## Molecular orbital theory

21. (d) $H_2^+$ has the bond order $\frac{1}{2}$, it has only one electron so it will be paramagnetic.

22. (c) When bond forms between two atom then their energy get lower than that of separate atoms because bond formation is an exothermic process.

23. (b) Valency of $A$ is 3 while that of $B$ is 2 so according to Criss Cross rule the formula of the compound between these two will be $A_2B_3$.

24. (c) Due to resonance bond order of $C-C$ bonds in benzene is between 1 and 2.

25. (a) Nitrogen does not have vacant 'd' -orbitals so it can't have +5 oxidation state i.e. the reason $PCl_5$ exists but $NCl_5$ does not.

26. (d) Molecules having unpaired electrons show paramagnetism.

27. (b) $NO_2$ has unpaired electrons so it would be paramagnetic.

28. **(b) More than that of 2s orbital**

**Explanation (Word-friendly format):**
In multi-electron atoms, **2s electrons are more penetrating** and experience greater attraction from the nucleus than 2p electrons.
As a result, the **2s orbital has lower energy**, and the **2p orbital has slightly higher energy**.
Only in hydrogen (or hydrogen-like atoms), 2s and 2p have the **same energy** (degenerate).

29. **(a) 16 shared and 8 unshared electrons**

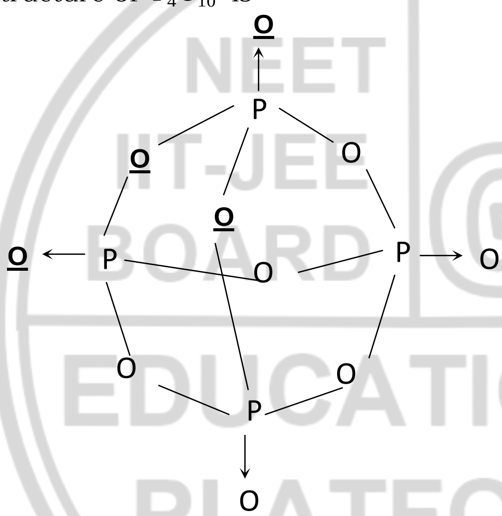
**Explanation:**
The molecular formula of acetic acid is **$CH_3COOH$**.

- Total valence electrons = 24
- **Shared electrons (bonding pairs):** 16 electrons form $\sigma$ and $\pi$ bonds.
- **Unshared (lone-pair) electrons:** 8 electrons remain as lone pairs on oxygen atoms.

Hence, acetic acid has **16 shared** and **8 unshared electrons**.

30. (c) Helium molecule does not exist as bond order of $He_2 = 0$.

31. (c) Structure of $P_4O_{10}$ is




Each phosphorus is attached to 4 oxygen atoms.

32. **(a) Oxygen and nitric oxide molecules are both paramagnetic because both contain unpaired electrons**

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

- **Oxygen ($O_2$):** According to Molecular Orbital Theory, $O_2$ has two unpaired electrons in $\pi$*2p orbitals → hence **paramagnetic**.
- **Nitric oxide (NO):** Total 15 electrons; molecular orbital configuration shows **one unpaired electron** → also **paramagnetic**.

Therefore, **both $O_2$ and NO are paramagnetic** due to the presence of **unpaired electrons** in their molecular orbitals.

33. (c) B.O. of carbon $= \frac{N_b - N_a}{2} = \frac{8-4}{2} = 2$.

34. (a) B.O. $= \frac{N_b - N_a}{2} = \frac{10-4}{2} = 3$.

35. **(c) Stabilization energy**

**Explanation (Word-friendly format):**
When atomic orbitals combine to form molecular orbitals, the **bonding molecular orbital** formed has **lower energy** than the original atomic orbitals.
This decrease in energy is known as **stabilization energy**, representing the **energy gain** due to bond formation.

36. **(d) Unpaired electrons in the antibonding $\pi$ molecular orbital**

**Explanation:**
In $O_2$, the molecular orbital configuration is:
$(\sigma 2s)^2 (\sigma 2s)^2 (\sigma 2p_x)^2 (\pi 2p\_y)^2 (\pi 2p\_z)^2 (\pi 2p\_y)^1 (\pi {*}2p\_z)^1$

The **two unpaired electrons** in the *antibonding $\pi$ (pi-star) orbitals** make $O_2$ **paramagnetic**.

37. (b) B.O. $= \frac{N_b - N_a}{2} = \frac{8-3}{2} = \frac{5}{2} = 2.5$.

38. (a) Electronic configuration of $O_2$ is

$$O_2 = \sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \sigma(2p_x)^2 \pi(2p_y)^2 \ \ \pi(2p_z)^2 \pi^*(2p_y)^1 \pi^*(2p_z)^1$$

The molecule has two unpaired electrons So, it is paramagnetic

39. **(a) $N_x$ > N_y**

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

According to **Molecular Orbital Theory**, the **stability** of a molecule depends on the number of electrons in bonding and antibonding orbitals.

- If $N_x > N_y$, more electrons occupy bonding orbitals → **bond order is positive** → molecule is **stable**.
- If $N_x = N_y$, bond order = 0 → molecule is **unstable**.
- If $N_x < N_y$, antibonding orbitals dominate → molecule becomes **unstable or does not exist**.

Therefore, a molecule is **stable when the number of bonding orbitals ($N_x$) is greater than the number of antibonding orbitals ($N_y$).**

40. (c) $\overset{*}{\pi} 2p_y$ has two nodal planes.