

### Hybridisation

101. (a) Bond angle of hydrides decreases down the group.
102. (b) Hybridization of  $N$  in  $NH_3$  is  $sp^3$  that of  $Pt$  in  $[PtCl_4]^{2-}$  is  $dsp^2$  that  $P$  in  $PCl_5$  is  $sp^3d$  and that of  $B$  in  $BCl_3$  is  $sp^2$ .
103. (d)  $NH_4^+$  and  $SO_4^{2-}$  both show  $sp^3$ -hybridization and tetrahedral structure.
104. (a) It shows  $sp^3d^3$ -hybridization. Hence the bond angle is about  $72^\circ$ .
105. (b)  $ClO_2$

#### Explanation (Word-friendly format):

- $CO_2 \rightarrow$  Linear shape ( $O=C=O$ ), hybridization of  $C$  is  $sp$ .
- $I_3^- \rightarrow$  Linear shape, central iodine is  $sp^3d$  hybridized (3 lone pairs cause linear geometry).
- $ClO_2 \rightarrow$  Bent (angular) shape because chlorine has one lone pair and two bonding pairs.

Hence,  **$ClO_2$  is not linear.**

106. (a)  $SCl_4$

#### Explanation (Word-friendly format):

- $SO_4^{2-} \rightarrow$  Tetrahedral (central  $S$  is  $sp^3$  hybridized).
- $Ni(CO)_4 \rightarrow$  Tetrahedral ( $Ni$  uses  $sp^3$  hybridization).
- $NiCl_4^{2-} \rightarrow$  Tetrahedral geometry due to  $sp^3$  hybridization in high-spin complex.
- $SCl_4 \rightarrow$  Has one lone pair on sulfur  $\rightarrow$  actual shape is **see-saw**, not tetrahedral.

Therefore,  **$SCl_4$  is not tetrahedral.**



107. (a) s-character increases with increase in bond angle.

Hybridization	s%	Angle
$sp$	50	$180^\circ$
$sp^2$	33.3	$120^\circ$
$sp^3$	25	$109.28^\circ$
$sp^3d^1$	20	$90^\circ$ and $120^\circ$

108. (b)  $IF_7$  molecule show  $sp^3d^3$ —hybridization.

109. (a) Spherically symmetrical

**Explanation (Word-friendly format):**

When all five d orbitals are completely filled ( $d^{10}$  configuration), the electron density is uniformly distributed around the nucleus. This results in **spherical symmetry**, similar to s orbitals.

Therefore, a  **$d^{10}$  configuration is spherically symmetrical**

110. (a)  $PCl_3$  contain three bonding and one lone pair electron. Hence shows  $sp^3$ —hybridization.

111. (a) Ammonia and  $(BF_4)^{-1}$  shows  $sp^3$ —hybridization.

112. (b) For square planar geometry hybridization is  $dsp^2$  involving s,  $p_x$ ,  $p_y$  and  $d_{x^2-y^2}$  orbital.

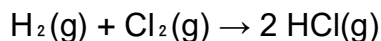
113. (b) All carbon atoms of benzene consist of alternate single and double bond and show  $sp^2$  hybridization.

114. (a)  $427 \text{ kJ}\cdot\text{mol}^{-1}$



**Working (Word-friendly):**

Consider the reaction:



Energy required to break bonds =  $D(\text{H-H}) + D(\text{Cl-Cl}) = 430 + 242 = 672 \text{ kJ}$ .

Energy released on forming 2 H-Cl bonds =  $2 \times D(\text{H-Cl})$ .

The reaction enthalpy  $\Delta H(\text{reaction}) = [\text{energy to break}] - [\text{energy released forming bonds}]$

So:  $\Delta H = 672 - 2 \cdot D(\text{H-Cl})$

Given  $\Delta H_f$  for HCl =  $-91 \text{ kJ} \cdot \text{mol}^{-1}$  (since 91 kJ is released per mole of HCl formed, the reaction  $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$  releases 182 kJ), the reaction enthalpy for 1 mol  $\text{H}_2 + 1 \text{ mol Cl}_2 \rightarrow 2 \text{HCl}$  is:

$$\Delta H = 2 \times (-91) = -182 \text{ kJ}$$

Plug in:  $-182 = 672 - 2 \cdot D(\text{H-Cl})$

Rearrange:  $2 \cdot D(\text{H-Cl}) = 672 + 182 = 854$

$$D(\text{H-Cl}) = 854 / 2 = \mathbf{427 \text{ kJ} \cdot \text{mol}^{-1}}$$

115. (d)  $\text{PtCl}_4^{2-}$ **Explanation (Word-friendly):**

- **$\text{dsp}^2$  hybridization** corresponds to a **square-planar** geometry (one d, one s and two p orbitals mix).
- $\text{PtCl}_4^{2-}$  (Pt(II),  $d^8$ ) is typically **square planar**  $\rightarrow \text{dsp}^2$ .
- $\text{NiCl}_4^{2-}$  is usually **tetrahedral** ( $\text{sp}^3$ ) for high-spin Ni(II).
- $\text{SCl}_4$  is see-saw (derived from trigonal bipyramidal,  $\text{sp}^3\text{d}$ ).
- $\text{NH}_4^+$  is tetrahedral ( $\text{sp}^3$ ).

116. (c)  $\text{BCl}_3$  molecule show  $\text{sp}^2$ -hybridization and planar structure.

117. (c)  $BCl_3$  Boron trichloride molecule show  $sp^2$ -hybridization and trigonal planar structure.
118. (b)  $SO_2$  molecule shows  $sp^2$ -hybridization and bent structure.
119. (c) Due to multiple bonding in  $N_2$  molecule.
120. (a) % of s-character in

$$CH_4 \underset{(sp^3)}{=} \frac{100}{4} = 25, \quad C_2H_4 \underset{(sp^2)}{=} \frac{100}{3} = 33,$$

$$C_2H_2 \underset{(sp)}{=} \frac{100}{2} = 50$$

