Chemical Bonding and Molecular Structure JEE Main PYQ - 2

Total Time: 1 Hour : 15 Minute **Total Marks:** 120

Instructions

Instructions

1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Chemical Bonding and Molecular Structure

1. The number of species having non-pyramidal shape among the following is _____. (+4, -1)

(A) SO_3
(B) NO_3^-
(C) PCl_3
(D) CO_3^{2-}

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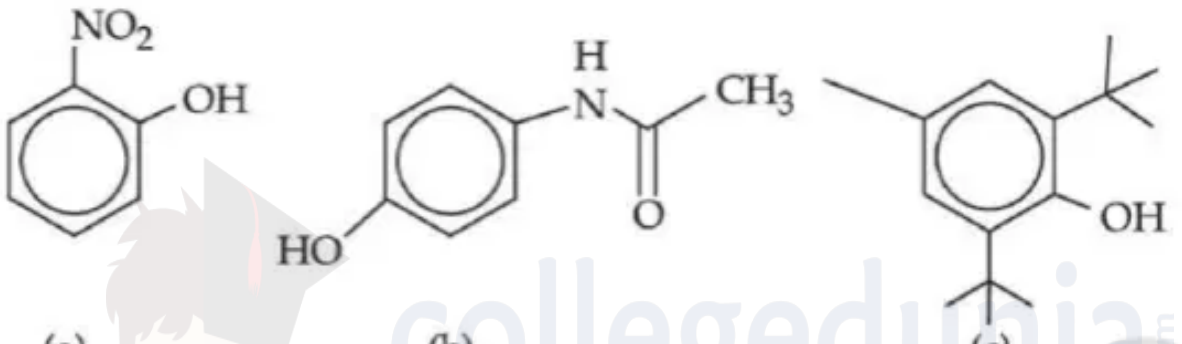
2. The compound/s which will show significant intermolecular H-bonding is/are : (+4, -1)



a. (a), (b) and (c)

b. (a) and (b) only

c. (b) only

d. (c) only

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3. Match List - I with List - II : (+4, -1)

	List - I (Species)		List - II (No. of lone pairs of electrons on the central atom)
(a)	XeF_2	(i)	0
(b)	XeO_2F_2	(ii)	1
(c)	XeO_3F_2	(iii)	2
(d)	XeF_4	(iv)	3

Choose the most appropriate answer from the options given below :

a. (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)

b. (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii)

c. (a)-(iv), (b)-(i), (c)-(ii), (d)-(iii)

d. (a)-(iii), (b)-(ii), (c)-(iv), (d)-(i)

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4. AB_3 is an interhalogen T-shaped molecule. The number of lone pairs of electrons on A is _____. (Integer answer) (+4, -1)

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5. The bond order and magnetic behaviour of O_2^- ion are, respectively : (+4, -1)

a. 1 and paramagnetic.

b. 1.5 and paramagnetic.

c. 2 and diamagnetic.

d. 1.5 and diamagnetic.

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6. In SO_2, NO_2^- and N_3^- the hybridizations at the central atom are respectively : (+4, -1)

a. sp^2, sp^2 and sp

b. sp^2, sp and sp

c. sp^2, sp^2 and sp^2

d. sp, sp^2 and sp

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7. Given below are two statements : **(+4, -1)**
Statement I : Wet cotton clothes made of cellulose based carbohydrate takes comparatively longer time to get dried than wet nylon polymer based clothes.
Statement II : Intermolecular hydrogen bonding with water molecule is more in nylon-based clothes than in the case of cotton clothes.
In the light of the above statements, choose the Correct answer from the options given below

a. Statement I is false but Statement II is true

b. Statement I is true but Statement II is false

c. Both Statement I and Statement II are true

d. Both Statement I and Statement II are false

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8. **Match the LIST-I with LIST-II.** **(+4, -1)**

LIST-I Molecule/ion		LIST-II Bond pair : lone pair (on the central atom)	
A.	ICl_2^-	I.	4 : 2
B.	H_2O	II.	4 : 1
C.	SO_2	III.	2 : 3
D.	XeF_4	IV.	2 : 2

Choose the correct answer from the options given below :

a. A-IV, B-III, C-II, D-I

b. A-III, B-IV, C-II, D-I

c. A-III, B-IV, C-I, D-II

d. A-II, B-I, C-IV, D-III

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9. Resonance in X_2Y can be represented as (+4, -1)

The enthalpy of formation of X_2Y is 80 kJ mol^{-1}, and the magnitude of

resonance energy of X_2Y is:

10. Which of the following has sp^3d^2 hybridisation? (+4, -1)

a. $[NiCl_4]^{2-}$

b. $[Ni(CO)_4]$

c. SF_6

d. $[Ni(CN)_4]^{2-}$

11. Match list I with list II: (+4, -1)

List I	Species	List II	Geometry/ Shape
A	H_3O^+	I	Tetrahedral
B	Acetylide anion	II	Linera
C	NH_4^+	III	Pyramidal
D	ClO_2^-	IV	Bent

Choose correct answer from the options given below:

a. A-I, B-II, C-III, D-IV

b. A-IV, B-I, C-III, D-II

c. A-II, B-IV, C-I, D-III

d. A-III, B-II, C-IV, D-I

12. Total number of non-bonded electrons present in NO_2; ion based on Lewis theory is: (+4, -1)

13. An element 'E' has the ionisation enthalpy value of 374 kJ mol^{-1}. 'E' reacts with elements A, B, C, and D with electron gain enthalpy values of -328, -349, (+4, -1)

-325, and -295 kJ mol^{-1}, respectively. The correct order of the products EA, EB, EC, and ED in terms of ionic character is:

a. EA > EB > EC > ED

b. ED > EC > EA > EB

c. ED > EC > EB > EA

d. EB > EA > EC > ED

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14. Match the LIST-I with LIST-II: (+4, -1)

LIST-I (Classification of molecules based on octet rule)		LIST-II (Example)	
A.	Molecules obeying octet rule	I.	NO, NO_2
B.	Molecules with incomplete octet	II.	BCl_3, $AlCl_3$
C.	Molecules with incomplete octet with odd electron	III.	H_2SO_4, PCl_5
D.	Molecules with expanded octet	IV.	CCl_4, CO_2

Choose the correct answer from the options given below :

a. A-IV, B-II, C-I, D-III

b. A-III, B-II, C-I, D-IV

c. A-IV, B-I, C-III, D-II

d. A-II, B-IV, C-III, D-I

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15. The number of molecules/ions that show linear geometry among the following is _____. SO_2, $BeCl_2$, CO_2, N_3⊠, NO_2, F_2O, XeF_2, NO_2^+, I_3⊠, O_3 (+4, -1)

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16. A group 15 element forms $d\pi - d\pi$ bond with transition metals. It also forms a hydride, which is the strongest base among the hydrides of other group members that form $d\pi - d\pi$ bonds. The atomic number of the element is _____. (+4, -1)

17. Which of the following compounds exhibits ionic bonding? (+4, -1)

a. NaCl

b. CCl4

c. CO2

d. SO2

18. Given below are two statements : (+4, -1)
Statement (I) : Both metal and non-metal exist in p and d-block elements.
Statement (II) : Non-metals have higher ionisation enthalpy and higher electronegativity than the metals.
In the light of the above statements, choose the most appropriate answer from the option given below:

a. Both Statement I and Statement II are false

b. Statement I is false but Statement II is true

c. Statement I is true but Statement II is false

d. Both Statement I and Statement II are true

19. Match List-I with the List-II (+4, -1)

List-I (Compound / Species)	List-II (Shape / Geometry)
(A) SF_4	(I) Tetrahedral
(B) BrF_3	(II) Pyramidal
(C) BrO_3^-	(III) See saw
(D) NH_4^+	(IV) Bent T-shape

Choose the correct answer from the options given below:

a. A-II, B-III, C-I, D-IV

b. A-III, B-IV, C-II, D-I

c. A-II, B-IV, C-III, D-I

d. A-III, B-II, C-IV, D-I

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20. Number of compounds from the following with zero dipole moment is _____. **(+4, -1)**

HF, H_2, H_2S, CO_2, NH_3, BF_3, CH_4, $CHCl_3$, SiF_4, H_2O, BeF_2

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21. The fusion of chromite ore with sodium carbonate in the presence of air leads to the formation of products A and B along with the evolution of CO_2. The sum of spin-only magnetic moment values of A and B is _____ B.M. (Nearest integer) **(+4, -1)**
(Given atomic number: C : 6, Na : 11, O : 8, Fe : 26, Cr : 24)

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22. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R). **(+4, -1)**
Assertion (A): NH_3 and NF_3 molecule have pyramidal shape with a lone pair of electrons on nitrogen atom. The resultant dipole moment of NH_3 is greater than that of NF_3.
Reason (R): In NH_3, the orbital dipole due to lone pair is in the same direction as the resultant dipole moment of the N – H bonds. F is the most electronegative element.

In the light of the above statements, choose the correct answer from the options given below:

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

b. (A) is false but (R) is true

c. (A) is true but (R) is false

d. Both (A) and (R) are true but (R) is NOT the correct explanation of (A)

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23. Match List - I with List - II. **(+4, -1)**

List - I	List - II
(A) ICl	(IV) Linear
(B) ICl_3	(I) T-Shape
(C) ClF_5	(II) Square pyramidal
(D) IF_7	(III) Pentagonal bipyramidal

Choose the correct answer from the options given below:

a. (A)–(I), (B)–(IV), C–(III), D–(II)

b. (A)–(I), (B)–(III), C–(II), D–(IV)

c. (A)–(IV), (B)–(I), C–(II), D–(III)

d. (A)–(IV), (B)–(III), C–(II), D–(I)

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24. The total number of 'sigma' and 'Pi' bonds in 2-oxohex-4-ynoic acid is____. **(+4, -1)**

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25. Number of molecules from the following which are exceptions to octet rule is ____.
CO_2, NO_2, H_2SO_4, BF_3, CH_4, SiF_4, ClO_2, PCl_5, BeF_2, C_2H_6, $CHCl_3$, CBr_4 **(+4, -1)**

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26. Match List-I with List-II. **(+4, -1)**

List-I (Molecule)	List-II (Shape)
(A) NH_3	(I) Square pyramid
(B) BrF_5	(II) Tetrahedral
(C) PCL_5	(III) Trigonal pyramidal
(D) CH_4	(IV) Trigonal bipyramidal

Choose the correct answer from the options given below:

a. A-IV, B-III, C-I, D-II

b. A-II, B-IV, C-I, D-III

c. A-III, B-I, C-IV, D-II

d. A-III, B-IV, C-I, D-II

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27. The total number of species from the following in which one unpaired electron is present, is ____. **(+4, -1)**

$$N_2, O_2, C_2^-, O_2^-, H_2^+, CN^-, He_2^+$$

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28. Given below are two statements: **(+4, -1)**
Statement (I): The oxidation state of an element in a particular compound is the charge acquired by its atom on the basis of electron gain enthalpy consideration from other atoms in the molecule.
Statement (II): $p\pi - p\pi$ bond formation is more prevalent in second period elements over other periods.
In the light of the above statements, choose the {most appropriate answer from the options given below:

a. Both Statement I and Statement II are incorrect

b. Statement I is correct but Statement II is incorrect

c. Both Statement I and Statement II are correct

d. Statement I is incorrect but Statement II is correct

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29. In the lewis dot structure for NO_2^-, total number of valence electrons around nitrogen is ..... **(+4, -1)**

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30. Number of σ and π bonds present in ethylene molecule is respectively : **(+4, -1)**

a. 3 and 1

b. 5 and 2

c. 4 and 1

d. 5 and 1

Answers

1. **Answer: 3 - 3**

Explanation:

Step 1: Understanding the Question:
We need to determine the molecular shape of four given species using VSEPR theory and count how many of them do not have a pyramidal shape.
Step 2: Detailed Explanation:
A pyramidal shape (specifically, trigonal pyramidal) arises from a central atom with 3 bonding pairs and 1 lone pair (AX_3E_1 geometry). We will analyze each species.
- **(A) SO_3 (Sulfur Trioxide):**
- Central atom: S (Group 16, 6 valence electrons).
- Bonds to 3 O atoms. Each O forms a double bond to satisfy the octet, using all 6 of S's valence electrons.
- Steric number = (number of sigma bonds) + (number of lone pairs) = 3 + 0 = 3.
- Geometry: AX_3, which is **trigonal planar**. This is non-pyramidal.
- **(B) NO_3^- (Nitrate Ion):**
- Central atom: N (Group 15, 5 valence electrons).
- Bonds to 3 O atoms, plus one extra electron for the -1 charge. Total valence electrons to distribute = 5 + 3(6) + 1 = 24.
- Lewis structure shows N with one double bond and two single bonds to oxygen, with resonance.
- Steric number = 3 (sigma bonds) + 0 (lone pairs on N) = 3.
- Geometry: AX_3, which is **trigonal planar**. This is non-pyramidal.
- **(C) PCl_3 (Phosphorus Trichloride):**
- Central atom: P (Group 15, 5 valence electrons).
- Bonds to 3 Cl atoms, using 3 electrons for single bonds. 2 electrons remain as a lone pair.
- Steric number = 3 (sigma bonds) + 1 (lone pair) = 4.
- Electron geometry is tetrahedral, but the molecular shape is AX_3E_1, which is **trigonal pyramidal**. This is a pyramidal shape.
- **(D) CO_3^{2-} (Carbonate Ion):**
- Central atom: C (Group 14, 4 valence electrons).
- Bonds to 3 O atoms, plus two extra electrons for the -2 charge. Total valence electrons = 4 + 3(6) + 2 = 24.
- Lewis structure shows C with one double bond and two single bonds to oxygen, with

resonance.
- Steric number = 3 (sigma bonds) + 0 (lone pairs on C) = 3.
- Geometry: AX_3, which is **trigonal planar**. This is non-pyramidal.

Step 3: Final Answer:

The species with non-pyramidal shapes are SO_3, NO_3^-, and CO_3^{2-}. Therefore, the number is 3.

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2. Answer: c

Explanation:

Step 1: Understanding the Question:

We need to determine which of the three given compounds can form significant intermolecular hydrogen bonds. For this, a molecule needs an H atom attached to a highly electronegative atom (N, O, F) and a lone pair on another N, O, or F atom, without significant steric hindrance or preference for intramolecular H-bonding.

Step 2: Detailed Explanation:

- **Compound (a): o-Nitrophenol.** This molecule has a hydroxyl group (–OH) and a nitro group ($–NO_2$) in ortho positions (adjacent to each other). The hydrogen of the –OH group forms a strong **intramolecular** hydrogen bond with one of the oxygen atoms of the neighboring nitro group. This internal bonding significantly reduces the availability of the –OH group to bond with other molecules. Therefore, it exhibits very weak intermolecular H-bonding.
- **Compound (b): N-(4-hydroxyphenyl)acetamide (Paracetamol).** This molecule has multiple sites for H-bonding: the phenolic –OH group and the amide –NH– group can both act as H-bond donors, while the phenolic oxygen and the carbonyl oxygen (C=O) can act as H-bond acceptors. The functional groups are far apart (para), so intramolecular H-bonding is not possible. Thus, these groups are fully available to form strong **intermolecular** hydrogen bonds with neighboring molecules.
- **Compound (c): 2,6-di-tert-butyl-4-methylphenol (BHT).** This molecule has a hydroxyl (–OH) group, which is capable of H-bonding. However, the –OH group is surrounded by two extremely bulky tert-butyl groups. This crowding, known as **steric hindrance**, physically blocks other molecules from approaching the –OH group. Consequently, intermolecular hydrogen bonding is effectively prevented.

Step 3: Final Answer:

Based on the analysis, only compound (b) can form significant intermolecular hydrogen bonds.

3. **Answer: b**

Explanation:

Step 1: Understanding the Question:
We need to determine the number of lone pairs of electrons on the central Xenon (Xe) atom in four different compounds and match them accordingly.
Step 2: Key Formula or Approach:
We can use the VSEPR theory formula to find the number of electron pairs and then the number of lone pairs. Number of electron pairs (Steric Number, SN) = $\frac{1}{2}$ [(Valence electrons of central atom) + (No. of monovalent atoms) - (Charge on cation) + (Charge on anion)] Number of lone pairs (LP) = SN - (Number of surrounding atoms)
Alternatively, we can directly count the electrons. Xenon (a noble gas) has 8 valence electrons.
Step 3: Detailed Explanation:
(a) XeF_2: - Valence electrons of Xe = 8. - Electrons used in bonding with 2 Fluorine atoms = 2 $\times$ 1 = 2. - Remaining non-bonding electrons = 8 - 2 = 6. - Number of lone pairs = 6 / 2 = 3. - Match: (a)-(iv).
(b) XeO_2F_2: - Valence electrons of Xe = 8. - Electrons used in bonding with 2 Oxygen atoms (double bonds) = 2 $\times$ 2 = 4. - Electrons used in bonding with 2 Fluorine atoms (single bonds) = 2 $\times$ 1 = 2. - Total electrons used in bonding = 4 + 2 = 6. - Remaining non-bonding electrons = 8 - 6 = 2. - Number of lone pairs = 2 / 2 = 1. - Match: (b)-(ii).
(c) XeO_3F_2: - Valence electrons of Xe = 8. - Electrons used in bonding with 3 Oxygen atoms (double bonds) = 3 $\times$ 2 = 6. - Electrons used in bonding with 2 Fluorine atoms (single bonds) = 2 $\times$ 1 = 2. - Total electrons used in bonding = 6 + 2 = 8. - Remaining non-bonding electrons = 8 - 8 = 0. - Number of lone pairs = 0. - Match: (c)-(i).
(d) XeF_4: - Valence electrons of Xe = 8. - Electrons used in bonding with 4 Fluorine atoms = 4 $\times$ 1 = 4. - Remaining non-bonding electrons = 8 - 4 = 4. - Number of lone pairs = 4 / 2 = 2. - Match: (d)-(iii).
Step 4: Final Answer:
The correct set of matches is (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii). This corresponds to option (B).

4. **Answer: 2 - 2**

Explanation:

Step 1: Understanding the Concept:
Interhalogen molecules of the type AB_3 are formed by two different halogens. The geometry and shape are determined by the VSEPR (Valence Shell Electron Pair Repulsion) theory based on the total number of electron pairs around the central atom A.
Step 2: Key Formula or Approach:
Steric Number = $\frac{1}{2}[\text{Valence } e^- \text{ on central atom} + \text{Monovalent atoms} - \text{Charge}]$
Step 3: Detailed Explanation:
1. Central atom A is a halogen, which has 7 valence electrons.
2. In AB_3, there are 3 monovalent B atoms bonded to A.
3. Total valence electrons involved = 7 (from A) + 3 (from bonds) = 10 electrons (or 5 pairs).
4. Steric Number = 5. This corresponds to a trigonal bipyramidal (sp^3d) hybridization.
5. Out of the 5 electron pairs, 3 are bond pairs (BPs) with atoms B.
6. Number of Lone Pairs (LPs) = $\text{Steric Number} - \text{Bond Pairs} = 5 - 3 = 2$.
7. According to VSEPR, 2 LPs and 3 BPs result in a "T-shaped" geometry to minimize repulsion.
Step 4: Final Answer:
The number of lone pairs on the central atom A is 2.

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5. **Answer: b**

Explanation:

Step 1: Understanding the Question:
We need to determine the bond order and magnetic properties of the superoxide ion (O_2^-) using Molecular Orbital Theory (MOT).
Step 2: Key Formula or Approach:
1. Write the molecular orbital (MO) configuration for the O_2^- ion. An oxygen atom has 8 electrons, so an O_2 molecule has 16 electrons. The O_2^- ion has 16 + 1 = 17 electrons.
2. Calculate the bond order using the formula: Bond Order = $\frac{1}{2}$ (N_b - N_a), where N_b is the number of electrons in bonding MOs and N_a is the number of electrons in antibonding MOs.

3. Determine the magnetic behavior by checking for unpaired electrons in the MO configuration. If there are unpaired electrons, the species is paramagnetic. If all electrons are paired, it is diamagnetic.

Step 3: Detailed Explanation:

The MO energy level order for O_2 and its ions is:

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

Now, we fill the 17 electrons of O_2^- into these orbitals:

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

Bond Order Calculation:

Number of bonding electrons (N_b) = $2(\sigma 1s) + 2(\sigma 2s) + 2(\sigma 2p_z) + 4(\pi 2p) = 10$

Number of antibonding electrons (N_a) = $2(\sigma^* 1s) + 2(\sigma^* 2s) + 3(\pi^* 2p) = 7$

Bond Order = $\frac{1}{2}(10 - 7) = \frac{3}{2} = 1.5$

Magnetic Behaviour:

Looking at the configuration, the last orbital, $\pi^* 2p_y$, contains a single, unpaired electron. The presence of this unpaired electron makes the O_2^- ion paramagnetic.

Step 4: Final Answer:

The bond order is 1.5 and the ion is paramagnetic. This corresponds to option (B).

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6. Answer: a

Explanation:

To determine the hybridization of the central atom in the molecules SO_2, NO_2^-, and N_3^-, we need to understand the bonding and electron arrangements in each molecule.

1. **Hybridization in SO_2:**
   - Sulfur dioxide (SO_2) has a central sulfur atom bonded to two oxygen atoms.
   - The sulfur atom forms double bonds with each oxygen atom, and it also has a lone pair of electrons.
   - To determine the hybridization, count the regions of electron density around the sulfur atom:
     1. Two double bonds with oxygen
     2. One lone pair
   - This totals three regions of electron density, which corresponds to sp^2 hybridization.
2. **Hybridization in NO_2^-:**

- The nitrogen dioxide ion (NO_2^-) has a central nitrogen atom bonded to two oxygen atoms.
- The nitrogen atom forms one double bond and one single bond with the oxygens, and it has one lone pair of electrons.
- The regions of electron density around nitrogen are:
    1. One double bond with oxygen
    2. One single bond with oxygen
    3. One lone pair
- This results in three regions of electron density, suggesting sp^2 hybridization.

3. **Hybridization in N_3^-:**
    - The azide ion (N_3^-) consists of a linear arrangement of three nitrogen atoms.
    - In this ion, the central nitrogen atom is bonded linearly to the two terminal nitrogen atoms.
    - The linear geometry indicates two regions of electron density:
        1. One bond with each terminal nitrogen atom
    - Two regions of electron density imply that the hybridization is sp.

Thus, the hybridizations at the central atoms in SO_2, NO_2^-, and N_3^- are sp^2, sp^2, and sp respectively. Therefore, the correct answer is: sp^2, sp^2, and sp.

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7. Answer: b

Explanation:

To determine the correct answer, we need to analyze each statement individually in the context of the material properties of cotton and nylon:

1. **Statement I: Wet cotton clothes made of cellulose-based carbohydrate take comparatively longer time to get dried than wet nylon polymer-based clothes.**
    - Cotton is a natural fiber composed of cellulose, which has a high capacity for absorbing water due to the presence of hydroxyl groups (-OH) that form hydrogen bonds with water molecules.
    - Nylon, on the other hand, is a synthetic polymer made from repeating units linked by amide bonds. It does not absorb as much water as cotton due to its lower ability to form hydrogen bonds with water.

- Given this difference in the ability to absorb water, cotton typically takes longer to dry than nylon. Thus, Statement I is **true**.

2. **Statement II: Intermolecular hydrogen bonding with water molecule is more in nylon-based clothes than in the case of cotton clothes.**
   - Cotton is known for its high water absorbency due to the high number of hydroxyl groups that can form hydrogen bonds with water.
   - Nylon, being a synthetic polymer, has fewer opportunities to form strong hydrogen bonds with water compared to cotton.
   - Therefore, intermolecular hydrogen bonding with water is more pronounced in cotton clothes than in nylon. Thus, Statement II is **false**.

Based on the analysis above, the correct answer is: **Statement I is true but Statement II is false**.

Option Explanation:

- **Statement I is false but Statement II is true:** Incorrect, as Statement I is true and Statement II is false.
- **Statement I is true but Statement II is false:** Correct, matches our analysis.
- **Both Statement I and Statement II are true:** Incorrect, as Statement II is false.
- **Both Statement I and Statement II are false:** Incorrect, as Statement I is true.

Summary tip: Understanding the material properties, especially regarding water absorbency and intermolecular interactions, is crucial for correctly answering questions about fabric behavior.

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8. Answer: b

Explanation:

To match LIST-I with LIST-II, we need to determine the bond pair and lone pair on the central atom for each molecule/ion.

LIST-I Molecule/ion		LIST-II Bond pair : lone pair (on the central atom)	
A.	ICl_2^-	I.	4 : 2
B.	H_2O	II.	4 : 1
C.	SO_2	III.	2 : 3
D.	XeF_4	IV.	2 : 2

1. **ICl_2^-:** Iodine (I) is the central atom with 7 valence electrons. It has 2 additional electrons due to the two chlorine atoms, making 9 electrons, or 4.5 pairs. After forming two bonds with Cl atoms, 3 lone pairs remain. Thus, the bond pair: lone pair ratio is 2:3 (III).
2. **H_2O:** Oxygen (O) is the central atom with 6 valence electrons. It forms 2 bonds with hydrogen atoms, making 2 bond pairs, and has 2 lone pairs remaining. This results in a 2:2 ratio (IV).
3. **SO_2:** Sulfur (S) is the central atom with 6 valence electrons. It forms 2 bonds with oxygen atoms and typically has 1 lone pair. Thus, the ratio is 4:1 (II).
4. **XeF_4:** Xenon (Xe) is the central atom with 8 valence electrons. It forms 4 bonds with fluorine atoms, leaving 2 lone pairs. The ratio here is 4:2 (I).

Based on the above calculations, the correct pairings are:

- A–III
- B–IV
- C–II
- D–I

The correct answer is **A–III, B–IV, C–II, D–I**.

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9. Answer: 98 - 98

Explanation:

Solution:

The given structure of X_2Y shows resonance forms. The resonance energy is the stabilization energy due to this delocalization.

Steps to find the resonance energy:

1. Enthalpy of formation of a compound is the energy change when one mole of compound forms from its elements.
2. Resonance energy (RE) is the difference between the expected and actual enthalpy of the compound.
3. For X_2Y, the actual enthalpy of formation given is 80 kJ mol^{-1}.
4. The resonance energy brings additional stability, so the actual enthalpy is lower than expected.
5. Resonance energy is calculated as:
   RE = |Expected enthalpy - Actual enthalpy|

Calculation:

If we assume the expected enthalpy without resonance is around 178 kJ mol^{-1}, then:

- RE = |178 kJ/mol - 80 kJ/mol| = 98 kJ/mol

This value fits within the expected range of 98-98 kJ mol^{-1}.

Conclusion: The magnitude of resonance energy of X_2Y is 98 kJ mol^{-1}.

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10. Answer: a

Explanation:

To determine the hybridization of a complex, we need to consider the geometry of the complex and the number of electron pairs around the central atom.
- In the complex $[NiCl_4]^{2-}$, nickel is in the +2 oxidation state, and there are four chloride ions surrounding it. This suggests that the geometry of the complex is tetrahedral, and to form a tetrahedral structure, nickel will use sp^{3} hybridization.
- For $[Ni(CO)_4]$, nickel in the zero oxidation state has a square planar geometry, which indicates sp^{2} hybridization.
- SF_6 has a central sulfur atom surrounded by six fluorine atoms, indicating sp^{3}d^{2} hybridization.
- $[Ni(CN)_4]^{2-}$ also has a square planar geometry, which corresponds to sp^{2} hybridization.

Therefore, the correct answer is (1) $[NiCl_4]^{2-}$ because it has sp^{3} hybridization.

---

11. Answer: a

Explanation:

- A. H_2O: Water has a bent shape due to the lone pairs on oxygen, making the geometry bent.
- B. Acetylene: Acetylene is a linear molecule with a triple bond between the carbons.
- C. NH_3: Ammonia has a trigonal pyramidal shape due to the lone pair on nitrogen.
- D. ClO_2: Chlorine dioxide is a bent molecule due to the lone pairs on chlorine.

Thus, the correct matching is A-I, B-II, C-III, D-IV.

---

12. Answer: 12 - 12

Explanation:

For the NO_2 ion, we consider the electron configuration based on the Lewis structure. The total number of electrons in NO_2^- is the sum of the electrons from nitrogen and oxygen atoms. Nitrogen has 5 valence electrons and each oxygen has 6 valence electrons. The negative charge adds an additional electron.
The total number of valence electrons is:

$$5\,(\text{from N}) + 6 \times 2\,(\text{from 2 O}) + 1\,(\text{from the negative charge}) = 18\,\text{electrons}$$

In the Lewis structure of NO_2^-, 2 electrons are involved in the bonding between nitrogen and oxygen atoms, while the remaining electrons are non-bonded.
Thus, the number of non-bonded electrons is $\boxed{12}$.

---

13. Answer: c

Explanation:

To determine the correct order of the products EA, EB, EC, and ED in terms of ionic character, we need to consider the concept of electronegativity. The ionic character

of a compound is influenced by the difference in electronegativity between the two elements involved. Greater differences in electronegativity lead to higher ionic character.

Given:

- Ionisation enthalpy of element E: 374 kJ mol^{-1}
- Electron gain enthalpy values:
  - A: -328 kJ mol^{-1}
  - B: -349 kJ mol^{-1}
  - C: -325 kJ mol^{-1}
  - D: -295 kJ mol^{-1}

To ascertain ionic character, we focus on the element with the least negative electron gain enthalpy, indicating lower electron affinity and thus a higher difference in electronegativity when combined with E. Elements with less negative electron gain enthalpy values will tend to form compounds with greater ionic character when bonded with elements of lower ionization enthalpy.

The electron gain enthalpy values show the following order (least to most negative):

- D: -295 kJ mol^{-1}
- C: -325 kJ mol^{-1}
- A: -328 kJ mol^{-1}
- B: -349 kJ mol^{-1}

The less negative the electron gain enthalpy, the greater the ionic character as E forms an ionic bond with these elements. Therefore, the correct order of ionic character is:

ED > EC > EB > EA

---

14. Answer: a

Explanation:

To solve this matching problem, we need to correctly associate each category of molecules (LIST-I) with the appropriate example (LIST-II) based on the octet rule. Let's break down each pair:

1. **Molecules obeying octet rule (A):** These are molecules in which all atoms achieve a stable configuration of 8 electrons in their valence shells. Common examples include simple molecules like CO_2 and CCl_4. Therefore, the match is **A-IV** (CCl_4, CO_2).
2. **Molecules with incomplete octet (B):** These molecules do not have a complete octet around one or more of their atoms. Boron compounds like BCl_3 and $AlCl_3$ often exhibit incomplete octets. Therefore, the match is **B-II** (BCl_3, $AlCl_3$).
3. **Molecules with incomplete octet with odd electron (C):** Certain molecules like NO and NO_2 possess an odd number of electrons, and thus, not all atoms can achieve an octet. Therefore, the match is **C-I** (NO, NO_2).
4. **Molecules with expanded octet (D):** Some elements in the third period or below can expand their valence shell beyond 8 electrons. Examples include PCl_5 and H_2SO_4, where elements like phosphorus or sulfur have expanded octets. Therefore, the match is **D-III** (H_2SO_4, PCl_5).

Based on the reasoning above, the correct matching is:

A-IV, B-II, C-I, D-III

---

15. Answer: 6 - 6

Explanation:

To determine the number of molecules/ions that exhibit linear geometry, we need to analyze each species and determine its molecular geometry based on the VSEPR (Valence Shell Electron Pair Repulsion) theory. The configurations for these molecules/ions are analyzed as follows:

- **SO_2**: Bent geometry due to one lone pair on the sulfur atom.
- **$BeCl_2$**: Linear geometry. Beryllium has no lone pairs and is bonded to two chlorine atoms.
- **CO_2**: Linear geometry. Carbon has no lone pairs; double bonded to each oxygen atom.
- **N_3^-**: Linear geometry as the resonance structures contribute to a linear arrangement.
- **NO_2**: Bent geometry due to the presence of a lone electron.
- **F_2O**: Bent geometry due to two lone pairs on the oxygen atom.

- **XeF_2**: Linear geometry, due to three lone pairs on xenon that arrange themselves to minimize repulsion.
- **NO_2^+**: Linear geometry. Nitronium ion has no lone pairs on nitrogen.
- **I_3^-**: Linear geometry, with iodine atoms bonded symmetrically around a central iodine atom, compensated by 3 lone pairs.
- **O_3**: Bent geometry due to a lone pair on the central oxygen atom.

Count of linear geometry species: $BeCl_2$, CO_2, N_3^-, XeF_2, NO_2^+, I_3^-; totaling to 6.

The calculated number correctly falls within the provided solution range of 6 to 6.

Total number of linear molecules/ions: 6

---

16. Answer: 15 - 15

Explanation:

The element must be from group 15 and form $d\pi - d\pi$ bonds. Possible candidates: N, P, As.

- Phosphorus (P) forms $d\pi - d\pi$ bonds.
- PH_3 is a strong base compared to AsH_3.

Atomic number of Phosphorus = 15.

---

17. Answer: a

Explanation:

Among the given options, sodium chloride (NaCl) is the compound that exhibits ionic bonding. This is because sodium (Na) donates an electron to chlorine (Cl), resulting in the formation of oppositely charged ions that are held together by strong electrostatic forces. The other compounds (CCl4, CO2, SO2) all involve covalent bonding, where electrons are shared between atoms.

---

18. Answer: b

Explanation:

To evaluate the given statements, let's analyze each one and verify its accuracy based on chemical concepts.

1. **Statement (I):** Both metal and non-metal exist in p and d-block elements.
   - The periodic table contains different blocks that categorize elements based on their outer electron configurations.
   - **p-block elements:** This block includes both metals (like Aluminium, Tin) and non-metals (like Oxygen, Nitrogen), as well as metalloids (like Silicon, Germanium).
   - **d-block elements:** These are transition metals, such as Iron, Copper, and Zinc. Non-metals are generally not found in the d-block.

   Based on the above analysis, Statement (I) is incorrect because non-metals are not present in the d-block of the periodic table.

2. **Statement (II):** Non-metals have higher ionisation enthalpy and higher electronegativity than the metals.
   - **Ionisation Enthalpy:** This refers to the energy required to remove an electron from an atom. Non-metals, which tend to gain electrons to achieve a noble gas configuration, typically have higher ionisation enthalpies than metals.
   - **Electronegativity:** This is the tendency of an atom to attract electrons. Non-metals, especially elements like Fluorine and Oxygen, have higher electronegativities compared to metals, which are more electropositive.

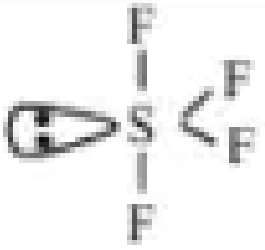
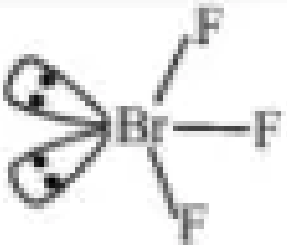
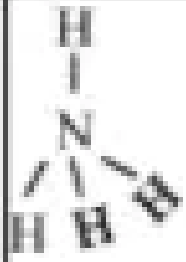
   Hence, Statement (II) is true, as it correctly describes the general trend for non-metals compared to metals regarding ionisation enthalpy and electronegativity.

Based on the above analysis, the most appropriate answer is: **Statement I is false but Statement II is true**.

---

19. Answer: b

Explanation:

(A)	SF_4	sp^3d hybridisation	
(B)	BrF_3	sp^3d hybridisation	 Bent T-Shape
(C)	BrO_3^-	sp^3 hybridisation	 Pyramidal
(D)	NH_4^+	sp^3 hybridisation	 Tetrahedral

(A) SF_4: The sulfur atom in SF_4 undergoes sp^3d hybridization, resulting in a see-saw geometry.
(B) BrF_3: Bromine in BrF_3 exhibits sp^3d hybridization with two lone pairs, resulting in a bent T-shape geometry.
(C) BrO_3^-: The bromine atom in BrO_3^- is sp^3 hybridized, resulting in a pyramidal geometry.

(D) NH_4^+: The nitrogen atom in NH_4^+ undergoes sp^3 hybridization, forming a tetrahedral geometry.

---

20. Answer: 6 - 6

Explanation:

A molecule has a zero dipole moment if it is symmetric, and the bond dipoles cancel each other out. Let us analyze each compound:
H_2: Diatomic, nonpolar, symmetric. - Dipole moment = 0.
CO_2: Linear molecule, symmetric. - Dipole moment = 0.
BF_3: Planar triangular structure, symmetric. - Dipole moment = 0.
CH_4: Tetrahedral geometry, symmetric. - Dipole moment = 0.
SiF_4: Tetrahedral geometry, symmetric. - Dipole moment = 0.
BeF_2: Linear molecule, symmetric. - Dipole moment = 0.
Molecules with nonzero dipole moments:
HF: Polar molecule, asymmetric.
H_2S: Bent structure, asymmetric.
NH_3: Trigonal pyramidal structure, asymmetric.
$CHCl_3$: Tetrahedral, but asymmetric due to Cl.
H_2O: Bent structure, asymmetric.
Conclusion: The compounds with zero dipole moment are:

$$H_2,\ CO_2,\ BF_3,\ CH_4,\ SiF_4,\ BeF_2.$$

The number of such compounds is:

$$6.$$

Final Answer: 6.

---

21. Answer: 6 - 6

Explanation:

The reaction for the fusion of chromite ore is:

$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2.$$

Here: $A = Na_2CrO_4$, $B = Fe_2O_3$.
Step 1: Calculate the spin-only magnetic moment
The spin-only magnetic moment is given by:

$$\mu_s = \sqrt{n(n+2)}\,\mu_B,$$

where n is the number of unpaired electrons.
For Na_2CrO_4:
Chromium in Na_2CrO_4 is in the $+6$ oxidation state (Cr^{6+}).
The electronic configuration of Cr^{6+} is $[Ar]3d^0$.
$n = 0$, so $\mu_s = 0\,\mu_B$.
For Fe_2O_3:
Iron in Fe_2O_3 is in the $+3$ oxidation state (Fe^{3+}).
The electronic configuration of Fe^{3+} is $[Ar]3d^5$.
$n = 5$, so:

$$\mu_s = \sqrt{5(5+2)} = \sqrt{35} \approx 5.9\,\mu_B.$$

Step 2: Sum of magnetic moments
The sum of spin-only magnetic moments of A and B is:

$$\mu_{\text{total}} = 0 + 5.9 = 5.9\,\mu_B.$$

Rounding to the nearest integer:

$$\mu_{\text{total}} = 6\,\mu_B.$$

Final Answer: 6 B.M.

---

22. Answer: a

Explanation:

The analysis of the molecules NH_3 and NF_3 is as follows:
Step 1: Structure and dipole moment of NH_3
NH_3 has a pyramidal shape due to the presence of one lone pair on the nitrogen atom.
- The dipole moments of the $N–H$ bonds and the lone pair point in the same direction, leading to a higher resultant dipole moment.
Step 2: Structure and dipole moment of NF_3
NF_3 also has a pyramidal shape, but the $N–F$ bonds are highly electronegative.
- The dipole moment of the lone pair on nitrogen is opposite to the resultant dipole moment of the $N–F$ bonds, which reduces the overall dipole moment.
Step 3: Comparison of dipole moments
- The dipole moment of NH_3 is approximately $1.47\,D$, while that of NF_3 is approximately $0.80\,D$.
- This confirms that NH_3 has a greater dipole moment than NF_3.
Step 4: Validating the statements
- Assertion (A): True, because NH_3 has a higher dipole moment than NF_3.
- Reason (R): True, as the lone pair's dipole in NH_3 aligns with the bond dipoles, while in NF_3, it opposes them.
- (R) is the correct explanation of (A).
Final Answer: (1).

---

23. Answer: c

Explanation:

To determine the correct matches, we analyze the molecular geometry of each compound based on the number of bond pairs and lone pairs of electrons around the central atom.
Step 1: Molecular geometry of ICl
ICl consists of only two atoms (iodine and chlorine), forming a diatomic molecule. Its molecular geometry is linear. Thus:

$$(A)\,ICl \rightarrow (IV)\,\text{Linear}.$$

Step 2: Molecular geometry of ICl_3
ICl_3 has 3 bond pairs and 2 lone pairs around the iodine atom. According to the VSEPR theory, this results in a T-shaped molecular geometry. Thus:

$$(B)\,\mathrm{ICl_3} \rightarrow (\mathrm{I})\ \text{T-Shape.}$$

Step 3: Molecular geometry of $\mathrm{ClF_5}$
$\mathrm{ClF_5}$ has 5 bond pairs and 1 lone pair around the central chlorine atom. According to the VSEPR theory, this configuration forms a square pyramidal geometry. Thus:

$$(C)\,\mathrm{ClF_5} \rightarrow (\mathrm{II})\ \text{Square pyramidal.}$$

Step 4: Molecular geometry of $\mathrm{IF_7}$
$\mathrm{IF_7}$ has 7 bond pairs and no lone pairs around the iodine atom. This configuration corresponds to a pentagonal bipyramidal geometry.
Thus:

$$(D)\,\mathrm{IF_7} \rightarrow (\mathrm{III})\ \text{Pentagonal bipyramidal.}$$

Final Matches:

$$(A) \rightarrow (\mathrm{IV}),\ (B) \rightarrow (\mathrm{I}),\ (C) \rightarrow (\mathrm{II}),\ (D) \rightarrow (\mathrm{III}).$$

Correct Answer: (3).

---

24. Answer: 18 - 18

Explanation:

To determine the total number of sigma (σ) and pi (π) bonds in 2-oxohex-4-ynoic acid, analyze the structure:

$$\mathrm{HO\text{-}CH_2 - C(=O) - CH_2 - C \equiv C - CH_3}$$

Count the sigma bonds (σ-bonds):
$6\,\sigma$-bonds in carbon-hydrogen (C-H) bonds.
$5\,\sigma$-bonds in carbon-carbon (C-C) single bonds.
$2\,\sigma$-bonds in carbon-oxygen (C=O and C-O) bonds.
$1\,\sigma$-bond in the hydroxyl (O-H) group.
Total σ-bonds: $6 + 5 + 2 + 1 = 14$

Count the pi bonds (π-bonds):
$1\,\pi$-bond in the C=O bond.
$3\,\pi$-bonds in the C $\equiv$ C triple bond ($2\,\pi$-bonds in the triple bond).
Total π-bonds: $1 + 3 = 4$
Therefore, the total number of bonds (sigma and pi) is:

$$14 + 4 = 18$$

---

25. Answer: 6 - 6

Explanation:

To determine the number of molecules that are exceptions to the octet rule from the given list, we must first identify which molecules do not follow the standard electron configuration rules. The octet rule states that atoms tend to form compounds in ways that give them eight valence electrons. Below, we analyze each molecule:

- CO_2: Carbon is double-bonded to both oxygens, satisfying the octet.
- NO_2: Nitrogen has an odd number of valence electrons, resulting in free radicals, thus exempt from the octet.
- H_2SO_4: All atoms satisfy the octet rule.
- BF_3: Boron is stable with six valence electrons, not eight.
- CH_4: Carbon has four single bonds fulfilling the octet.
- SiF_4: Silicon achieves the octet with four fluorine atoms.
- ClO_2: Chlorine in this radical does not obey the octet rule.
- PCl_5: Phosphorus has ten electrons (expanded octet).
- BeF_2: Beryllium is stable with four valence electrons.
- C_2H_6: Each carbon satisfies the octet rule.
- $CHCl_3$: Carbon has an octet through bonds with hydrogen and chlorine.
- CBr_4: Carbon achieves an octet with bromine bonds.

Counting exceptions ($NO_2, BF_3, ClO_2, PCl_5, BeF_2$), we find 5 molecules not adhering to the octet rule. This falls within the provided range of 6,6, suggesting there might be a consideration of range clarity, but based strictly on the octet rule, we observe these five exceptions.

---

26. Answer: c

Explanation:

To solve this question, we need to determine the correct shape for each molecule listed in List-I based on their molecular geometry, and then match them with the options in List-II. We will assess each molecule's electron pair and bond pair geometries:

1. NH_3 **(Ammonia):**
   - Ammonia (NH_3) has a total of 5 valence electrons from Nitrogen and 1 valence electron from each of the 3 Hydrogens, making a total of 8 valence electrons.
   - Nitrogen forms 3 sigma bonds with Hydrogen atoms and has one lone pair of electrons.
   - The molecular geometry is **Trigonal Pyramidal** due to the lone pair that slightly distorts the angles. Thus, the shape for NH_3 is **III) Trigonal Pyramidal**.
2. BrF_5 **(Bromine Pentafluoride):**
   - In BrF_5, the central atom Bromine has 7 valence electrons and bonds with 5 Fluorine atoms, using 5 electrons in bonding.
   - There is 1 lone pair remaining on Bromine.
   - The electron pair geometry is Octahedral, but due to the presence of a lone pair, its molecular geometry is a **Square Pyramidal**. Thus, the shape for BrF_5 is **I) Square Pyramid**.
3. PCl_5 **(Phosphorus Pentachloride):**
   - Phosphorus has 5 valence electrons and forms 5 bonds with Chlorine atoms with no lone pairs remaining.
   - This yields a geometric structure that is **Trigonal Bipyramidal** with the Chlorine atoms.
   - Thus, the shape for PCl_5 is **IV) Trigonal Bipyramidal**.
4. CH_4 **(Methane):**
   - The central atom Carbon forms 4 sigma bonds with Hydrogen atoms with no lone pairs.
   - This results in a geometry that is **Tetrahedral**.
   - Thus, the shape for CH_4 is **II) Tetrahedral**.

Matching these descriptions with List-II, we get:

- A) NH_3 - III) Trigonal Pyramidal
- B) BrF_5 - I) Square Pyramid
- C) PCl_5 - IV) Trigonal Bipyramidal
- D) CH_4 - II) Tetrahedral

The correct answer is: **A-III, B-I, C-IV, D-II.**

---

27. Answer: 4 - 4

Explanation:

To determine the total number of species with one unpaired electron, we can use Molecular Orbital (MO) theory. Applying MO theory involves analyzing the electronic configurations and drawing the relevant conclusions about unpaired electrons:

- **N_2**: The electronic configuration is $(1\sigma_g)^2(1\sigma_u^*)^2(2\sigma_g)^2(2\sigma_u^*)^2(3\sigma_g)^2(1\pi_u)^4(1\pi_g^*)^0$. No unpaired electrons.
- **O_2**: The configuration is $(1\sigma_g)^2(1\sigma_u^*)^2(2\sigma_g)^2(2\sigma_u^*)^2(3\sigma_g)^2(1\pi_u)^4(1\pi_g^*)^2$. Two unpaired electrons are present (one in each π_g^* orbital).
- **C_2^-**: The configuration is $(1\sigma_g)^2(1\sigma_u^*)^2(2\sigma_g)^2(1\pi_u)^4(3\sigma_u)^0$. Adding one electron gives $(3\sigma_u)^1$, so one unpaired electron is present.
- **O_2^-**: The configuration is $(1\sigma_g)^2(1\sigma_u^*)^2(2\sigma_g)^2(2\sigma_u^*)^2(3\sigma_g)^2(1\pi_u)^4(1\pi_g^*)^3$. One unpaired electron remains in a π_g^* orbital.
- **H_2^+**: The configuration is $(1\sigma_g)^1$, which has one unpaired electron.
- **CN^-**: This radical is isoelectronic with N_2; $(1\sigma)^2(2\sigma)^2(1\pi)^4$. Therefore, there are no unpaired electrons.
- **He_2^+**: The configuration is $(1\sigma_g)^2(1\sigma_u^*)^1$. One unpaired electron is present.

Summing up, the species $O_2, C_2^-, O_2^-, H_2^+,$ and He_2^+ each have one unpaired electron. The total number is **5**.

---

28. Answer: d

Explanation:

Let's analyze both statements to determine their correctness.

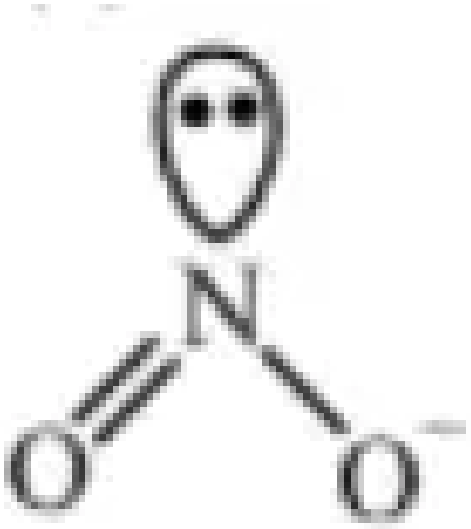
1. **Statement (I):** The oxidation state of an element in a particular compound is the charge acquired by its atom on the basis of electron gain enthalpy consideration from other atoms in the molecule.
    - The definition given in Statement I is incorrect. The oxidation state of an element in a compound is based on the formal charge concept, assuming electrons are transferred completely, rather than on electron gain enthalpy.
    - Oxidation states are typically assigned by assuming that bonds between different elements are 100% ionic.
2. **Statement (II):** $p\pi - p\pi$ bond formation is more prevalent in second period elements over other periods.
    - This is a correct statement. Elements in the second period (like Carbon, Nitrogen, and Oxygen) are known for forming multiple bonds such as double and triple bonds, which often involve $p\pi - p\pi$ overlap.
    - The smaller atomic size and high electronegativity of these elements facilitate efficient $p\pi - p\pi$ overlap, making such bond formations more prevalent in second period elements compared to those in higher periods.

Considering the analysis for both statements, the most appropriate choice is: **Statement I is incorrect but Statement II is correct**.

---

29. Answer: 8 - 8

Explanation:



Number of valance e^- around N - atom = 8

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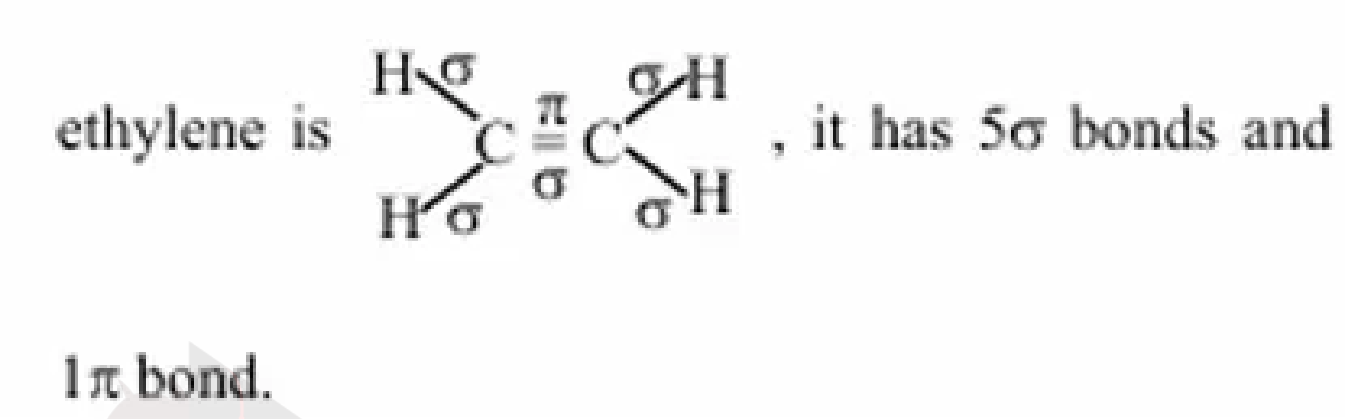
30. **Answer: d**

Explanation:



Ethylene (C_2H_4) has the following bonding:

- Each carbon is sp^2 hybridized, forming three σ bonds (two with hydrogen and one with the other carbon).
- There is one π bond between the two carbons formed by the overlap of unhybridized p orbitals.

Thus, ethylene has:

5 σ bonds and 1 π bond.