

SACRED HEART MATRICULATION HIGHER SECONDARY SCHOOL**COMMON HALFYEARLY EXAM – DECEMBER 2022**

STD: 11

CHEMISTRY ANSWERKEY

TIME: 180 MINUTES

MAXIMUM MARKS: 70

PART – A

I. Answer all the questions. Choose the correct answer from the given four alternatives and write the option code and the corresponding answer. (15x1=15)

1. c) $\frac{\text{molar mass of ferrous oxalate}}{3}$
2. b) spin quantum number
3. a) $s > p > d > f$
4. b) 12.3
5. c) Potassium carbonate can be prepared by solvay process
6. a) Boyle's law
7. b) negative
8. b) 3, 1, 4, 2
9. d) Ethanol + water
10. a) O_2 and B_2
11. d) Glucose
12. c) planar
13. b) $-NO_2$
14. b) If both assertion and reason are true but reason is not the correct explain of assertion
15. b) Coal smoke and fog

PART – B

II. Answer any six questions. Question No.24 is compulsory. (6x2=12)

16. Distinguish between oxidation and reduction.

	Oxidation	Reduction
(i)	Addition of oxygen and removal of hydrogen	Additional of hydrogen and removal of oxygen
(ii)	This process involves loss of electrons $Fe^{2+} \rightarrow Fe^{3+} + e^-$	This process involves gain electrons. $Cu^{2+} + 2e^- \rightarrow Cu$
(iii)	Oxidation number increases	Oxidation number decreases
(iv)	$Ca + S \rightarrow Ca^{2+} + 2e^-$	$Zn^{2+} + 2e^- \rightarrow Zn$
(v)	Removal of Metal $2KI + H_2O_2 \rightarrow 2KOH + I_2$	Addition of metal $HgCl_2 + Hg \rightarrow Hg_2Cl_2$

17. Define Modern Periodic law.

The modern periodic law states that, “the physical and chemical properties of the elements are periodic functions of their atomic numbers.”

18. Give the uses of heavy water.

- ✚ Heavy water is widely used as moderator in nuclear reactors as it can lower the energies of fast neutrons.
- ✚ It is commonly used as a tracer to study organic reaction mechanisms and mechanism of metabolic reactions.
- ✚ It is also used as a coolant in nuclear reactors as it absorbs the heat generated.

19. What is Joule – Thomson effect?

This phenomenon of lowering of temperature when a gas is made to expand adiabatically from a region of high pressure into a region of low pressure is known as Joule-Thomson effect.

20. Which bond is stronger σ or π ? Why?

- ✚ Sigma bonds σ are stronger than pi (π) bonds. Because sigma bonds are formed from bonding orbitals directly between the nuclei of the bonding atoms resulting in greater overlap and a strong sigma bond (axial overlapping).
- ✚ Pi bonds results from overlap of atomic orbitals that are in contact through overlap (lateral overlapping). Pi bonds are more diffused bonds than sigma bonds.

21. Give the general characteristics of organic compounds.

- ✚ They are covalent compounds of carbon and generally insoluble in water and readily soluble in organic solvent such as benzene, toluene, ether, chloroform etc...
- ✚ Many of the organic compounds are inflammable (except CCl_4). They possess low boiling and melting points due to their covalent nature
- ✚ Organic compounds are characterized by functional groups. A functional group is an atom or a specific combination of bonded atoms that react in a characteristic way, irrespective of the organic molecule in which it is present. In almost all the cases, the reaction of an organic compound takes place at the functional group. They exhibit isomerism which is a unique phenomenon.
- ✚ **Homologous series:** A series of organic compounds each containing a characteristic functional group and the successive members differ from each other in molecular formula by a CH_2 group is called homologous series. Eg.
 - **Alkanes:** Methane (CH_4), Ethane (C_2H_6), Propane (C_3H_8) etc.
 - **Alcohols:** Methanol (CH_3OH), Ethanol ($\text{C}_2\text{H}_5\text{OH}$) Propanol ($\text{C}_3\text{H}_7\text{OH}$) etc.)
 - Compounds of the homologous series are represented by a general formula Alkanes $\text{C}_n\text{H}_{2n+2}$, Alkenes C_nH_{2n} , Alkynes $\text{C}_n\text{H}_{2n-2}$ and can be prepared by general methods. They show regular gradation in physical properties but have almost similar chemical property.

22. Why chlorination of methane is not possible in dark?

Methane does not react with chlorine in dark. Reaction of methane with Cl_2 proceeds by free radical mechanism. The initiation step in the free radical chain reaction is $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$ This step requires more energy. The excess energy is provided by heat or light.

23. What are particulate pollutants? Give an example.

Particulate pollutants are small particles and liquid droplets suspended in air.

Ex: Smoke, Dust, Mists & Fog.

24. Calculate the molality of the solution containing 45g of glucose dissolved in 2kg of water?

Given: solute in grams = 45g; Solvent mass = 2kg

$$\text{molality (m)} = \frac{\text{Number of moles of solute}}{\text{Mass of the solvent (in kg)}} \quad \text{molality (m)} = \frac{\left(\frac{45}{180}\right)}{2} = \frac{0.25}{2} = 0.125 \text{ m}$$

PART – C

III. Answer any six questions. Question No.33 is compulsory.

(6x3=18)

25. Write the postulates of Bohr atomic model.

The Postulates of Bohr atom model:

- ✚ The energies of electrons in an atom are quantised.
- ✚ The electron is revolving around the nucleus in a certain circular path of fixed energy called stationary orbit.
- ✚ Electron can revolve only in those orbits in which the angular momentum (mvr) of the electron must be equal to an integral multiple of $h/2\pi$.

$$\text{i.e. } mvr = nh/2\pi$$

$$\text{where } n = 1, 2, 3, \dots \text{etc.,}$$

- ✚ As long as an electron revolves in the fixed stationary orbit, it doesn't lose its energy. However, when an electron jumps from higher energy state (E_2) to a lower energy state (E_1), the excess energy is emitted as radiation. The frequency of the emitted radiation is

$$E_2 - E_1 = h\nu$$

Conversely, when suitable energy is supplied to an electron, it will jump from lower energy orbit to a higher energy orbit.

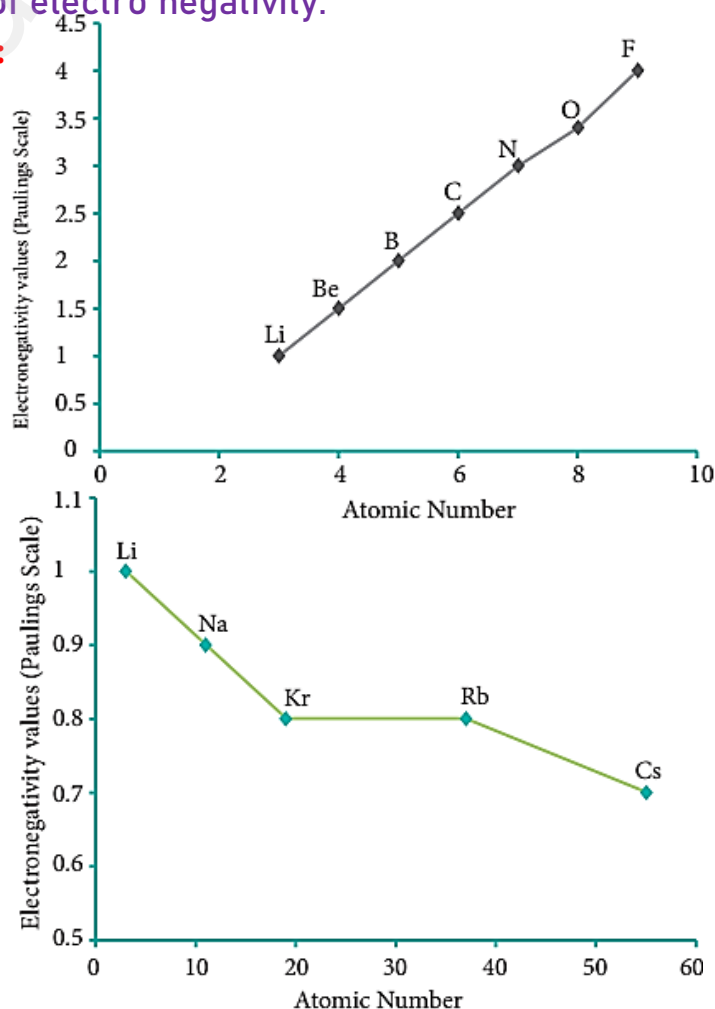
26. Briefly give the basis for Pauling scale of electro negativity.

Variation of Electronegativity in a period:

The electronegativity generally increases across a period from left to right. As discussed earlier, the atomic radius decreases in a period, as the attraction between the valence electron and the nucleus increases. Hence the tendency to attract shared pair of electrons increases. Therefore, electronegativity also increases in a period.

Variation of Electronegativity in a group:

The electronegativity generally decreases down a group. As we move down a group the atomic radius increases and the nuclear attractive force on the valence electron decreases. Hence, the electronegativity decreases.



27.

28. List the characteristics of Gibbs free energy?

Free energy is defined as $G = H - TS$. 'G' is a state function.

G-Extensive property; ΔG -intensive property when mass remains constant between initial and final state of systems.

'G' has a single value for the thermodynamic state of the system.

G and ΔG values correspond to the system only.

Process	Spontaneous	Equilibrium	Non-Spontaneous
ΔG	-Ve	Zero	+Ve

Gibbs free energy and the net work done by the system,

For any system at constant pressure and temperature,

$$\Delta H = \Delta U + P\Delta V$$

$$\therefore \Delta G = \Delta U + P\Delta V - T\Delta S$$

From first law of thermodynamics

$$\Delta U = q + w$$

From second law of thermodynamics

$$\Delta S = \frac{q}{T} \quad \Delta G = q - w + P\Delta V - T\left(\frac{q}{T}\right)$$

$$\Delta G = w + P\Delta V$$

$$-\Delta = -w - P\Delta V$$

But $-P\Delta V$ represents the work done due to expansion against a constant external pressure.

29. Define the term "isotonic solution".

Two solutions having same osmotic pressure at a given temperature are called **isotonic solutions**. When such solutions are separated by a semipermeable membrane, solvent flow between one to the other in either direction is same, i.e. the net solvent flow between the two isotonic solutions is zero.

30. Derive an expression for the equilibrium constant K_c for the reaction.



	N_2	H_2	NH_3
Initial number of moles	a	b	0
number of moles reacted	x	3x	0
Number of moles at equilibrium	a-x	b-3x	2x
Active mass or molar concentration at equilibrium	$\frac{a-x}{V}$	$\frac{b-3x}{V}$	$\frac{2x}{V}$

Applying law of mass action,

$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

$$= \frac{\left(\frac{2x}{V}\right)^2}{\left(\frac{a-x}{V}\right)\left(\frac{b-3x}{V}\right)^3}$$

$$K_c = \frac{\left(\frac{4x^2}{V^2}\right)}{\left(\frac{a-x}{V}\right)\left(\frac{b-3x}{V}\right)^3} = \frac{4x^2 V^2}{(a-x)(b-3x)^3}$$

31. What are the electrophiles and nucleophiles? Give suitable examples for each.

- Electrophiles are electron deficient species and can accept an electron pair from electron rich species. Examples include carbocations and carbonyl compounds.
- A nucleophile is electron rich species and donates electron pairs to electron deficient species. Examples include carbanions, water, ammonia, cyanide ion etc.

32. How is acid rain formed? Explain its effect?

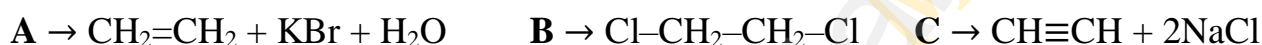
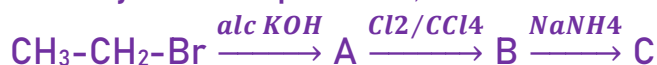
Burning of fossil fuels (coal and oil) in power stations, furnaces and petrol, diesel in motor engines produce SO_2 and NO_2 . The main contributors of acid rain are SO_2 and NO_2 . They are converted into H_2SO_4 and HNO_3 respectively by the reaction with O_2 and H_2O .

$$2\text{SO}_2 + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 2\text{H}_2\text{SO}_4 \quad 4\text{NO}_2 + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{HNO}_3$$

Harmful effects of acid rain: Some harmful effects are discussed below.

- Acid rain causes extensive damage to buildings and structural materials of marbles. This attack on marble is termed as Stone leprosy. $\text{CaCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2 \uparrow$
- Acid rain affects plants and animal life in aquatic ecosystem. It is harmful for agriculture, trees and plants as it dissolves and removes the nutrients needed for their growth.
- It corrodes water pipes resulting in the leaching of heavy metals such as iron, lead and copper into drinking water which have toxic effects. It causes respiratory ailment in humans and animals.

33. Identify the compound A, B and C in the following series of reactions.



PART - D

IV. Answer all the questions.

(5x5=25)

34.(a) (i) An organic compound present in vinegar has 40 % carbon, 6.6 % hydrogen and 53.4 % oxygen. Find the empirical formula of the compound.

Element	%	Atomic Mass	Relative number of moles	Simple ratio	Simplest ratio (in whole no)
C	40	12	$\frac{40}{12} = 3.3$	$\frac{3.3}{3.3} = 1$	1
H	6.6	1	$\frac{6.6}{1} = 6.6$	$\frac{6.6}{3.3} = 2$	2
O	53.4	16	$\frac{53.4}{16} = 3.3$	$\frac{3.3}{3.3} = 1$	1

\therefore Empirical formula is CH_2O

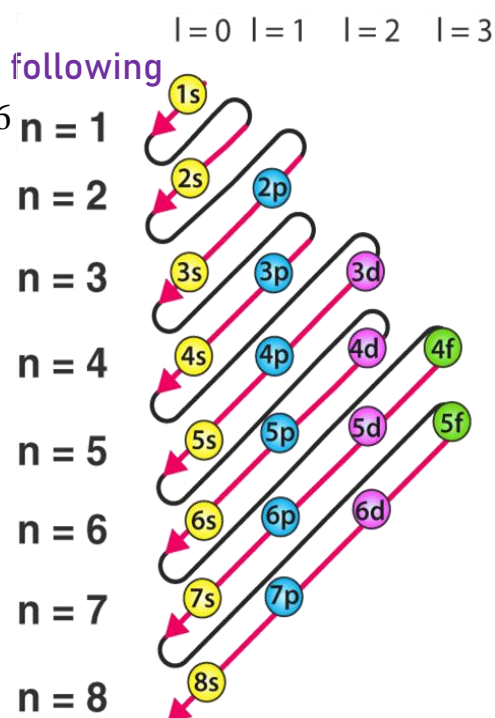
(ii) Calculate the oxidation number of Cr and S from the following



(OR)

(b) (i) Describe the Aufbau principle.

The word Aufbau in German means 'building up'. In the ground state of the atoms, the orbitals are filled in the order of their increasing energies. That is the electrons first occupy the lowest energy orbital available to them. Once the lower energy orbitals are completely filled, then the electrons enter the next higher energy orbitals. The order of filling of various orbitals as per the Aufbau principle which is in accordance with $(n+l)$ rule.



(ii) Why halogens act as oxidizing agents?

Halogens act as oxidising agents because their electronic configuration is $ns^2 np^5$. So all halogens are ready to gain one electron to attain the nearest inert gas configuration.

An oxidising agent is the halogens act as electronegative with low disorientation energy and high negative electron gain enthalpies. Therefore, halogens have a high tendency to gain an electrons.

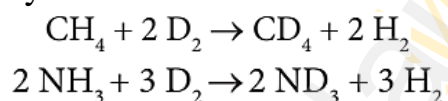
35.(a) (i) Describe ortho and para hydrogen.

Ortho hydrogen : Hydrogen molecule in which protons in the nuclei of both H-atoms are known to spin in same direction is termed as ortho hydrogen.

Para hydrogen : Hydrogen molecule in which protons in the nuclei of both -H - atoms spin in opposite direction is termed as para hydrogen

(ii) Explain the exchange reaction of deuterium.

Deuterium can replace reversibly hydrogen in compounds either partially or completely depending upon the reaction conditions. These reactions occur in the presence of deuterium or heavy water.



(OR)

(b) Discuss briefly the similarities between Beryllium and Aluminum.

S.No.	Properties
1	Beryllium chloride forms a dimeric structure like aluminium chloride with chloride bridges. Beryllium chloride also forms polymeric chain structure in addition to dimer. Both are soluble in organic solvents and are strong Lewis acids.
2	Beryllium hydroxide dissolves in excess of alkali and gives beryllate ion and $[\text{Be}(\text{OH})_4]^{2-}$ and hydrogen as aluminium hydroxide which gives aluminate ion, $[\text{Al}(\text{OH})_4]^-$.
3	Beryllium and aluminium ions have strong tendency to form complexes, BeF_4^{2-} , AlF_6^{3-} .
4	Both beryllium and aluminium hydroxides are amphoteric in nature.
5	Carbides of beryllium (Be_2C) like aluminium carbide (Al_4C_3) give methane on hydrolysis.
6	Both beryllium and aluminium are rendered passive by nitric acid.

36.(a) Derive critical constants V_c and P_c interms of Vander Waals constants.

The van der Waals equation for n moles is

$$\left(P + \frac{a n^2}{V^2} \right) (V - nb) = nRT \text{ ----- (6.22)}$$

For 1 mole

$$\left(P + \frac{a}{V^2} \right) (V - b) = RT \text{ ----- (6.23)}$$

From the equation we can derive the values of critical constants P_c , V_c and T_c in terms of a and b , the van der Waals constants, On expanding the above equation

$$PV + \frac{a}{V} - Pb - \frac{ab}{V^2} - RT = 0 \text{ ----- (6.24)}$$

Multiply equation (6.24) by V^2 / P

$$\frac{V^2}{P} (PV + \frac{a}{V} - Pb - \frac{ab}{V^2} - RT) = 0$$

$$V^3 + \frac{aV}{P} - bV^2 - \frac{ab}{P} - \frac{RTV^2}{P} = 0 \text{ --- (6.25)}$$

When the above equation is rearranged in powers of V

$$V^3 - \left[\frac{RT}{P} + b \right] V^2 + \left[\frac{a}{P} \right] V - \left[\frac{ab}{P} \right] = 0 \text{ --- (6.26)}$$

The equation (6.26) is a cubic equation in V . On solving this equation, we will get three solutions. At the critical point all these three solutions of V are equal to the critical volume V_c . The pressure and temperature becomes P_c and T_c respectively i.e., $V = V_c$

$$V - V_c = 0$$

$$(V - V_c)^3 = 0$$

$$V^3 - 3V_c V^2 + 3V_c^2 V - V_c^3 = 0 \text{ ---- (6.27)}$$

As equation (6.26) is identical with equation (6.27), we can equate the coefficients of V^2 , V and constant terms in (6.26) and (6.27).

$$-3V_c V^2 = - \left[\frac{RT_c}{P_c} + b \right] V^2$$

$$3V_c^2 = \frac{a}{P_c} \text{ ---- (6.29)}$$

$$3V_c = \frac{RT_c}{P_c} + b \text{ ---- (6.28)}$$

$$V_c^3 = \frac{ab}{P_c} \text{ ---- (6.30)}$$

Divide equation (6.30) by equation (6.29)

$$\frac{V_c^3}{3V_c^2} = \frac{ab/P_c}{a/P_c}$$

$$\frac{V_c}{3} = b$$

$$\text{i.e. } V_c = 3b \text{ ----- (6.31)}$$

when equation (6.31) is substituted in (6.29)

$$3V_c^2 = \frac{a}{P_c}$$

$$P_c = \frac{a}{3V_c^2} = \frac{a}{3(3b)^2} = \frac{a}{3 \times 9b^2} = \frac{a}{27b^2}$$

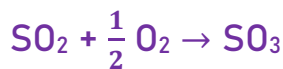
$$P_c = \frac{a}{27b^2} \text{ ----- (6.32)}$$

(OR)

(b) (i) Explain intensive properties with two examples.

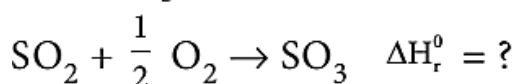
The property that is independent of the mass or the size of the system is called an intensive property.

Examples: Refractive index, Surface tension, density, temperature, Boiling point, Freezing point, molar volume, etc.,

(ii) The standard enthalpies of formation of SO_2 and SO_3 are -297 KJmol^{-1} and -396 KJmol^{-1} respectively. Calculate the standard enthalpy of reaction for the reaction.

$$\Delta H_f^\circ (\text{SO}_2) = -297 \text{ kJ mol}^{-1}$$

$$\Delta H_f^\circ (\text{SO}_3) = -396 \text{ kJ mol}^{-1}$$



$$\Delta H_r^\circ = (\Delta H_f^\circ)_{\text{compound}}$$

$$- \sum (\Delta H_f^\circ)_{\text{elements}}$$

$$\Delta H_r^\circ = \Delta H_f^\circ (\text{SO}_3) - \left(\Delta H_f^\circ (\text{SO}_2) + \frac{1}{2} \Delta H_f^\circ (\text{O}_2) \right)$$

$$\Delta H_r^\circ = -396 \text{ kJ mol}^{-1}$$

$$- (-297 \text{ kJ mol}^{-1} + 0)$$

$$\Delta H_r^\circ = -396 \text{ kJ mol}^{-1} + 297$$

$$\Delta H_r^\circ = -99 \text{ kJ mol}^{-1}$$

37.(a) (i) Explain how will you predict the direction of a equilibrium reaction..

- ✚ A large value of K_c indicates that the reaction reaches equilibrium with high product yield.
- ✚ A low value of K_c indicates that the reaction reaches equilibrium with low product formed.
- ✚ In general if the K_c is greater than 10^3 , the reaction proceeds nearly to completion. If it is less than 10^{-3} the reaction rarely proceeds.
- ✚ If $K_c < 10^{-3}$, reverse reaction is favoured, If $K_c < 10^3$, forward reaction is favoured.

(ii) Write the conditions for the solution of behave ideally.

- ✚ There is no change in the volume on mixing the two components (solute & solvents) ($\Delta V_{\text{mixing}} = 0$)
- ✚ There is no exchange of heat when the solute is dissolved in solvents ($\Delta H_{\text{mixing}} = 0$)
- ✚ Escaping tendency of the solute and the solvent present in it should be same as in pure liquids.

(OR)

(b) Describe Fajan's rule.

The ability of a cation to polarize an anion is called its polarising ability and the tendency of an anion to get polarized is called its polarisability. The extent of polarisation in an ionic compound is given by the Fajans rules

Fajans Rules

- ✚ To show greater covalent character, both the cation and anion should have high charge on them. Higher the positive charge on the cation, greater will be the attraction on the

electron cloud of the anion. Similarly higher the magnitude of negative charge on the anion, greater is its polarisability. Hence, the increase in charge on cation or in anion increases the covalent character. Let us consider three ionic compounds aluminum chloride, magnesium chloride and sodium chloride. Since the charge of the cation increase in the order $\text{Na}^+ < \text{Mg}^{2+} < \text{Al}^{3+}$, the covalent character also follows the same order $\text{NaCl} < \text{MgCl}_2 < \text{AlCl}_3$.

✚ The smaller cation and larger anion show greater covalent character due to the greater extent of polarisation. Lithium chloride is more covalent than sodium chloride. The size of Li^+ is smaller than Na^+ and hence the polarising power of Li^+ is more. Lithium iodide is more covalent than lithium chloride as the size of I^- is larger than the Cl^- . Hence I^- will be more polarized than Cl^- by the cation, Li^+ .

✚ Cations having $ns^2 np^6 nd^{10}$ configuration show greater polarizing power than the cations with $ns^2 np^6$ configuration. Hence, they show greater covalent character. CuCl is more covalent than NaCl . Compared to Na^+ (1.13 Å) . Cu^+ (0.6 Å) is small and have $3s^2 3p^6 3d^{10}$ configuration.

Electronic configuration of Cu^+

$[\text{Ar}] 3d^{10}$

Electronic Configuration of Na^+

$[\text{He}] 2s^2, 2p^6$

38.(a) Discuss the structure of Benzene

1. Molecular formula

Elemental Analysis and molecular weight determination have proved that the molecular formula of benzene is C_6H_6 . This indicates that benzene is a highly unsaturated compound.

2. Straight chain structure not possible:

Benzene could be constructed as a straight chain or ring compound but it not feasible since it does not show the properties of alkenes or alkynes. for example, it did not decolourise bromine in carbon tetrachloride or acidified KMnO_4 . It did not react with water in the presence of acid.

3. Evidence of cyclic structure:

I) substitution of benzene:

Benzene reacts with bromine in the presence of AlCl_3 to form mono bromo benzene.



Formation of only one monobromo compound indicates that all the six hydrogen atoms in benzene were identical. This is possible only if it has a cyclic structure of six carbons each containing one hydrogen.

II) addition of hydrogen:

Benzene can add on to three moles of hydrogen in the presence of nickel catalyst to give cyclohexane.



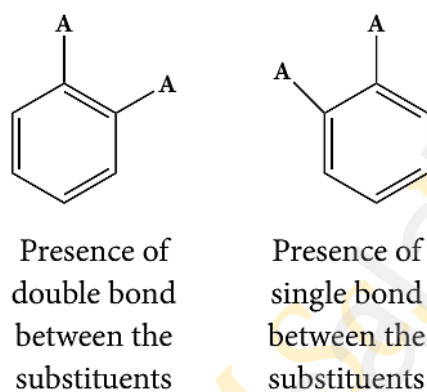
This confirms cyclic structure of benzene and the presence of three carbon-carbon double bond.

4. Kekule's structure of benzene:

In 1865, August Kekule suggested that benzene consists of a cyclic planar structure of six carbon with alternate single and double bonds.

There were two objections:

(i) Benzene forms only one ortho disubstituted products whereas the Kekule's structure predicts two o-di substituted products as shown below.

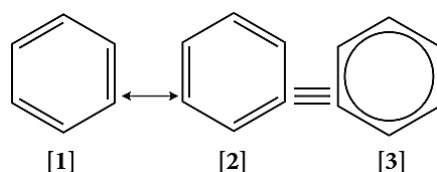


ii) Kekule's structure failed to explain why benzene with three double bonds did not give addition reactions like other alkenes. To overcome this objection, Kekule suggested that benzene was mixture of two forms (1 and 2) which are in rapid equilibrium.



5. Resonance description of benzene:

The phenomenon in which two or more structures can be written for a substance which has identical position of atoms is called resonance. The actual structure of the molecule is said to be resonance hybrid of various possible alternative structures. In benzene, Kekule's structures I & II represented the resonance structure, and structure III is the resonance hybrid of structure I & II



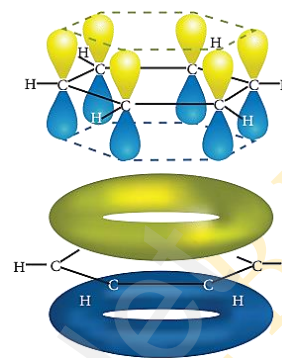
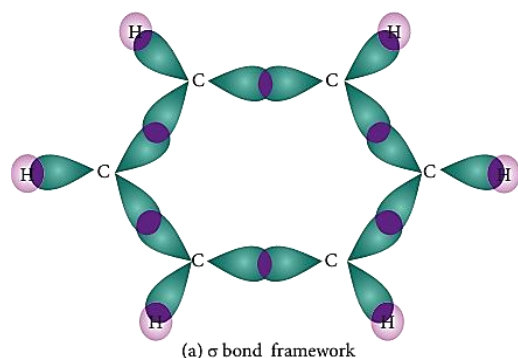
The structures 1 and 2 exist only in theory. The actual structure of benzene is the hybrid of two hypothetical resonance structures.

6. Spectroscopic measurements:

Spectroscopic measurements show that benzene is planar and all of its carbon-carbon bonds are of equal length 1.40\AA . This value lies between carbon-carbon single bond length 1.54\AA and carbon=carbon double bond length 1.34\AA .

7. Molecular orbital structure:

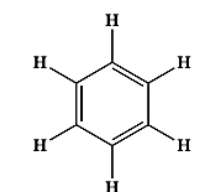
The structure of benzene is best described in terms of the molecular orbital theory. All the six carbon atoms of benzene are sp^2 hybridized. Six sp^2 hybrid orbitals of carbon linearly overlap with six $1s$ orbitals of hydrogen atoms to form six C - H sigma bonds. Overlap between the remaining sp^2 hybrid orbitals of carbon forms six C-C sigma bonds.



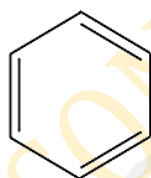
All the σ bonds in benzene lie in one plane with bond angle 120° . Each carbon atom in benzene possess an unhybridized p-orbital containing one electron. The lateral overlap of their p-orbital produces 3 π - bond. The six electrons of the p-orbitals cover all the six carbon atoms and are said to be delocalised. Due to delocalization, strong π -bond is formed which makes the molecule stable. Hence unlike alkenes and alkynes benzene undergoes substitution reactions rather addition reactions under normal conditions.

8. Representation of benzene:

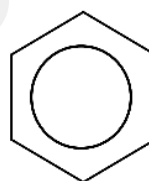
Hence, there are three ways in which benzene can be represented.



Expanded form



Kekule structure



Short hand representation

(OR)

(b) (i) Compare S_N^1 and S_N^2 reaction mechanisms.

S_N^1

The rate of reaction is unimolecular.

It is a two-step mechanism

Carbocation is formed as an intermediate part of the reaction.

There is no partial bond formed with the carbon during this reaction.

There are many steps in this reaction which start with the removal of the group while attacking the nucleophile.

S_N^2

The rate of reaction is bimolecular

It is only a one-step mechanism

No carbocation is formed during the reaction.

Carbon forms a partial bond with the nucleophile and the leaving group.

The process takes place in only one cycle, with a single intermediate stage.

(ii) Write the uses of DDT.

- ✚ DDT is used to control certain insects which carries diseases like malaria and yellow fever
- ✚ It is used in farms to control some agricultural pests
- ✚ It is used in building construction as pest control
- ✚ It is used to kill various insects like housefly and mosquitoes due to its high and specific toxicity.

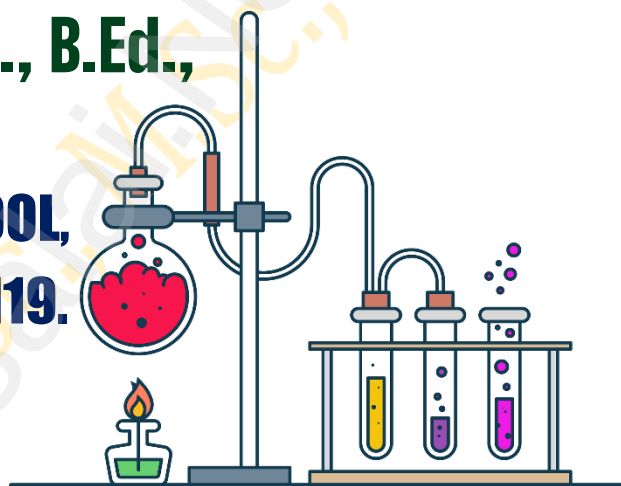
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**Happy Christmas &
Happy New Year 2023**