ULTIMATE KCET

CRASH COURSE 2026

Chemistry | Lecture - 01

Chemical bonding and molecular

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Recap *of previous lecture*

1. Thermodynamics

Topics *to be covered*

1. Thermodynamics – synopsis + MCQ
2. Chemical bonding and molecular structure

Heat Capacity (C)

$$\boxed{C_p - C_v = R}$$

$\rightarrow$ heat energy at constant pressure

$q \rightarrow$ heat energy at constant pressure $\longrightarrow \boxed{\Delta H}$

Heat capacity is the amount of heat required to raise the temperature of a system by 1 K (or 1°C). ✓

$$\boxed{q \propto \Delta T \Rightarrow q = C \times \Delta T}$$

$$\boxed{C = \frac{q}{\Delta T}}$$

$C = \frac{q}{\Delta T}$; where, q is the amount of heat supplied and where, ΔT is the increase in temperature.

Heat capacity at constant volume, $C_V = \left(\frac{dU}{dT}\right)_V$

Heat capacity at constant pressure, $C_P = \left(\frac{dH}{dT}\right)_P$

$\Delta U = q_v$

$W = -P_{ext} \Delta V$

$W = 0$

at constant volume.

Specific heat capacity

Specific heat capacity (or specific heat) is the quantity of heat required to raise the temperature of one gram of a substance through 1 K (or 1°C).

$$\text{Specific heat capacity} = \boxed{\frac{\text{Heat capacity}}{\text{Mass}} = \frac{C}{m}}$$

Molar heat capacity

The molar heat capacity may be defined as the quantity of heat needed to raise the temperature of one mole of a substance by 1 K (or 1°C).

Molar heat capacity is denoted by 'C_m' and $\boxed{C_m = \frac{C}{n}} = \frac{q}{n\Delta T} \longrightarrow \text{J K}^{-1}\text{mol}^{-1}$

- Specific heat capacity ✓ × ✓ molar mass = molar heat capacity.
- Units of molar heat capacity are J K^{-1} mol^{-1}.

$$\frac{C}{m} \times \text{Mole} = \frac{C}{\text{Molar mass}}$$

Relationship between C_p and C_v

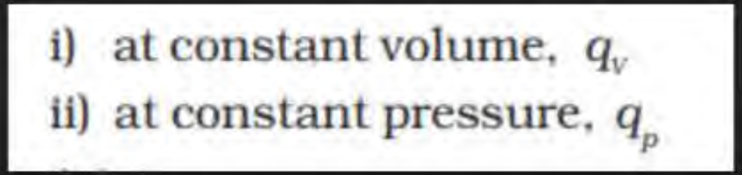
$C_p - C_v = R$

For n moles of a gas, $\boxed{C_p - C_v = nR}$; Thus, $C_p > C_v$

- Ratio of C_p and C_v is denoted by γ. Thus, $\gamma = \frac{C_p}{C_v}$
- Value of γ is used to determine atomicity of a gas,

Measurement of ΔU and ΔH : Calorimetry

Measurements are made under two different conditions:



i) at constant volume, q_v
ii) at constant pressure, q_p

$$C_v = \frac{q}{\Delta T} = \frac{\Delta U}{\Delta T}$$

$$\boxed{C_v = \frac{\Delta U}{\Delta T}}$$

→ C_v value → heat capacity at constant volume

→ $\Delta T \to T_1, T_2$

→ $\Delta U = q$

$$\boxed{\Delta H = \Delta U + \Delta n RT}$$

ΔH → Change in enthalpy

ΔU → Change in internal energy

Δn → Change in no. of moles.

QUESTION

ΔH and ΔU for the reaction, $2S_{(s)} + 3O_{2(g)} \rightarrow \underline{\underline{2}}SO_{3(g)}$; are related as

A $\Delta H = \Delta U - 1.5\ RT$

B $\Delta H = \Delta U - 0.5\ RT$

[✓ C] $\Delta H = \Delta U - RT$

D $\Delta H = \Delta U + 1.5\ RT$

$\Delta n = n_p - n_r$.

$2 - 3$

$\boxed{\Delta n = -1}$

$\Delta H = \Delta U + \Delta n RT$

$\boxed{\Delta H = \Delta U - RT}$

QUESTION

$\boxed{\Delta H = \Delta U + \Delta n RT}$ $\rightarrow \underbrace{\Delta H - \Delta U}_{} = \Delta n RT$

$= \text{zero}$

The difference in ΔH and ΔU for the combustion of methane forming water in liquid state at 25°C would be

A zero

B 2 × 298 × (–2) cal

C 2 × 298 × (–3) cal

D 2 × 25 × (–3) cal

$$CH_{4(g)} + 2O_{2(g)} \rightarrow 1CO_{2(g)} + 2H_2O_{(g)} + \text{heat}$$

at 25°C

$$\Delta n = n_p - n_r.$$

$$= 3 - 3 = 0$$

QUESTION

For the reaction $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$; $\Delta H = ?$

$$\boxed{\Delta H = \Delta U + \Delta n RT}$$

$\Delta U - 2RT$

- A $\Delta U + 2RT$
- [✓ B] $\Delta U - 2RT$
- C $\Delta U + RT$
- D $\Delta U - RT$

$$\Delta n = n_p - n_r$$

$$= 2 - 4$$

$$\underline{\underline{= -2}}$$

QUESTION

Which of the following is an endothermic reaction?

A $C_2H_{2(g)} + 2H_{2(g)} \rightarrow C_2H_{(g)}; \Delta H = -314.0\ \text{kJ}$

B $2HgO_{(s)} \rightarrow 2Hg_{(l)} + O_{2(g)}; \Delta H = -180{,}8\ \text{kJ}$

C $2Zn_{(s)} + O_{2(g)} \rightarrow 2ZnO_{(s)}; \Delta H = 693.8\ \text{kJ}$

D $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} + 393.6\ \text{kJ}$

QUESTION

Thermochemistry is concerned with the study of

A change in temperature

[✓ **B**] change in heat energy

C change in volume

D change in internal energy.

heat at constant Pressure → Enthalpy

$$\boxed{\begin{array}{l} H = U + nRT \\ H = U + PV \end{array}}$$

$$\Delta H = \Delta U + \Delta nRT$$

$$\boxed{\Delta H = \Delta U + P\Delta V}$$

QUESTION

How much heat is evolved when 12 g of CO reacts with NO_2 according to the following reaction?

$4CO_{(g)} + 2NO_{2(g)} \rightarrow 4CO_{2(g)} + N_{2(g)}, \Delta H^\circ = -1198\ kJ$

- **A** 105 kJ
- **B** 128 kJ
- **C** 50 kJ
- **D** 30.5 kJ

$4 \times CO$

$4 \times (12+16)$

$4 \times 28g \longrightarrow -1198\ kJ$

$12g \longrightarrow ?$

QUESTION

Since the enthalpy of elements in their natural state is taken to be zero, the heat of formation (ΔH) of compounds

A is always negative

B is always positive

[✓ **C**] may be negative or positive

D is zero.

$$\underline{\underline{\Delta_f H}} \longrightarrow \left\{ \begin{matrix} -ve \\ \text{or} \\ +ve \end{matrix} \right\}$$

QUESTION

Which of the following reactions defines $\underline{\Delta H_f^\circ}$?

Ⓐ $H_{2(g)} + I_{2(g)} \rightarrow 2HI_{(g)}$ ✗

Ⓑ ✓ $\boxed{\frac{1}{2}H_{2(g)} + \frac{1}{2}F_{2(g)} \rightarrow \boxed{HF_{(g)}}}$

Ⓒ $N_{2(g)} + 3H_{2(g)} \rightarrow 2NH_{3(g)}$ ✗

Ⓓ $CO_{(g)}$ ✗ $+ \frac{1}{2}O_{2(g)} \rightarrow \boxed{CO_{2(g)}}$

QUESTION

For which of the substance, ΔH_f° is zero?

A $CaCO_{3(g)}$

B $CH_3OH_{(l)}$

[✓ C] P (red)

D $H_2O_{(l)}$

QUESTION

$$\begin{tikzcd} A \arrow[r, "x"] \arrow[dr] & B \arrow[d, "y"] \\ & C \end{tikzcd}$$

Homework

Hess's law states that

$A \rightarrow C \quad \Delta H = ?$ $\quad \Delta H = x + y$

[✓ **A**] the standard enthalpy of an overall reaction is the sum of the enthalpy changes in individual reactions

B enthalpy of formation of a compound is same as the enthalpy of decomposition of the compound into constituent elements, but with opposite sign ✗

C at constant temperature the pressure of a gas is inversely proportional to its volume ✗

D the mass of a gas dissolved per litre of a solvent is proportional to the pressure of the gas in equilibrium with the solution. ✗

Melting/fusion

at STP → 1kg of solid (H_2O)

↓ $\Delta_f H = ?$

liquid

$\Delta_f H$ → enthalpy of fusion.

$I_{2(s)} \xrightarrow{\text{sublimation}} I_{2(g)}$

at STP

$\Delta_{sub}H$

1kg of solid I_2 → Gaseous substance

$H_2O_{(l)} \longrightarrow H_2O_{(g)}$ $\Delta_{evap}H = ?$

at STP → 1kg of liquid → vapour

$\Delta_{vap}H$ → enthalpy of vapourisation

Enthalpy of Combustion

The enthalpy of combustion of a substance is defined as the heat change when 1 mole of substance is completely burnt in oxygen.

$$\boxed{CH_{4\,(g)}} + 2O_{2\,(g)} \longrightarrow CO_{2\,(g)} + 2\,H_2O_{\,(l)}\ \Delta H = -890.4\ \text{kJ mol}^{-1}$$

Standard enthalpy of combustion is the amount of heat evolved when one mole of the substance under standard conditions (298 K, 1 bar pressure) is completely burnt to form the products also under standard conditions. It is represented by $\Delta_c H^0$

$$C_4H_{10\,(g)} + \frac{13}{2}O_{2\,(g)} \longrightarrow 4CO_{2\,(g)} + 5H_2O_{\,(l)}\ ;\ \Delta_c H^0 = -2658.0\ \text{kJ mol-1}$$

Standard enthalpy of formation

Amount of energy changed when 1 mole of substance formed from their constituent elements.

$$H_2 + \frac{1}{2}O_2 \longrightarrow \boxed{H_2O}$$

1 mole

$$\Delta_f H = ?$$

$$NaOH + HCl \rightarrow \boxed{NaCl} + H_2O$$

$$\Delta_f NaCl \rightarrow ?$$

$$\Delta_r H = \Delta H_{product} - \Delta H_{reactant}$$

$$\Delta_f H = p - r$$

QUESTION

$6O_2 + \frac{3}{2}O_2$

$\rightarrow \frac{12+3}{2}O_2$

$15/2\,O_2$

Calculate the standard enthalpy of formation of benzene. For the reaction,

$$\underline{C_6H_{6(l)}} + \frac{15}{2}O_{2(g)} \rightarrow 6CO_{2(g)} + 3H_2O_{(g)}, \Delta H^\circ_{Comb} = -3267\ \text{kJ} \longrightarrow ①$$

$(\Delta_f H^\circ(CO_2) = -393.5\ \text{kJ mol}^{-1}, \Delta_f H^\circ(H_2O) = -285.8\ \text{kJ mol}^{-1})$

(A) 35.5 kJ mol^{-1}

[✓ (B)] 48.6 kJ mol^{-1}

(C) 10.7 kJ mol^{-1}

(D) 5.7 kJ mol^{-1}

$6C + 3H_2 \longrightarrow \boxed{C_6H_6}$ $\quad \Delta_f H_{(benzene)} = ?$

1 mole

$\cancel{6CO_2} + \cancel{3H_2O} \longrightarrow C_6H_6 + \cancel{\frac{15}{2}O_2}$ $\quad \Delta H_{(com)} = 3267\ \text{kJ}$

$6C + \cancel{6O_2} \longrightarrow 6\boxed{\cancel{CO_2}}$ $\quad \Delta_f H = -393.5\ \text{kJ} \times 6$

$3H_2 + \cancel{3O_2}\ \frac{1}{2} \longrightarrow \boxed{\cancel{3H_2O}}$ $\quad \Delta_f H = 3 \times 285.8\ \text{kJ mol}^{-1}$

$6C + 3H_2 \longrightarrow C_6H_6 \longrightarrow 3267 - (2361 + 855) = 48$

Bond Enthalpy (Bond Energy)

- The enthalpy change required to break a particular covalent bond in one mole of gaseous molecules to produce gaseous atoms and/or radicals is called bond enthalpy.
- **Average bond enthalpy in polyatomic molecules:** Each covalent bond in polyatomic molecules is associated with its own specific bond enthalpy. The thermochemical equation for dissociation of H_2O molecules is

$$H_2O_{(g)} \rightarrow 2H_{(g)} + O_{(g)}, \Delta_r H^{\circ} = 927 \text{ kJ}$$

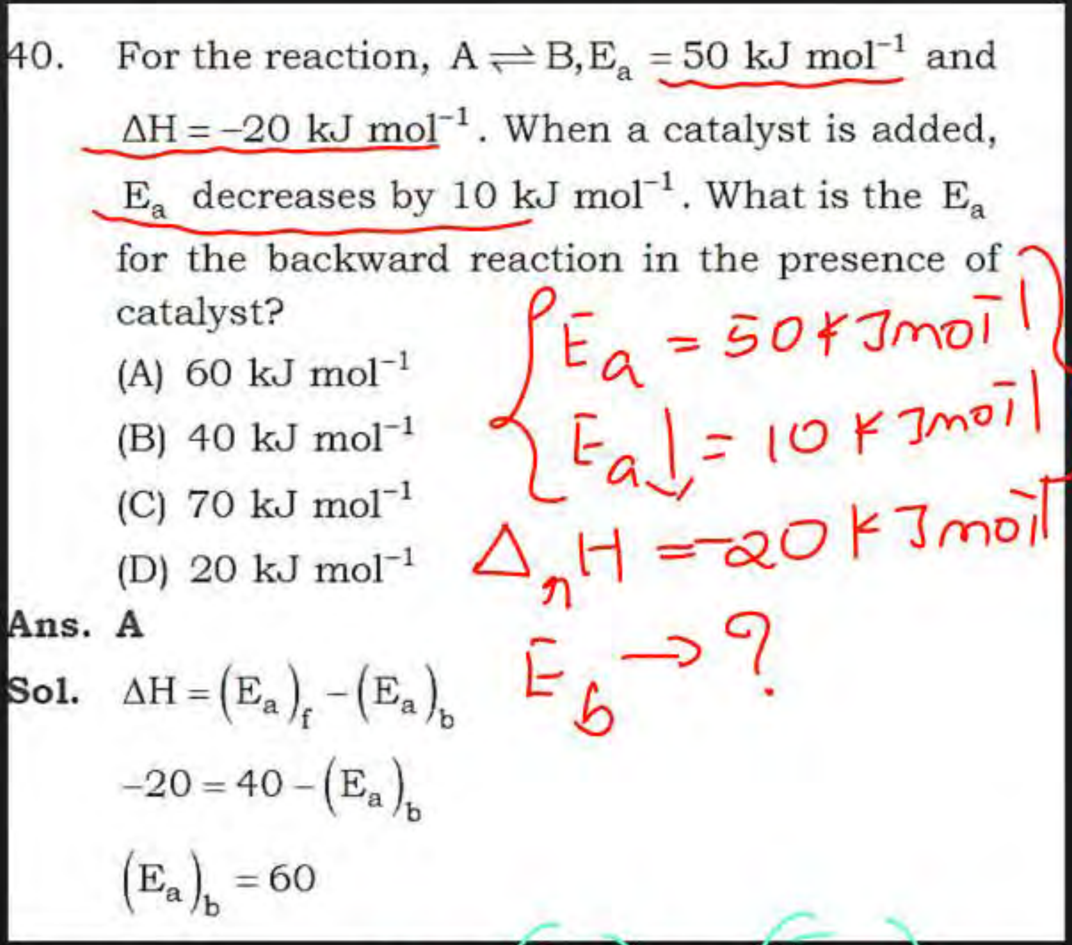
For polyatomic molecules the average bond enthalpy of a particular bond would be considered. Thus, the average bond enthalpy of the O–H bond = 927/2 = 463.5 kJ or ΔH° (O–H) = 463.5 kJ mol^{-1}. However, the energies needed to break individual O–H bonds are different.

- The standard enthalpy of reaction, ΔH° is related to the bond enthalpies of the reactants and products in gas phase reaction as

$$\boxed{\Delta H^\circ_{(\text{reaction})} = \Sigma\Delta H^\circ_{(\text{re}\underline{\text{actant}}\text{ bonds})} - \Sigma\Delta H^\circ_{(\underline{\text{product}}\text{ bonds})}} \checkmark$$

$$\Delta H_r = \Delta H^\circ_{\underline{\text{formation}}} = \sum \Delta_f H_{(\text{product})} - \sum \Delta_f H_{(\text{reactant})} \checkmark$$

KCET - 2024 ASKED QUESTIONS



40. For the reaction, $A \rightleftharpoons B, E_a = 50\ kJ\ mol^{-1}$ and $\Delta H = -20\ kJ\ mol^{-1}$. When a catalyst is added, E_a decreases by 10 kJ mol^{-1}. What is the E_a for the backward reaction in the presence of catalyst?

(A) 60 kJ mol^{-1}

(B) 40 kJ mol^{-1}

(C) 70 kJ mol^{-1}

(D) 20 kJ mol^{-1}

Ans. A

Sol. $\Delta H = (E_a)_f - (E_a)_b$

$-20 = 40 - (E_a)_b$

$(E_a)_b = 60$

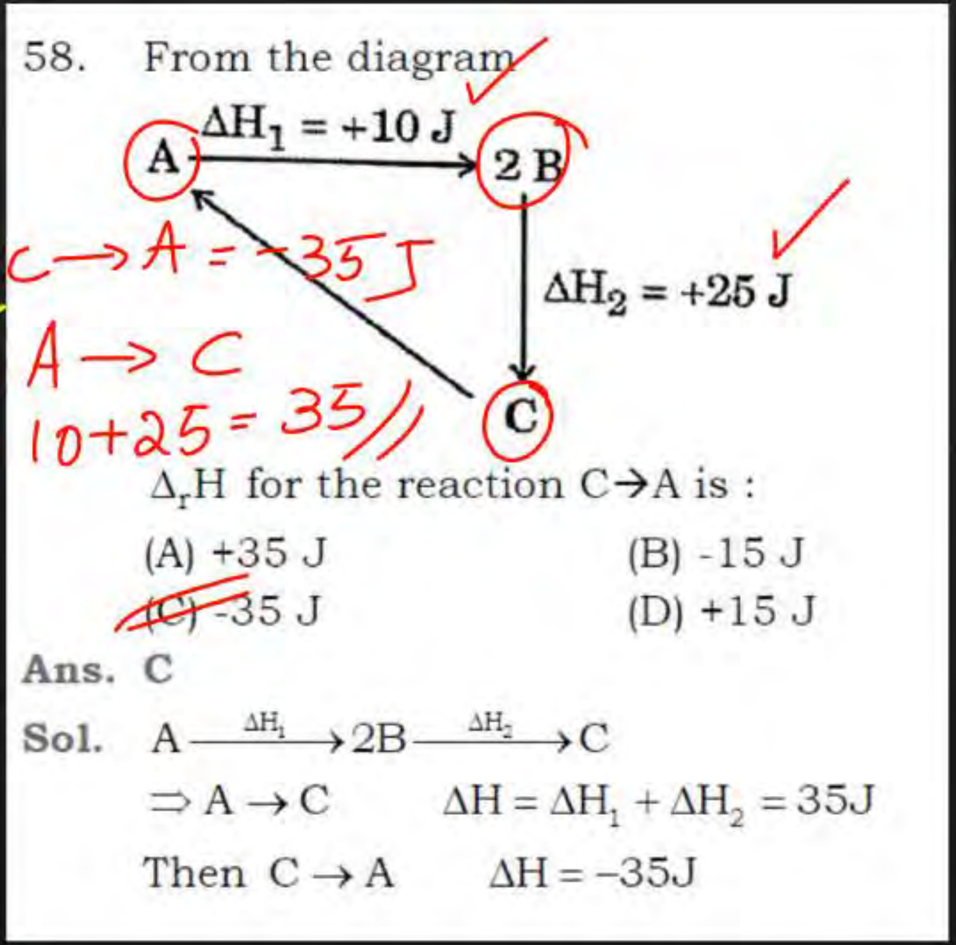
$E_a = 50\ kJ\ mol^{-1}$

$E_a \downarrow = 10\ kJ\ mol^{-1}$

E_{af}

$\Delta_r H = -20\ kJ\ mol^{-1}$

$E_b \rightarrow ?$



58. From the diagram ✓

$C \rightarrow A = -35\ J$

$A \rightarrow C$

$10 + 25 = 35$

$\Delta_r H$ for the reaction $C \rightarrow A$ is :

(A) +35 J

(B) -15 J

~~(C)~~ -35 J

(D) +15 J

Ans. C

Sol. $A \xrightarrow{\Delta H_1} 2B \xrightarrow{\Delta H_2} C$

$\Rightarrow A \rightarrow C \qquad \Delta H = \Delta H_1 + \Delta H_2 = 35J$

Then $C \rightarrow A \qquad \Delta H = -35J$

$\Delta_r H = (E_a)_f - (E_a)_b$

$\underbrace{-20 = 40 - (E_a)_b}$ $= 60\ kJ\ mol^{-1}$

Enthalpy of Atomization

When one mole of a given substance dissociates into gaseous atoms, the enthalpy change accompanying the process is called enthalpy of atomisation, represented by the symbol $\Delta_a H^0$

$H_{2\,(g)} \rightarrow 2H_{(g)}\,;\ \Delta_a H^0 = 435.0\ \text{kJ mol}^{-1}$

$Na_{(s)} \rightarrow Na_{(g)}\,;\ \Delta_a H^0 = 108.4\ \text{kJ mol}^{-1}$

$CH_{4(g)} \rightarrow C_{(g)} + 4H_{(g)},\ \Delta_{atom} H^{\circ} = 1665\ \text{kJ mol}^{-1}$

STP

760 mmHg

→ 1 bar / 1atm

T = 0°C

273K

Bond Energy

It is the amount of energy released when one mole of bonds are formed from the isolated atoms in the gaseous state or amount of energy required to dissociate one mole of bonds present between the atoms in the gaseous molecules. It is represented by $\Delta_b H$.

$H_{2\,(g)} \rightarrow 2H_{(g)}$; $\Delta_{H\text{-}H}H^0 = 435.0$ kJ mol^{-1}

$Cl_{2\,(g)} \rightarrow 2Cl_{(g)}$; $\Delta_{Cl\text{-}Cl}H^0 = 242$ kJ mol^{-1}

$2H \longrightarrow \boxed{H_2} \longrightarrow$ Energy released

$H_2 \longrightarrow 2H$

Energy is required.

Enthalpy of hydration

The amount of enthalpy change (i.e., the heat evolved or absorbed) when one mole of the anhydrous salt combines with the required number of moles of water so as to change into the hydrated salt, is called the enthalpy of hydration or heat of hydration.

anhydrous salt + H_2O

$CuSO_4 + H_2O \longrightarrow \boxed{CuSO_4 \cdot 5H_2O}$ $\Delta_{Hyd}H = ?$

Enthalpy of Solution

It is the enthalpy change when 1 mole of substance dissolves in a specified amount of solvent.

2023

The enthalpy of solution in water / solvent determined by

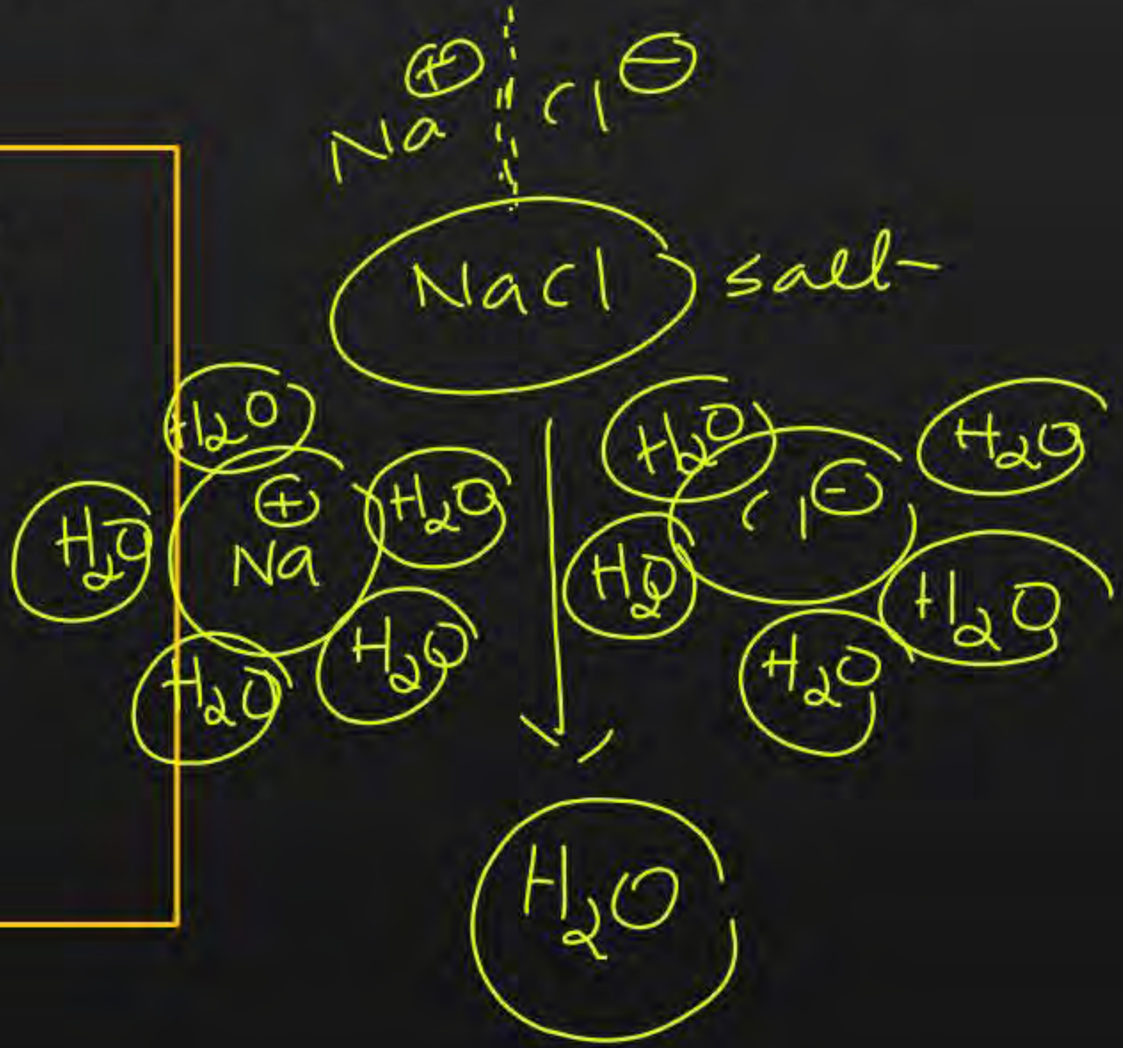
$\Delta_{sol}H^0 = \Delta_{lattice}H^0 + \Delta_{hyd}H^0$

$= (788 - 784) = 4\ kJ/mol^{-1}$

Example :

$\Delta_{lattice}H^0 = +788\ kJ\ mol^{-1}$

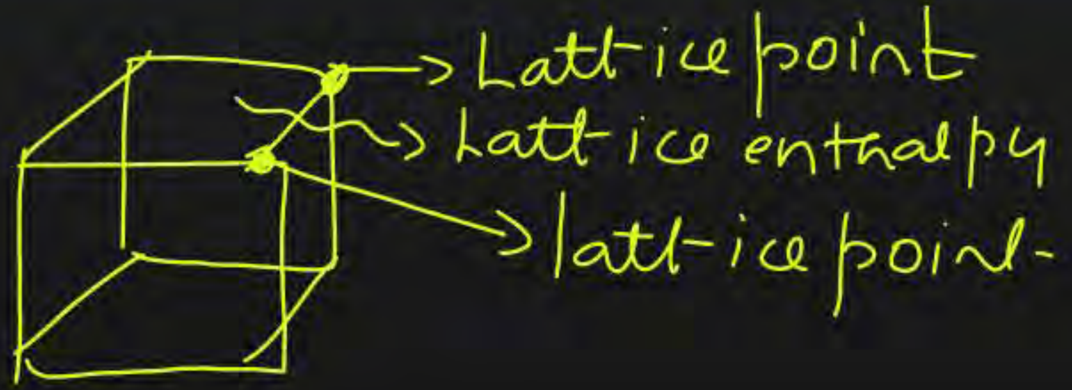
$\Delta_{hyd}H^0 = -784\ kJ\ mol^{-1}$



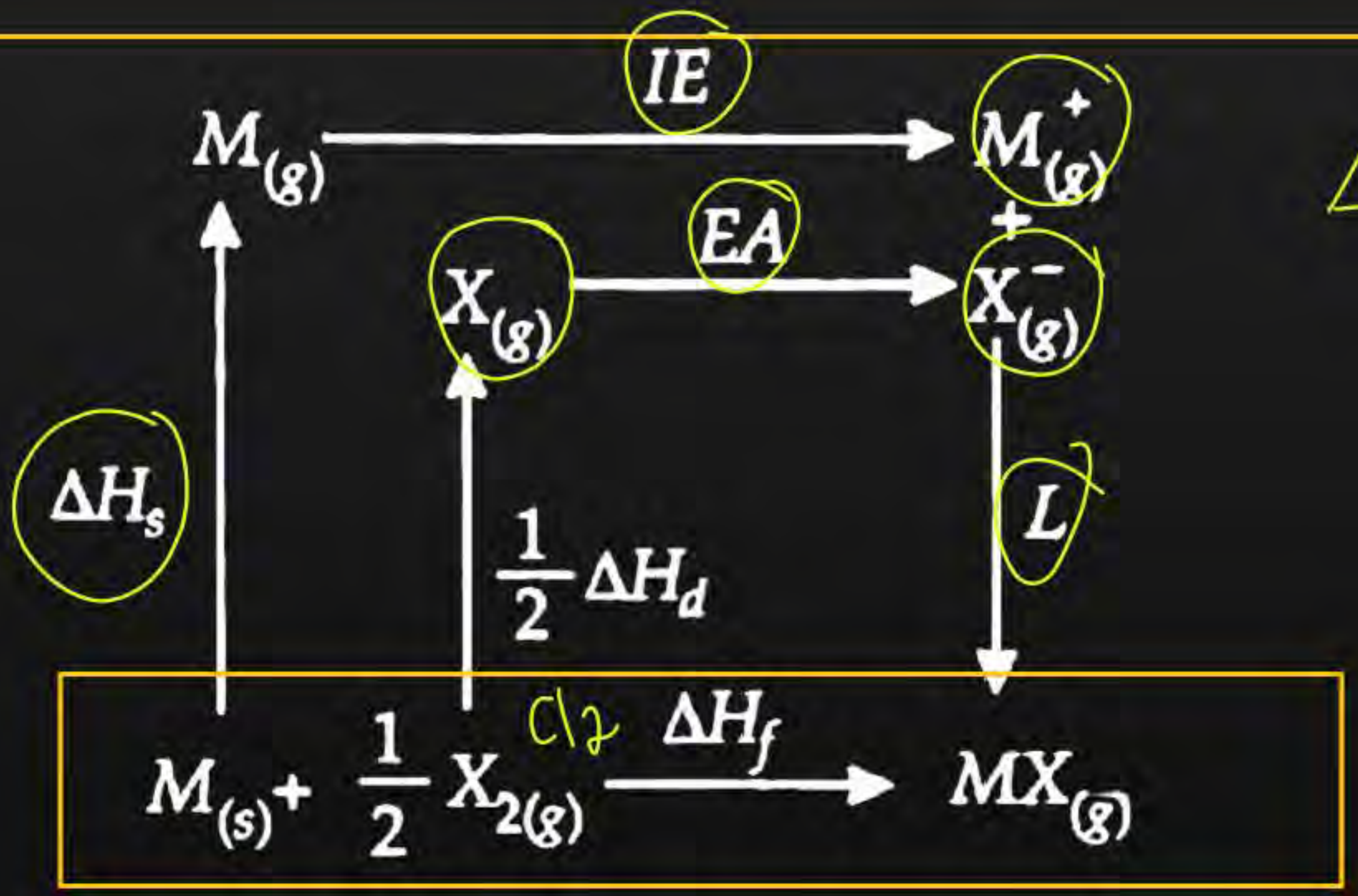
Lattice Enthalpy

- The lattice enthalpy of an ionic compound is the enthalpy change which occurs when one mole of an ionic compound dissociates into ions in gaseous state.

$$\boxed{Na^+Cl^-_{(s)} \rightarrow Na^+_{(g)} + Cl^-_{(g)}; \Delta_{lattice}H^\circ = \underline{778\ kJ\ mol^{-1}}}$$



- **Born-Haber cycle:** The Born-Haber cycle is an approach to analyse reaction energies. It involves the formation of an ionic compound from the reaction of a metal (often a group I or group II element) with a non-metal. Born-Haber cycles are used primarily as means of calculating lattice energies, which cannot otherwise be measured directly.



$$\Delta H_f = \Delta_s H + \Delta_{IE} H + \tfrac{1}{2}\Delta H_d + EA + L$$

- This cycle is based on Hess's law, i.e., the formation of an ionic crystal may occur either by direct combination of the element or by an alternate process in which various steps are involved.

$$\Delta H_f = \underset{(+)}{\Delta H_s} + \underset{(+)}{IE} + \frac{1}{2}\underset{(+)}{\Delta H_d} + \underset{(-ve)}{EA} + L$$

Where, ΔH_f = Enthalpy of formation,

ΔH_s = Enthalpy of sublimation,

IE = Ionisation energy,

ΔH_d = Enthalpy of dissociation,

EA = Electron affinity and

L = Lattice energy.

NaCl → lattice enthalpy

= 778 kJ/mol

Hess's Law of Constant Heat Summation

Example 1 :

$$\boxed{C_{(s)} + O_{2\,(g)} \rightarrow CO_{2\,(g)}\,,\ \Delta_r H^0 = -393.5\ \text{kJ mol}^{-1}}$$

$$C_{(s)} + \frac{1}{2}O_{2\,(g)} \rightarrow CO_{(g)}\,,\ \Delta_r H_1^{\,0} = \underline{-110.5}\ \text{kJ mol}^{-1}$$

+

$$CO_{(g)} + \frac{1}{2}O_{2\,(g)} \rightarrow CO_{2\,(g)},\ \Delta_r H_2^{\,0} = \underline{-283.0}\ \text{kJ mol}^{-1}$$

$$\Delta_r H^0 = (-110.5) + (-283.0) = \boxed{-393.5\ \text{kJ mol}^{-1}}$$

QUESTION

Hess's law $= 21 + (-94.1 \times 2) + (-68.3 \times 3)$

$= 21 - 188.2 - 204.9$

The standard molar heat of formation of ethane, CO_2 and water (1) respectively are –21.0, –94.1 and –68.3 kcal. The standard molar heat of combustion of ethane will be

- **A** ✓ –372 kcal
- **B** –340 kcal
- **C** 162 kcal
- **D** 183.5 kcal

$$\boxed{C_2H_6} + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O \quad \Delta_{comb}H = ?$$

1mole of ethane is burning.

$$2C + 3H_2 \longrightarrow \boxed{\cancel{C_2H_6}} \quad \Delta_f H = -21.0\ KJ\ mol^{-1}$$

$$\cancel{C_2H_6} \longrightarrow \cancel{2C} + \cancel{3H_2} \ ; \ \Delta_f H = +21.0\ KJ\ mol^{-1} \times$$

$$\cancel{2C} + 2O_2 \longrightarrow 2CO_2 \ ; \ \Delta_f H\ CO_2 = -94.1 \times 2$$

$$\cancel{3H_2} + \frac{3}{2}O_2 \longrightarrow 3H_2O \ ; \ \Delta_f H_2O = -68.3 \times 3$$

$$C_2H_6 + \frac{7}{2}O_2 \longrightarrow 2CO_2 + 3H_2O = \Delta_{comb} ?$$

QUESTION

For the given reaction

$H_{2(g)} + F_{2(g)} \rightarrow 2HF_{(g)}$ ΔH° = –124 kcal

$H_{2(g)} \rightarrow 2H_{(g)}$ ΔH° = 104 kcal

$F_{2(g)} \rightarrow 2F_{(g)}$ ⟶ ΔH° = 37.8 kcal

then the value of ΔH° for $H_{(g)} + F_{(g)} \rightarrow HF_{(g)}$ is

$2HF \longrightarrow 265.8$

$HF \longrightarrow ?$

$$\frac{265.8}{2} = -132.9$$

A 142 kcal

formation enthalpy

B –132.9 kcal

C 132 kcal

D 134 kcal.

$$\Delta_r H = \sum \Delta H_{reactant} - \sum \Delta H_{product}$$

$$= \sum (104\ kcal + 37.8) - \sum 2 \times (-124)$$

$$\boxed{= 265.8\ kcal}$$

QUESTION

The heats of neutralization of CH_3COOH, HCOOH, HCN and H_2S are –13.2, –13.4, –2.9 and –3.8 kcal per equivalent respectively. The correct increasing order of acid strength is

A $HCOOH < CH_3COOH < H_2S < HCN$

B $HCN < H_2S < CH_3COOH < HCOOH$

C $HCOOH < CH_3COOH < HCN < H_2S$

D $CH_3COOH < H_2S < HCN < HCOOH$

$NaOH + HCl \longrightarrow NaCl + H_2O$

heat of Neutralisation → ; $\Delta H_{\text{Neutralisation}} = -ve$.

heat energy released when equivalent acid react equivalent base

Strong acid + Strong base = −57.1 kJ

Spontaneous (Irreversible) Process

- The spontaneous process is defined as a process that takes place on its own without the external influence.
- A spontaneous process is irreversible process and may only be reversed by some external agency.

Entropy

- Entropy (S) is a measure of the degree of randomness or disorder of the system.
- Greater the disorder of a system larger is its entropy.
- • The melting of ice and vaporization of liquid water show that disorder is increasing and hence, entropy of substance increases as it passes from solid to liquid to gas.
- ΔS is related with q and T for a reversible reaction as $\Delta S = \frac{q_{rev}}{T}$

  Unit of $\Delta S = JK^{-1}mol^{-1}$

Entropy and Spontaneity

- The total entropy of the system and its surroundings (universe) increases in a spontaneous process. ⟶ 2nd law of thermodynamics.

$\Delta S_{universe} = \Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings} > 0$

- ➢ $\Delta S_{total} > 0$, the process is spontaneous.
- ➢ $\Delta S_{total} < 0$, the process is non-spontaneous.
- ➢ $\Delta S_{total} = 0$, the process is at equilibrium. ✓

Second Law of Thermodynamics

- The various statements of second law of thermo- dynamics are :
  - All spontaneous processes are thermodynamically irreversible. ✓✓
  - The entropy of the universe is continuously increasing. ✓✓ > 0

QUESTION

Entropy of a system

- **A** is a measure of disorder in the system
- **B** is a measure of randomness in the system
- **C** is a measure of energy content of the system
- **D** [✓ both (a) and (b).]

QUESTION

For the reaction, $\boxed{2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}}$ at room temperature, the value of ΔS is

- A positive
- [✓ B] negative
- C zero
- D unpredictable. S

QUESTION

Mark the correct statement.

$\Delta H = -ve \rightarrow$ Exo
↳ spontaneous

$\Delta H = +ve \rightarrow$ few
Endothermic reaction
↓
Spontaneous

A For a chemical reaction to be feasible, ΔH should be zero. ✗

B Entropy is a measure of order in a system. ✗

C For a chemical reaction to be feasible, ΔG should be positive. ✗ $\Delta G = -ve$

D The total energy for an isolated system is constant. $\Delta U = 0$

QUESTION

For a reversible isothermal process in equilibrium, the entropy change is given by the expression

(A) $\Delta S = \frac{T}{q_{rev}}$

[✓ (B)] $\Delta S = \frac{q_{rev}}{T}$

(C) $\Delta S = \frac{\Delta U}{T}$

(D) $\Delta S = \frac{\Delta H}{T}$

Gibbs Energy (G)

- Gibbs energy is the net energy available to do useful work and it is the criterion of spontaneity in terms of thermodynamic properties of system alone. $G = H - TS$
- Gibbs-Helmholtz equation : $\boxed{\Delta G = \Delta H - T\Delta S.}$

Gibbs Energy and Spontaneity

- ΔG gives a criteria for spontaneity at constant pressure and temperature.
  - If $\Delta G < 0$, process is spontaneous. -ve
  - If $\Delta G > 0$, process is non-spontaneous. +ve
  - If $\Delta G = 0$, process is in equilibrium.

$\Delta H = -ve$
$\Delta S = -ve$
Temp → high

$$\Delta G = \Delta H - T\Delta S \longrightarrow +ve - \underset{(low)}{T}\,(+ve)$$
$$= -ve - T(-ve)$$
$$= \underbrace{-ve + ve(T)}\longrightarrow +ve$$

Effect of temperature on spontaneity of reactions

$\Delta_r H^\circ$	$\Delta_r S^\circ$	$\Delta_r G^\circ$	**Description***
–	+	–	Reaction spontaneous at all temperatures *
–	–	–(at low T)	Reaction spontaneous at low temperature
–	–	+(at high T)	Reaction non-spontaneous at high temperature
+	+	+(at low T)	Reaction non-spontaneous at low temperature
+	+	–(at high T)	Reaction spontaneous at high temperature
+	–	+	→ Reaction non- spontaneous at all temperatures

$$\Delta G = \underset{+ve}{\Delta H}\ \underset{(+ve)}{-T\Delta S}$$

$$\Delta G = -ve$$

Gibbs Function and Equilibrium Constant

- $\Delta G = \Delta G^\circ + RT\ln(Q)$, where, Q = reaction quotient
- At equilibrium, $\Delta G = 0$ and $Q = K$ (equilibrium constant)

  $\Delta G^\circ = -2.303\,RT\log K$

$Q > K$ → reaction takes is backward direction

$Q = K$ → equilibrium

$Q < K$ → reaction takes forward direction.

$$aA + bB \longrightarrow cC + dD$$

$$Q = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Chemical Bonding $\rightarrow \begin{matrix}02\\ \downarrow\\ 03\end{matrix}$ Qsn

& Molecular structure.

Most imp. topics.

- → VSEPR Theory + hybridization* + structure.
- → Molecular orbital theory.*
- → Bond order + Magnetic property.*
- → Dipole moment*
- → Octet rule.
- → fajan's rule
  - → % ionic character
  - → % covalent character.

$$\boxed{n = \frac{1}{2}[V + M - C + A]}$$

n = no. of hybrid orbitals

V = valence electron

M = Monovalent atoms (F, Cl, Br,)

A = Anionic charge

C = Cationic charge

$\boxed{SF_4} \to {}_{16}S \to 1s^2, 2s^2, 2p^6, \boxed{3s^2, 3p^4}$

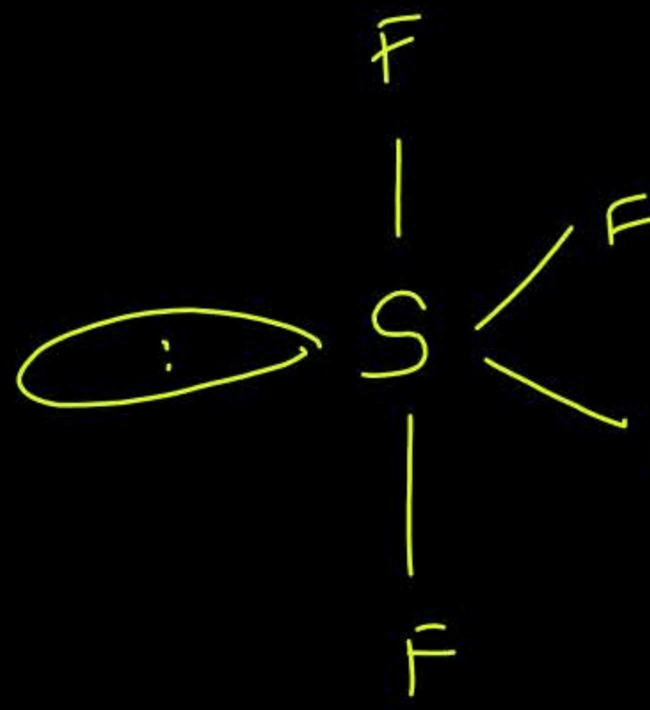
$= \frac{1}{2}[6+4] = \frac{10}{2} = \textcircled{5} \to s, p, p, p, d$

$\downarrow$

$\boxed{sp^3d}$

$\boxed{\text{Lonepair}_{e^\ominus} = n - M - D}$

$lp = 5 - 4 - 0 = 1$



→ Seasaw

→ sp^3d.

$n = 2, \longrightarrow sp \longrightarrow$ linear.

$n = 3 \longrightarrow sp^2 \longrightarrow$

$\longrightarrow$ Trigonal planar.

$n = 4 \longrightarrow sp^3 \longrightarrow$

$\longrightarrow$ tetrahedral

$n = 5 \longrightarrow sp^3d \longrightarrow$

$\longrightarrow$ Trigonal bipyramidal

$n = 6 \longrightarrow sp^3d^2 \longrightarrow$

$\longrightarrow$ Octahedral or Square bipyramidal

$n = 7 \longrightarrow sp^3d^3 \longrightarrow$

$\longrightarrow$ pentagonal bipyramidal

Shape without lonepairs.

$_7N$

$1s^2, 2s^2, 2p^3$

valence shell electron repulsion theory.

sp^2 → No lonepair → Trigonal planar.

sp^2 → 1 lone pair → Bent shape / v shape
angular shape.

sp^3 → No lonepairs → Tetrahedral

sp^3 → 1 lone pair → 

→ pyramidal.

sp^3 → 2 lonepair → 

→ bent shape or v shape or angular.

SO_2

$$n = \frac{1}{2}[V+M-C+A]$$

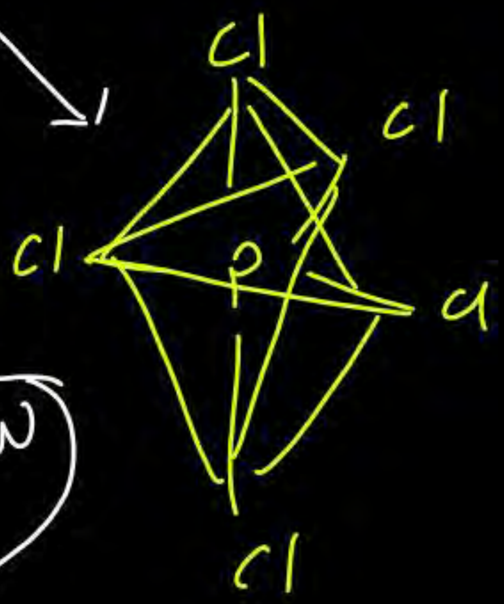
$$= \frac{1}{\cancel{2}}[\cancel{6}]^{3} = 3 \rightarrow sp^2$$

$$lp = n - M - D$$

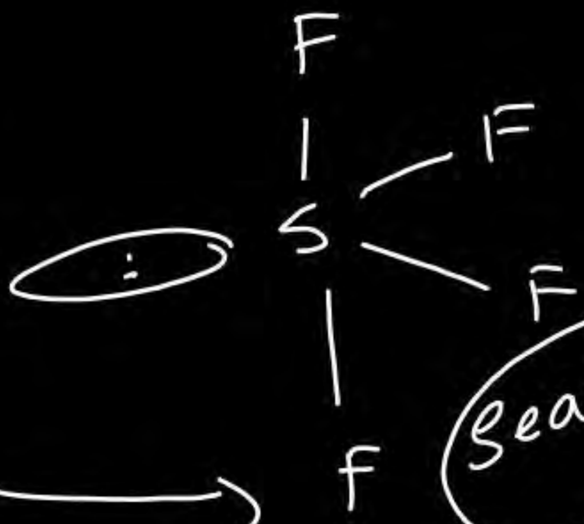
$$= 3 - 2 = \boxed{1 \text{ lonepair.}}$$

$\boxed{Sp^3d}$ → 5 orbitals → No lonepair → trigonal bipyramidal

PCl5



sp^3d → 1 lonepair → SF_4



Seasaw

sp^3d → $\boxed{\text{2 lonepair}}$ →

→ $\boxed{\text{T shape.}}$

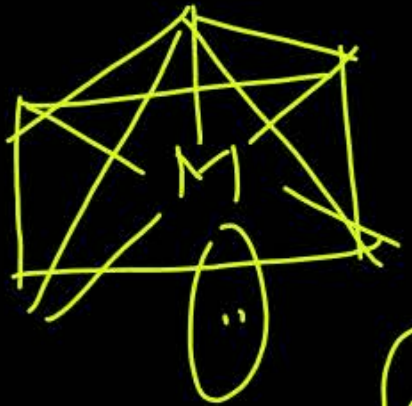
sp^3d → 3 lonepair →

→ $\boxed{\text{linear.}}$

sp^3d^2.

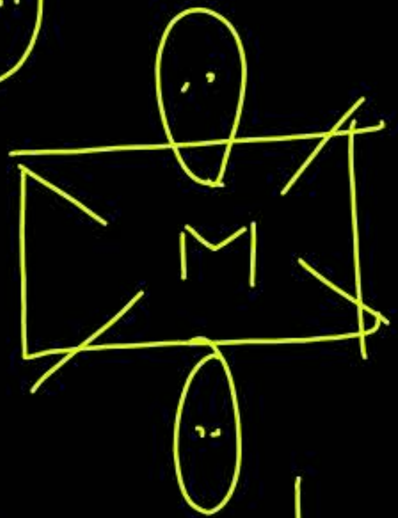
* 6 orbitals → sp^3d^2 → No lonepair → octahedral

* sp^3d^2 → 1 lonepair →



→ Square pyramidal

* Sp^3d^2 → 2 lonepair →



→ Square planar.

* sp^3d^3 → 1 lonepair.

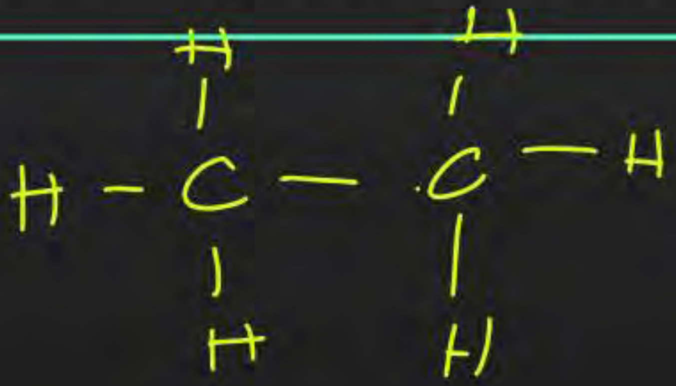
→ pentagonal bipyramidal.

QUESTION

Octet rule

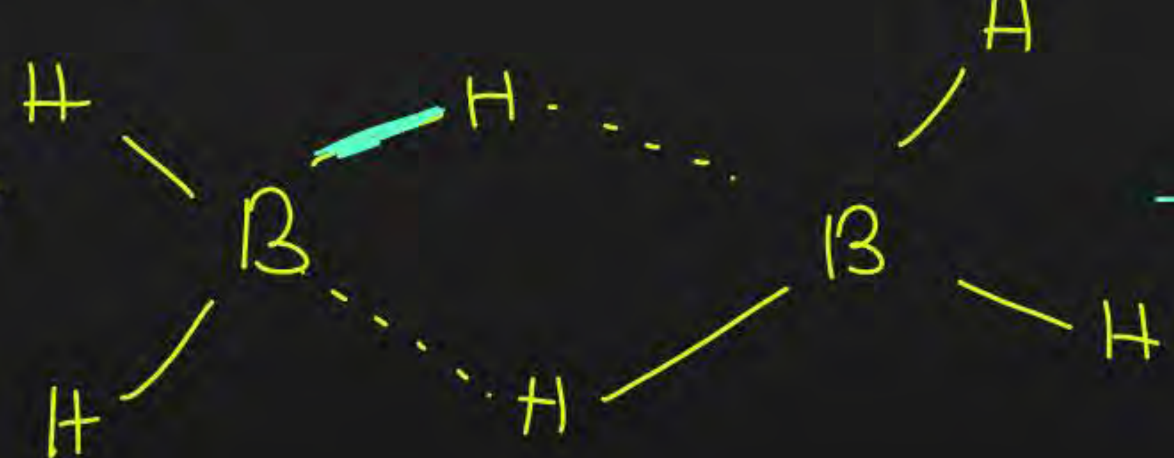
BCl_3 $BeCl_2$
BF_3
$AlCl_3$ $FeCl_3$

Which of the following is the electron deficient molecule?

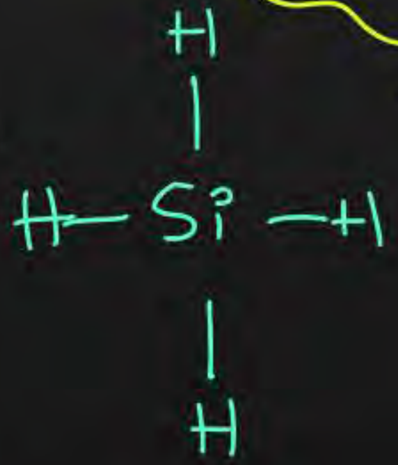


(A) C_2H_6

(B) B_2H_6

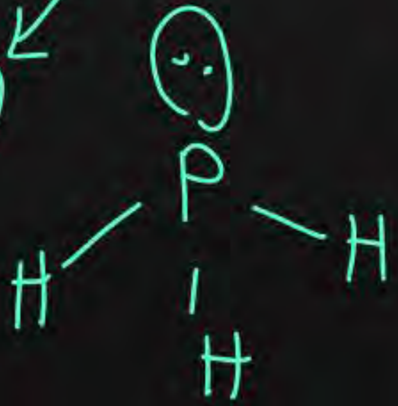


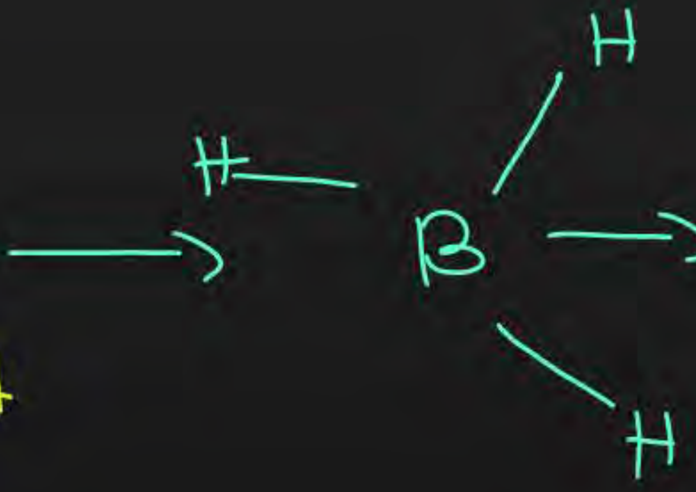
(C) SiH_4



(D) PH_3

(15)





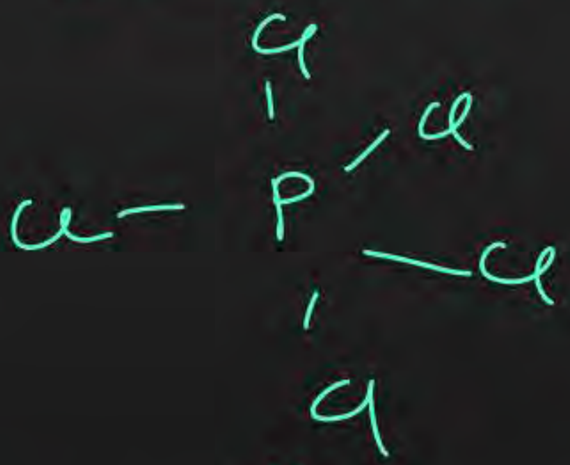
3 bonds

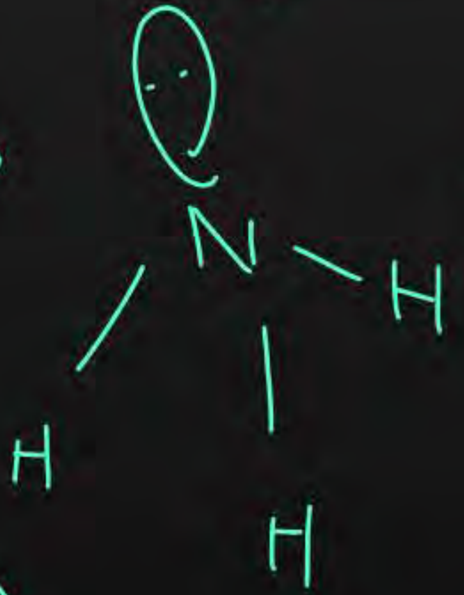
Electron deficient

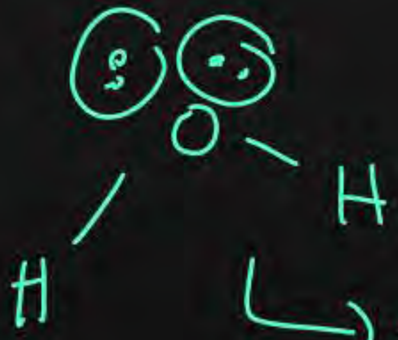
QUESTION

Expanded octet is observed in

- **A** CO_2 → 8e⊖ $O=C=O$ → 4 bonds.
- **B** PCl_5 10e⊖ → 5 bonds.
- **C** NH_3 → 8e⊖
- **D** H_2O







→ 8e⊖

$_8O$
→ $1s^2, 2s^2, 2p^4$

[↑↓] [↑↓ | ↑ | ↑]

Ö:

Ionic bond

- Columbic or electrostatic force of attractions between two oppositely charged ions formed due to complete transfer of valence electrons from one atom to another is known as ionic bond or electrovalent bond.

Factors influencing ionic bond formation :

- Low Ionisation enthalpy
- Greater negative electron gain enthalpy
- High Lattice energy – [Bi-bivalent ion>bi-univalent ion >Uni-Univalent ion]

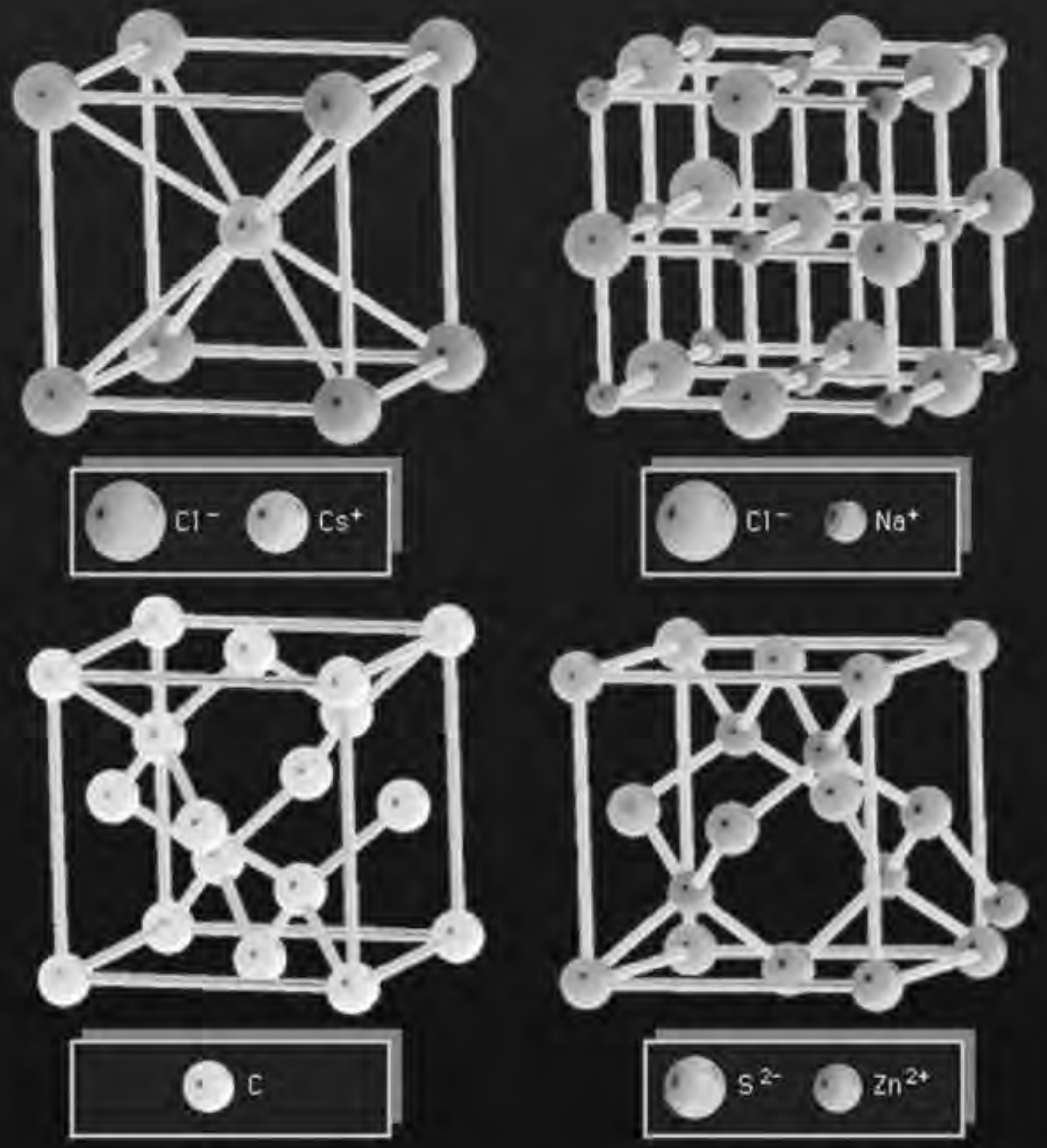
Properties of Ionic compounds

- Insoluble in organic solvents [Non-polar]
- Most of the ionic compounds are Soluble in water
- Conducts electricity in aqueous state or molten state
- Greater the lattice enthalpy, higher is the melting point

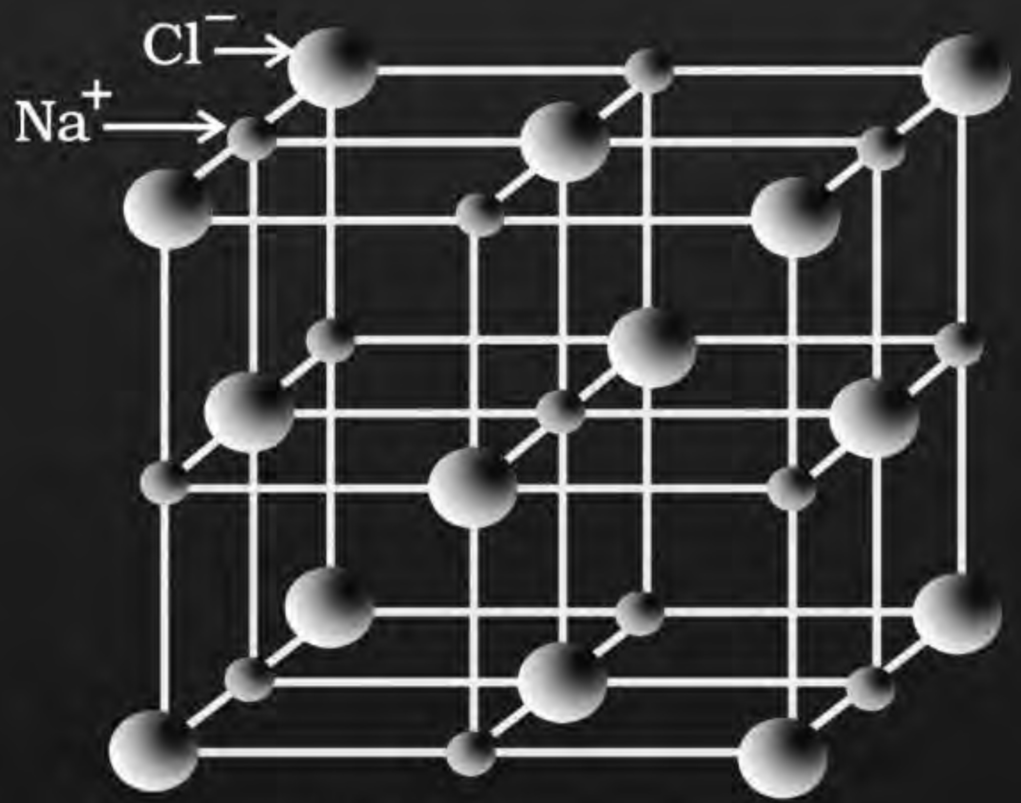
Ionic bond

- **Crystal Lattice** : Geometrical arrangement of the atoms, ions or molecules of the crystalline solid as points in space.

- In a crystal lattice, each atom, molecule or ions (constituent particle) is represented by a single point.
- These points are called lattice site or lattice point.
- When lattice sites are together joined by a straight line in a crystal lattice we get a three-dimensional view of the structure.



Lattice enthalpy



Rock salt structure

Lattice Enthalpy:
The Lattice Enthalpy of an ionic solid is defined as the energy required to completely separate one mole of a solid ionic compound into gaseous constituent ions.

The lattice enthalpy of NaCl is 788 kJ mol^{-1}.
This means that 788kJ of energy is required to separate one mole of solid NaCl into one mole of Na^+ (g) and one mole of Cl^- (g) to an infinite distance.

Covalent bond

Covalent bond : Type of chemical bond formed by sharing of valence electrons between the participating atom is known as covalent bond.

Single covalent bond: when two atoms share one electron pair they are said to be joined by a single covalent bond.

Double covalent bond : If two atoms share two pairs of electrons, the covalent bond between them is called a double bond.

When combining atoms share three electron pairs , triple bond is formed.

Fajans rules : Covalent character of ionic bond

- The smaller the **size** of the cation and the larger the size of the anion, the greater the covalent character of an ionic bond.
- The greater the **charge** on the cation, the greater the covalent character of the ionic bond.
- For cations of the same size and charge, Most of the d block elements polarizes [pulling the electronic charge toward itself] than S – block elements.
- The charge/size ratio of a cation determines its polarizing power

$\text{valence } e^{\ominus} - \text{unshared } e^{\ominus} - \frac{1}{2}(\text{bonding } e^{\ominus})$

QUESTION

In PO_4^{3-} ion, the formal charge on the oxygen atom of P-O bond is

$P = 5e^{\ominus}\ 0 - \frac{1}{\cancel{2}}(\overset{5}{\cancel{10}}e^{\ominus}) = 0$

(A) +1

$O_1 = 6e^{\ominus} - 4 - \frac{1}{\cancel{2}}(\overset{2}{\cancel{2}}) = 6-6=0$

(B) −1 ✓

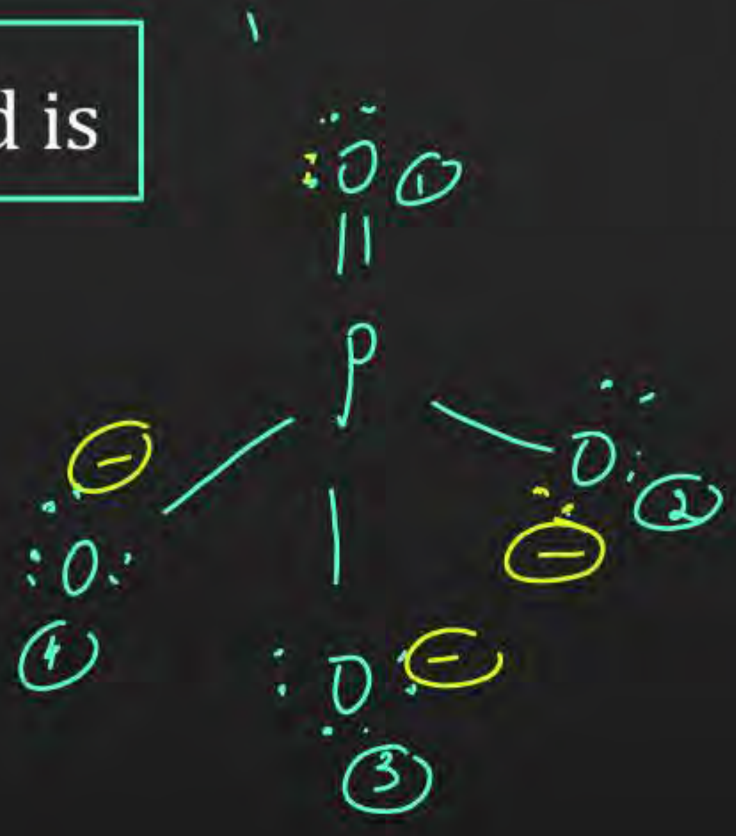
$O_2 = 6e^{\ominus} - 6e^{\ominus} - \frac{1}{\cancel{2}}(\cancel{2})^{1} = -1e^{\ominus}$

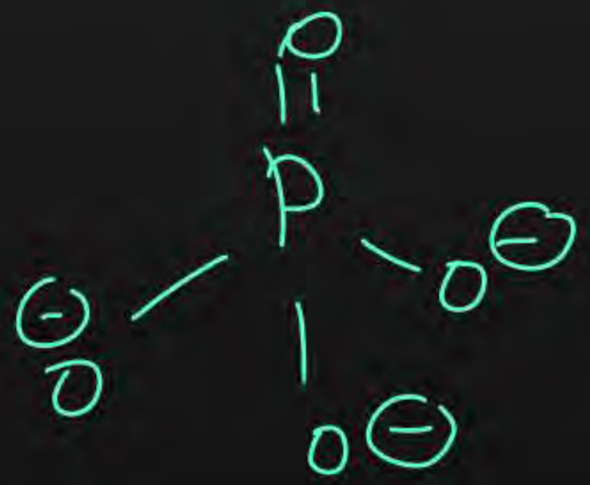
(C) −0.75

$6e^{\ominus} - 7e^{\ominus}$

(D) +0.75

$O_3 = 6e^{\ominus} - 6e^{\ominus} - 1e^{\ominus} = 6-7 = -1e^{\ominus}$





QUESTION

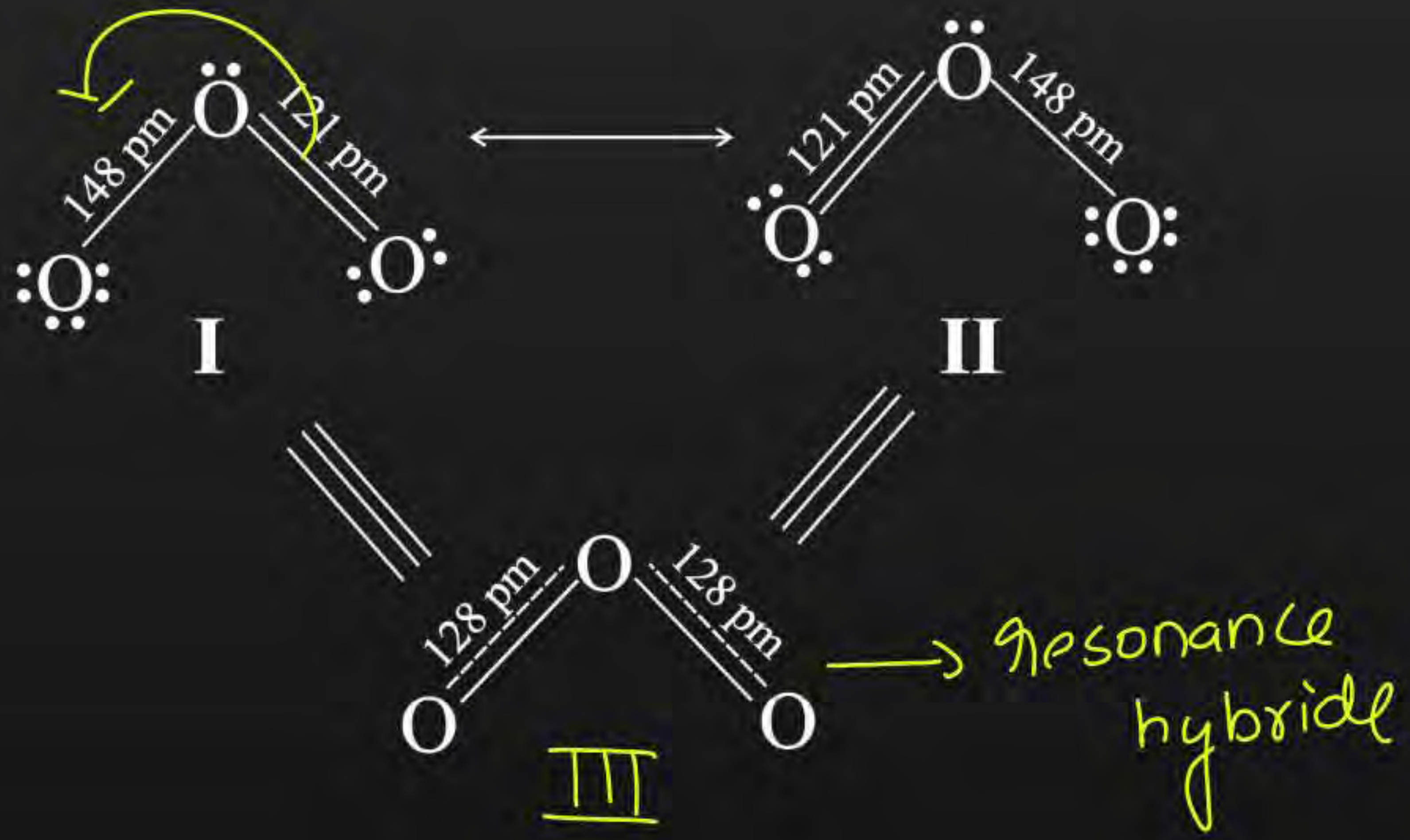
Which of the following structure represents structure of O_3 more accurately?

A I

B II

[✓ C] III

D I and II

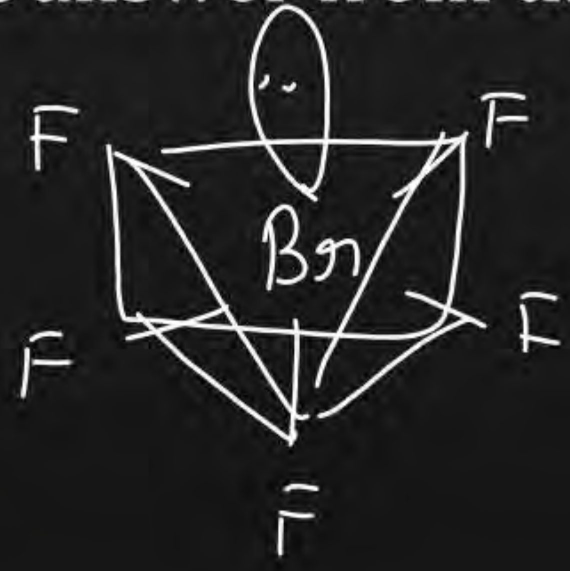


QUESTION

Match list-I with list-II.

List-I	List-II
A. PCl_5	I. Square pyramidal
B. SF_6	II. Trigonal planar
C. BrF_5	III. Octahedral
D. BF_3	IV. Trigonal bipyramidal

Choose the correct answer from the options given below



	A	B	C	D
(A)	IV	III	I	II
(B)	III	I	IV	II ✗
(B)	II	III	IV	I ✗
(D)	IV	III	II	I

$PCl_5 = \frac{1}{2}[5+5] = \frac{10}{2} = 5$

sp^3d $\quad lp = \boxed{n - M - D} = 5 - 5 = 0$

$SF_6 = \frac{1}{2}[6+6) = \frac{12}{6} = sp^3d^2$

$lp = n - M - D$

$= 6 - 6 = 0$

$\boxed{BrF_5} \rightarrow \frac{1}{2}[7+5]$

$sp^3d^2 = \frac{12}{2} = 6$

$lp = n - M - D$

$= 6 - 5 = 1$ lone pair

Thank you