_2(s) (in basic medium) (b) MnO_4^- (aq) + SO_2 (g) $\rightarrow$ Mn^{2+} (aq) + HSO_4^- (aq) (in acidic solution) (c) H_2O_2 (aq) + Fe^{2+} (aq) $\rightarrow$ Fe^{3+} (aq) + H_2O (l) (in acidic solution)	**3**
27.	**(a)** Discuss the chemistry of Lassaigne's test **(b)** Give a brief description of the principles of the following techniques taking an example in each case. (a) Distillation (b) Chromatography	**3**

28.	Addition of HBr to propene yields 2-bromopropane, while in the presence of benzoyl peroxide, the same reaction yields 1-bromopropane. Explain and give mechanism	**3**
	SECTION D	
29.	In thermodynamics, the change in internal energy (ΔU) and enthalpy (ΔH) are essential concepts for understanding heat flow during chemical reactions. When a reaction occurs at constant volume, the heat absorbed or evolved is equal to the change in internal energy ($\Delta U = q_v$). However, most chemical reactions occur at constant pressure, where the heat absorbed is equal to the enthalpy change ($\Delta H = q_p$). For an ideal gas, the relationship between ΔH and ΔU is given by the equation: $\Delta H = \Delta U + \Delta n_g RT$; where Δn_g is the change in number of moles of gaseous products and reactants, R is the gas constant, and T is the temperature in Kelvin. (i) The maximum value of ($\Delta H - \Delta U$) at 27°C among the following reactions is: (a) $H_2(g)+Cl_2(g) \longrightarrow 2HCl(g)$ (b) $PCl_5(g) \longrightarrow PCl_3(g)+Cl_2(g)$ (c) $N_2O_4(g) \longrightarrow 2NO_2(g)$ (d) $NH_4HS(s) \longrightarrow NH_3(g)+H_2S(g)$ (ii) Chemical reactions in industries are often carried out at constant pressure. In such conditions, explain why enthalpy (ΔH) is preferred over internal energy (ΔU) to measure heat changes in reactions. (iii) A system undergoes a change where $\Delta U = 1000$ J and it expands against a constant external pressure, doing 300 J of work. Calculate the change in enthalpy (ΔH)?	**4**
30.	Nisha is studying the chapter "Organic Chemistry – Some Basic Principles and Techniques." Her teacher gives her a chart with the following compounds: **Compound A:** CH_3CH_2OH **Compound B:** CH_3COOH **Compound C:**CH_3Cl **Compound D:** CH_3CHO **Compound E:** $CH_3CH(OH)CH_3$ She is asked to identify the functional groups and understand their naming and properties 1. Identify the functional group in compound B and D 2. Write the IUPAC name of compound E 3. Which compounds among A–E belong to the same homologous series? Name the series..	**4**
31	**(a) Electrons are emitted with zero velocity from a metal surface when it is exposed to radiation of wavelength 6800 Å. Calculate threshold frequency (v0) and work function (W0) of the metal.** **(b) Explain Heisenberg's uncertainity principle and de Broglie's principle** **OR** **(a) The energy associated with the first orbit in the hydrogen atom is -2.18×10^{-18} J atom^{-1}. What is the energy associated with the fifth**	**5**

	orbit? (b) Calculate the radius of Bohr’s fifth orbit for hydrogen atom. (c) What is Pauli Exclusion Principle.	
32	Attempt any five : (a)Which out of NH_3 and NF_3 has higher dipole moment and why ? (b) why BeH_2 molecule has a zero dipole moment although the Be–H bonds are polar (c)Write the resonance structures for NO_3^- (d)Although geometries of NH_3 and H_2O molecules are distorted tetrahedral, bond angle in water is less than that of ammonia. Discuss (e) What is meant by hybridisation of atomic orbitals? (f) Describe the change in hybridisation (if any) of the Al atom in the following reaction. $AlCl_3 + Cl^- \rightarrow AlCl_4^-$ (g) In PCl_5, why are the axial bonds longer as compared to equatorial bonds?	5
33	(a) An alkene ‘A’ on ozonolysis gives a mixture of ethanal and pentan-3-one. Write structure and IUPAC name of ‘A (b) What are the necessary conditions for any system to be aromatic? Write any two . (c) Draw the cis and trans structures of hex-2-ene. Which isomer will have higher b.p. and why? OR (a) What effect does branching of an alkane chain has on its boiling point? (b) Give example of Wurtz reaction (c) How will you convert benzene into (i) p-nitrobromobenzene (ii) acetophenone? (d) Why is benzene extra ordinarily stable though it contains three double bonds?	5

End of Paper

Important links

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