This print-out should have 16 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 10.0 points
Which of the following molecules is/are polar?

I) NO$^{-3}$
II) NO
III) NO$^2$

1. II only
2. III only
3. II and III correct
4. I only
5. I and II
6. I, II and III
7. I and III

Explanation:
All of the molecules contain polar N-O and N=O bonds. But, nitrate is symmetrical and therefore non-polar. Nitric oxide and nitrogen dioxide are both asymmetrical and polar.

002 10.0 points
Which of the following is the correct Lewis structure of Nitric Oxide (NO)?

1. N\(\cdot\cdot\cdot\)O
2. \(\cdot\cdot\cdot\)N\(\cdot\cdot\cdot\)O
3. \(\cdot\cdot\cdot\)N\(\cdot\cdot\cdot\)O \textbf{correct}
4. \(\cdot\cdot\cdot\)N\(\cdot\cdot\cdot\)O

Explanation:

003 10.0 points
Which of the following is the correct Lewis structure of Sodium Fluoride (NaF)?

1. Na—\(\ddot{\text{F}}\):
2. \(\ddot{\text{Na}}—\ddot{\text{F}}\):
3. Na$^+$, [\(\ddot{\text{F}}\)]$^-$ \textbf{correct}
4. [\(\ddot{\text{NaF}}\)]$^+$, F$^-$

Explanation:

004 10.0 points
Which of the following statements about polarity is false?

1. CCl$_4$ is a polar molecule. \textbf{correct}
2. Lone (unshared) pairs of electrons on the central atom play an important role in influencing polarity.
3. Polar molecules must have a net dipole moment.
4. Dipole moments can “cancel”, giving a net non-polar molecule.
5. Linear molecules can be polar.

Explanation:
The Lewis Dot structure for CCl$_4$ is
\[\begin{array}{c}
\ddot{\text{C}}_1 \\
\ddot{\text{C}}_2 \\
\ddot{\text{C}}_3 \\
\ddot{\text{C}}_4 \\
\end{array} \\
\begin{array}{c}
\ddot{\text{C}}_1 \\
\ddot{\text{C}}_2 \\
\ddot{\text{C}}_3 \\
\ddot{\text{C}}_4 \\
\end{array}
\]

The molecule has tetrahedral electronic and molecular geometry. The C-Cl bond is polar, but because of the symmetry of the molecule, the individual dipole moments cancel. The molecule is therefore nonpolar.

005 10.0 points
How many different molecular geometries are necessary to describe the central atoms in the molecule below?
H — C ≡ C — C — N — O — H

(Note: You will need to add the non-bonding electron pairs.)

1. 4 correct
2. 2
3. 3
4. 1

Explanation: The central atoms’ molecular geometries from left to right are: linear, linear tetrahedral, trigonal pyramidal, bent, for a total of 4 different molecular geometries.

006 10.0 points
Which of the following is a polar molecule composed entirely of non-polar bonds?

1. SiCl₄
2. Bi₃
3. O₃ correct
4. C₂H₄
5. CS₂

Explanation: Ozone (O₃) is the only polar molecule composed of non-polar bonds. The other molecules are all symmetrical and therefore non-polar.

007 10.0 points
Which of the following substances has a delocalized bond?

1. NH₃
2. CO₂²⁻ correct
3. AsCl₃ correct
4. CCl₄

Explanation: Delocalized bonds occur whenever resonance occurs. In a molecule that exhibits resonance, the bond has partial double and partial single bond character. This means that electrons are delocalized around the resonance bond. CO₂⁻ is the only compound that exhibits resonance and therefore delocalization.

008 10.0 points
The electronic geometry of the central atom in H₂O is (angular, tetrahedral); its molecular geometry (angular, linear, tetrahedral).

1. angular; angular
2. angular; tetrahedral
3. tetrahedral; linear
4. tetrahedral; angular correct
5. tetrahedral; tetrahedral

Explanation: H₂O has 2 O—H single bonds and 2 lone pairs on O. There are 4 regions of HED corresponding to tetrahedral electronic geometry. The molecular geometry is angular because of the presence of the 2 lone pairs on O. The bond angle is slightly less than 109.5°.

009 10.0 points
Which of the following is a polar molecule?

1. CO₂
2. SiH₄
3. AsCl₃ correct
4. CCl₄
5. \( \text{Br}_2 \)

**Explanation:**

<table>
<thead>
<tr>
<th>010</th>
<th>10.0 points</th>
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</thead>
<tbody>
<tr>
<td>How many ( \pi ) bonds are in the molecule ethyne (HCCH or acetylene)?</td>
<td></td>
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<tr>
<td>1. 0</td>
<td></td>
</tr>
<tr>
<td>2. 4</td>
<td></td>
</tr>
<tr>
<td>3. 1</td>
<td></td>
</tr>
<tr>
<td>4. 3</td>
<td></td>
</tr>
<tr>
<td>5. 2 correct</td>
<td></td>
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</tbody>
</table>

**Explanation:**
The molecule of ethyne contains a triple bond between the two carbon atoms that is composed of one sigma (\( \sigma \)) bond and two pi (\( \pi \)) bonds.

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4. III and IV only

5. I and III only

**Explanation:**

Draw the Lewis Dot structure for each.

[Diagram of AlCl₃ molecule]

There are 3 Al — Cl single bonds and no lone pairs around Al in the AlCl₃ molecule; the result is 6 valence electrons around Al.

[Diagram of SF₆ molecule]

There are 6 S — F single bonds and no lone pairs around S in the SF₆ molecule; the result is 12 valence electrons around S.

[Diagram of CCl₄ molecule]

CCl₄ has 4 C — Cl single bonds and no lone pairs; the result is 8 valence electrons on C, which follows the octet rule.

[Diagram of XeF₄ molecule]

There are 4 Xe — F single bonds and 2 lone pairs on Xe in the XeF₄ molecule; the result is 12 valence electrons.

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3. octahedral.

4. trigonal bipyramidal. correct

5. trigonal planar.

**Explanation:**

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011 | 10.0 points |
---|-------------|
The electronic geometry of SnCl₅⁻ is

1. tetrahedral.

2. linear.

3. octahedral.

4. trigonal bipyramidal. correct

5. trigonal planar.

**Explanation:**

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012 | 10.0 points |
---|-------------|
Which of the compounds

I. AlCl₃

II. SF₆

III. CCl₄

IV. XeF₄

follow the octet rule?

1. III only correct

2. IV only

3. I only
3. b) and c) only

4. c) and e) only

**Explanation:**
Of the species listed, only O\textsubscript{3} and CO are polar. CO is polar due to the difference in electronegativity between O and C; O\textsubscript{3} is polar because it has 3 RHED and one lone pair on the central atom. This lone pair is an area where negative charge is concentrated, so this results in the molecule having an overall dipole moment. In the other species, I\textsubscript{2} and CS\textsubscript{2} are both linear and in the case of CS\textsubscript{2}, the two opposing dipoles of the C-S bonds will cancel. Finally I\textsuperscript{−} has 5 RHED and three lone pairs on the central atom but they are arranged at 120° so their effects cancel and the ion is nonpolar.

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**014 10.0 points**

Which of the following molecules is polar?

1. CF\textsubscript{4}

2. NH\textsubscript{3} **correct**

3. H\textsubscript{2}

4. CH\textsubscript{4}

5. BH\textsubscript{3}

**Explanation:**
CH\textsubscript{4} and CF\textsubscript{4} are both tetrahedral and symmetric. Polar bonds will cancel. H\textsubscript{2} is a diatomic molecule and is not polar. Both Hs have the same EN and therefore there is no $\Delta$EN and the bond is not polar. BH\textsubscript{3} is trigonal planar and symmetric. There are no lone pairs because B is an exception to the octet rule. The 3 B$\equiv$H bonds cancel each other. NH\textsubscript{3} has 3 polar N$\equiv$H bonds and 1 lone pair on N. NH\textsubscript{3} has tetrahedral electronic geometry and trigonal pyramidal geometry. The molecule is not symmetric, the N$\equiv$H bonds polarities do not cancel, and it is therefore a polar molecule.

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**015 10.0 points**

What are the molecular geometries of the labeled atoms in the Lewis structure below?

Note: **only bonding electrons are shown.**

\[
\begin{array}{ccc}
H & H & O \\
\mid & \mid & \\
C^a & C \equiv O \equiv & P^c \equiv O \\
\mid & \\
H & O
\end{array}
\]

1. trigonal planar; linear; trigonal bipyramidal

2. trigonal planar; bent; tetrahedral **correct**

3. trigonal pyramidal; linear; see-saw

4. bent; tetrahedral; t-shaped

5. bent; trigonal pyramidal; t-shaped

**Explanation:**
Atom a has three bonded atoms and no non-bonding pairs of electrons and is therefore trigonal planar. Atom b has two bonded atoms and two non-bonding pairs of electrons and is therefore bent. Atom c has four bonded atoms and no non-bonding pairs of electrons and is therefore tetrahedral.

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**016 10.0 points**

Which pair of elements is listed in order of increasing electronegativity?

1. N, O **correct**

2. F, Cl

3. S, As

4. N, C

5. S, Se

**Explanation:**
Electronegativity generally increases from left to right and from bottom to top of the Periodic Table. Thus N $<$ O.