This print-out should have 30 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

LDE Ranking Bonding Trends 004

001 10.0 points

The following molecules are composed of hydrogen(s) bound to another atom, X. Rank the H—X bonds in terms of decreasing polarity: LiH, NH_3, BH_3, HF.

1. $LiH > NH_3 > BH_3 > HF$

2. $NH_3 > BH_3 > HF > LiH$

3. $HF > LiH > NH_3 > BH_3$ **correct**

4. $NH_3 > HF > BH_3 > LiH$

5. $BH_3 > HF > LiH > NH_3$

Explanation:

Note that all of the bonds within both NH_3, BH_3 are identical to each other and the fact that there are multiple bonds does not change the polarity of the individual bonds. The ΔEN for LiH, NH_3, BH_3, HF are 1.2, 0.8, 0.2, 1.8, respectively. Arranged from greatest to least: $HF > LiH > NH_3 > BH_3$.

LDE Identifying Bonds 002

002 10.0 points

Which of the following exhibits non-polar bonds in a polar molecule?

1. O_3 **correct**

2. C_2H_4

3. BI_3

4. CS_2

5. $SiCl_4$

Explanation:

Ozone (O_3) is the only polar molecule composed of non-polar bonds. The other molecules are all symmetrical and therefore non-polar.

LDE VSEPR Molecular Geometry 003

003 10.0 points

In a molecule of the form AB_2U_x where A is a central atom, B is a bonded atom, and U is an unbonded electron pair, what value of x would yield a non-polar molecule that is not hypervalent?

1. 2

2. 0 **correct**

3. 4

4. 1

5. 3

Explanation:

Having 2 identical bonded atoms and 0 non-bonding electrons would correspond to linear molecular geometry and be non-polar. Having 1 or 2 non-bonding electron pairs would correspond to angular molecular geometry and be polar. Having 3 or 4 non-bonding electron pairs would be hypervalent.

LDE VSEPR Molecular Geometry 004

004 10.0 points

Which one of the compounds listed below is NOT expected to exhibit bond angles distorted from expected VSEPR values by unbonded electron pairs?

1. SCl_4

2. NH_3

3. O_3

4. H_2O

5. I_3^- **correct**

Explanation:

All of the choices except I_3^- have asymmetrically placed non-bonding electron pairs on their central atoms and thus have distorted

bond angle. I_3^- has three non-bonding electron pairs in equatorial positions and thus has a single bond angle of exactly 180°.

LDE VB Hybridization 003

005 10.0 points

Which of the following statements concerning valence bond theory is/are true?

I) Hybridizing one $2s$ orbital with three $2p$ orbitals would produce four sp^3 orbitals.

II) When a $2s$ orbital is hybridized with a single $2p$ orbital, there will be a single unhybridized $2p$ orbital left to form a π bond with.

III) Among the types of hybrid orbitals we have learned about, the minimum amount of s-character for a hybrid orbital is $1/6^{\text{th}}$.

1. II only

2. I only

3. I, II

4. I, III **correct**

5. III only

6. I, II, III

7. II, III

Explanation:

Statement II is false because there will be a pair of unhybridized p orbitals available for π bonding. Statements I is true because hybridizing any number of atomic orbitals always results in an equal number of hybrid orbitals. Statement III is true because sp^3d^2 hybrid orbitals have $1/6^{\text{th}}$ s-character.

Msci 08 1540

006 10.0 points

Choose the species that is incorrectly matched with electronic geometry about the central atom.

1. NH_3 : tetrahedral

2. PF_3 : pyramidal **correct**

3. CF_4 : tetrahedral

4. H_2O : tetrahedral

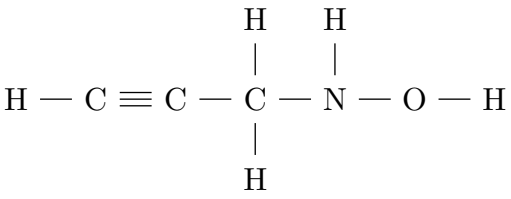
5. $BeBr_2$: linear

Explanation:

LDE VSEPR Molecular Geometry 005

007 10.0 points

How many different molecular geometries are necessary to describe the central atoms in the molecule below? *(Note: You will need to add the non-bonding electron pairs.)*



1. 1

2. 3

3. 4 **correct**

4. 2

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.

LDE VB Sigma Pi Bonds 002

008 10.0 points

How many sigma (σ) and pi (π) bonds are in the Lewis structure for $CHCCH_2COOH$?

1. 11 σ, 1 π

2. 9 σ, 3 π **correct**

3. 10 σ, 2 π

4. 8 σ, 2 π

5. 9 σ, 2 π

Explanation:

LDE VB Sigma Pi Bonds 003

009 10.0 points

What atomic orbitals comprise the molecular orbitals in $SiBr_4$?

1. $3p, sp^3$

2. $3s, 4p$

3. $3p, 4p$

4. sp^3, sp^3 **correct**

5. $3s, sp^3$

Explanation:

The silicon atom is sp^3 hybridized and the bromine atoms are as well.

LDE MO Theory 001

010 10.0 points

Which of the following statements concerning molecular orbital theory is/are true?

I) Bonding orbitals are lower in energy than their corresponding anti-bonding orbitals.

II) Removing electrons from anti-bonding orbitals destabilizes molecules.

III) Unlike filling atomic orbitals, filling molecular orbitals doesn't obey the aufbau principle.

1. I only **correct**

2. I, II

3. II, III

4. III only

5. I, II, III

6. I, III

7. II only

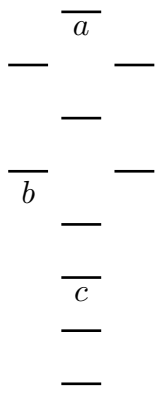
Explanation:

Statement II is false because removing electrons from anti-bonding orbitals would actually increase the bond order of the molecule, thereby stabilizing it. Statement III is false, because molecular orbitals are filled from lowest to highest energy according to the aufbau principle just like atomic orbitals.

LDE MO Diagram 001

011 10.0 points

Consider the following molecular orbital diagram:



What are the names of the labeled orbitals, a through c, respectively?

1. $\sigma^*_{2p}, \pi_{2p}, \sigma_{2s}$ **correct**

2. $\pi_{2p}, \sigma^*_{2p}, \sigma^*_{2s}$

3. $\sigma^*_{2p}, \pi_{2p}, \sigma^*_{1s}$

4. $\sigma^*_{2p}, \pi_{2p}, \sigma^*_{2s}$

5. $\sigma_{2p}, \sigma^*_{2p}, \sigma^*_{2s}$

Explanation:

LDE Bond Order 002

012 10.0 points

All of the molecules below have the same bond order, except for one. Which one is the outlier?

1. LiB^-

2. OF^{2-}

3. $H_2{}^-$

4. NO^- **correct**

5. $Be_2{}^+$

Explanation:
NO^- would have a bond order of 2 (16 total electrons). The other choices all have a bond order of 0.5

LDE Paramagnetism 002
013 10.0 points
Which of the following is the most paramagnetic?

1. O_2 **correct**

2. H_2

3. N_2

4. NO

Explanation:
Molecular oxygen has 2 unpaired electrons. Molecular nitrogen and molecular hydrogen have 0 unpaired electrons. Nitrous Oxide has 1 unpaired electron.

LDE Ranking Bonding Trends 005
014 10.0 points
Rank the following species in terms of increasing bond length: $H_2{}^+, C_2, F_2$.

1. $C_2 < F_2 < H_2{}^+$ **correct**

2. $F_2 < C_2 < H_2{}^+$

3. $F_2 < H_2{}^+ < C_2$

4. $C_2 < H_2{}^+ < F_2$

5. $H_2{}^+ < F_2 < C_2$

Explanation:
Since bond length is inversely proportional to bond order, ranking by increasing bond length requires ranking by decreasing bond order; the bond orders for $H_2{}^+, C_2$, and F_2 are 0.5, 2 and 1 respectively.

LDE Delocalization 002
015 10.0 points
Choose the species below that exhibits delocalization.

1. $NH_4{}^+$

2. $PO_4{}^{3-}$ **correct**

3. H_2

4. NaCl

5. H_2O

Explanation:
NaCl is a salt, and thus has no covalent bonds of any sort in which to delocalize electrons. The species $NH_4{}^+, H_2$, and H_2O all have only single (σ) bonds, and so cannot exhibit delocalization. The phosphate anion is all that remains and does in fact exhibit delocalization.

LDE Ideal Gas 003
016 10.0 points
Which of the following statements about gas laws is/are true?

I) Robert Boyle determined that there was a direct proportionality between the pressure and volume of a gaseous system.
II) Jacques Charles determined that there was an inverse proportionality between the volume and temperature of a gaseous system.
III) The ideal gas law described the behavior of all gases equally well.

1. I, III

2. II, III

3. I only

4. I, II, III

5. I, II

6. III only

7. None are true **correct**

8. II only

Explanation:
All three statements are false. Boyle's law describes a inverse proportionality between P and V. Charles' law describes a direct proportionality between V and T. Only gases that closely approximate the assumptions of kinetic molecular theory are well described by the ideal gas law.

LDE Ideal Gas Calculation 001
017 10.0 points

If we increase the volume of a gaseous system by a factor of 3 and raise the temperature by a factor of 6, then the pressure of the system will (increase/decrease) by a factor of (2/18):

1. increase, 2 **correct**

2. decrease, 2

3. increase, 18

4. decrease, 18

Explanation:
Tripling the volume will decrease the pressure by a factor of 3 and sextupling the temperature will increase the pressure by a factor of 6, resulting a double the original pressure.

LDE Ideal Gas Calculation 002
018 10.0 points

A 45 g sample of an unidentified gas is allowed to reach equilibrium in a closed 10 L container at 27 °C. The equilibrium pressure is measured as 0.8 atm. What is the molecular weight of the gas?

1. 3.6 $\mathrm{g \cdot mol^{-1}}$

2. 12.5 $\mathrm{g \cdot mol^{-1}}$

3. 138.5 $\mathrm{g \cdot mol^{-1}}$ **correct**

4. 45 $\mathrm{g \cdot mol^{-1}}$

Explanation:
$T = 27\ ^\circ\mathrm{C} = 300\ \mathrm{K}$

$$\mathrm{MW} = \frac{\mathrm{g}}{\mathrm{mol}} = \frac{m}{n} = \frac{m}{PV/RT}$$

$$= \frac{45\ \mathrm{g}}{\frac{10\ \mathrm{L} \cdot 0.8\ \mathrm{atm}}{(0.0821\ \mathrm{L \cdot atm \cdot mol^{-1} \cdot K^{-1}} \cdot 300\ \mathrm{K})}}$$

$$= 138.5\ \mathrm{g \cdot mol^{-1}}$$

LDE Ideal Gas Reaction 001
019 10.0 points

The thermal decomposition of $CaCO_3$ obeys the following balance equation:

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$

If we heat and thermally decompose 1 kg of $CaCO_3$, what volume will the evolved CO_2 occupy at 0.9 atm and 40 °C?

1. 82.9 L

2. 648.9 L

3. 285.5 L **correct**

4. 36.5 L

5. 0.3 L

Explanation:
1 kg $CaCO_3$ = 10 mol $CaCO_3$

= 10 mol CO_2

$T = 40\ ^\circ\mathrm{C} = 313\ \mathrm{K}$

$$V = \frac{nRT}{P}$$

$$= \frac{10\ \mathrm{mol} \cdot 0.0821\ \mathrm{L \cdot atm \cdot mol^{-1} \cdot K^{-1}} \cdot 313\ \mathrm{K}}{0.9\ \mathrm{atm}}$$

$$= 285.5\ \mathrm{L}$$

LDE Kinetic Theory 002

020 10.0 points

At any given temperature, how much more quickly will H_2 diffuse than N_2?

1. 3.7 times more quickly **correct**

2. .07 times more quickly

3. 0.3 times more quickly

4. 14 times more quickly

5. they will diffuse at the same rate

Explanation:

$m_1 v_1^2 = m_2 v_2^2$

$$\frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}} = \sqrt{\frac{28}{2}} = 3.7$$

LDE Ranking Gases 002

021 10.0 points

Which of the following molecules would have the largest a and b term, respectively, in the van der Waals equation: $N_2, SF_6, SF_5Cl, SiH_4, He$.

1. SiH_4 and SF_6, respectively

2. N_2 and He, respecitvely

3. SF_5Cl and SF_5Cl, respectively **correct**

4. SF_6 and SiH_4, respectively

5. SF_5Cl and He, respectively

Explanation:

SF_5Cl is the only polar molecule and thus has the largest a term and it is also the largest (in terms of molecular weight) and so has the largest b term as well.

LDE Gas Non-ideality 001

022 10.0 points

To promote ideal behavior of a gas, one should (raise/lower) the pressure and (raise/lower) the temperature of the gas.

1. raise, lower

2. lower, lower

3. lower, raise **correct**

4. raise, raise

Explanation:

Low pressure and high temperature both favor ideal behavior. Low pressure helps to ensure that the likelihood of molecules interacting with each other is small, thus helping to satisfy one of the assumptions of kinetic molecular theory, namely that gas molecules are not attracted to each other. High temperature gives the molecules a greater kinetic energy, helping to ensure that collisions will be as elastic as possible, again helping to satisfy one of the assumptions of kinetic molecular theory.

LDE Intermolecular Forces 001

023 10.0 points

Which of the following statements regarding intermolecular forces (IMF) is/are true?

I) Intermolecular forces result from attractive forces between regions of positive and negative charge density in neighboring molecules.

II) The stronger the bonds within a molecule are, the stronger the intermolecular forces will be.

III) Only non-polar molecules have London forces.

1. I only **correct**

2. I and III

3. II and III

4. I, II, and III

5. I and II

6. III only

7. II only

Explanation:

Statement I is true - all IMF result from

Coulombic attraction. Statements II and III are both false; the strength of the bonds within a molecule have no bearing on the strength of the bonds between molecules; all molecules have London forces.

LDE Intermolecular Forces 002

024 10.0 points

Which of the following compounds is not correctly paired with the strongest intermolecular foreces that it exhibits?

1. SiH_4, dispersion forces

2. NH_3, hydrogen bonding

3. HBr, hydrogen bonding **correct**

4. CaO, ionic

5. C_6H_6 (benzene), London forces

Explanation:

London forces, dispersion forces, van der Waals' forces or induced dipoles all describe the same intermolecular force. London forces are induced, short-lived, and very weak. Molecules and atoms can experience London forces because they have electron clouds. London forces result from the distortion of the electron cloud of an atom or molecule by the presence of nearby atoms or molecules.

Permanent dipole-dipole interactions are stronger than London forces and occur between polar covalent molecules due to charge separation.

H-bonds are a special case of very strong dipole-dipole interactions. They only occur when H is bonded to small, highly electronegative atoms – F, O or N only.

Ion-ion interactions are the strongest due to extreme charge separation and occur between ions (including polyatomic ions). They can be thought of as both inter- and intramolecular bonding.

HBr is a polar molecule that does not contain H bonds; therefore, dipole-dipole forces will be the most significant type of intermolecular forces present.

LDE Intermolecular Forces 003

025 10.0 points

Assign the strongest relevant intermolecular force to the following species, respectively: $RbCl_2$, C_6H_6 (benzene), HI, Fe_2O_3, CH_2NH.

I) ionic
II) hydrogen bonding
III) dipole-dipole
IV) van der Waals' forces

1. I, II, IV, I, III

2. I, II, III, II, I

3. II, IV, III, IV, IV

4. III, IV, I, I, II

5. III, II, IV, III, III

6. I, III, III, IV, II

7. I, IV, III, I, II **correct**

Explanation:

Rubidium Chloride and Iron(III) oxide are both ion-ion. Benzene is non-polar and thus has only van der Waal's forces. Hydroiodic acid is polar and has dipole-dipole interactions. Methylimine has H-bonding.

LDE Physical Properties 001

026 10.0 points

Which of the following statements about boiling is false?

1. Boiling always occurs at a temperature above the melting point.

2. As intermolecular forces increase, boiling point increases as well.

3. Boiling occurs when vapor pressure exceeds atmospheric pressure.

4. The boiling point of a liquid is independent of atmospheric pressure. **correct**

Explanation:

Boiling point is directly proportional to at-

mospheric pressure.

LDE Ranking by IMF 001

027 10.0 points

Rank the following compounds in terms of increasing boiling point: HF, sugar ($C_6H_{12}O_6$), H_2O, NH_3.

1. $NH_3 < HF < H_2O <$ sugar **correct**

2. $H_2O < NH_3 <$ sugar $< HF$

3. $HF < H_2O <$ sugar $< NH_3$

4. $H_2O <$ sugar $< NH_3 < HF$

Explanation:

Knowing the ranking of hydrofluoric acid, ammonia and water is a matter of memorization and sugar obviously comes last because it is the only species that is solid at room temperature.

LDE Ranking by IMF 002

028 10.0 points

Rank the following liquids in terms of decreasing viscosity: C_5H_{12}, CH_4, C_3H_8, C_2H_6, C_4H_{10}.

1. $CH_4 > C_2H_6 > C_3H_8 > C_5H_{12} > C_4H_{10}$

2. $CH_4 > C_2H_6 > SC_3H_8 > C_4H_{10} > C_5H_{12}$

3. $CH_4 > C_2H_6 > C_4H_{10} > C_3H_8 > C_5H_{12}$

4. $C_5H_{12} > C_3H_8 > C_4H_{10} > C_2H_6 > CH_4$

5. $C_5H_{12} > C_4H_{10} > C_3H_8 > C_2H_6 > CH_4$ **correct**

Explanation:

All of these molecules are non-polar, and viscosity is directly proportional to IMF, so one simply has to rank them from largest to smallest.

LDE Ranking by IMF 003

029 10.0 points

Rank the following species in terms of increasing enthalpy of vaporization (ΔH_{vap}) : K_2S, Ne, Kr, CH_3NH_2.

1. $CH_3NH_2 <$ Ne $< K_2S <$ Kr

2. $CH_3NH_2 < K_2S <$ Ne $<$ Kr

3. Ne $<$ Kr $< CH_3NH_2 < K_2S$ **correct**

4. Kr $< CH_3NH_2 < K_2S <$ Ne

Explanation:

Enthalpy of vaporization (ΔH_{vap}) is directly proportional to intermolecular forces, so ranking by increasing ΔH_{vap} requires ranking by increasing IMF. Neon and krypton are both non-polar and thus only have dispersion forces, but krypton is much larger and thus has stronger dispersion forces. Methylamine has hydrogen bonding. Potassium sulfide has ion-ion interactions.

LDE Solid Type 001

030 10.0 points

Which of the following is not a covalent network solid?

1. cellulose

2. diamond

3. graphite

4. table sugar **correct**

5. glass

6. starch

Explanation:

Table sugar is a molecular covalent solid. The other choices are all covalent network solids.