**CH301 2008 Practice Quiz 4 Answer Key**

1. Using molecular orbital theory, determine the bond order for $CN^-$?

1. 1
2. 2
3. 2.5
4. **3 correct**
5. 1.5

Explanation: The molecule would have 14 total electrons, 10 of which would be bonding and 4 of which would be anti-bonding. Therefore the bond order would be: (10-4)/2 = 3.

2. Which of the following statements is true regarding paramagnetism?

I. A molecule is paramagnetic if it has an odd number of total electrons
II. A molecule is not paramagnetic if it has an even number of total electrons
III. A molecule is paramagnetic if it has no unpaired electrons

1. I and III
2. I and II
3. **I only Correct**
4. III only
5. I, II, and III

Explanation: A molecule is paramagnetic if it has unpaired electrons. If a molecule has an odd number of electrons, at least one of these will be unpaired. However, if the molecule has an even number of electrons, some of these can still be unpaired, since we are following Hund's Rule.

3. Using molecular orbital theory, rank the following species in terms of increasing bond energy: $N_{2\,(3)}$, $O_{2\,(2)}$, $C_{2\,(2)}$, $B_{2}$ (1), and $Li_{2\,(1)}$.

1. **$Li_2 = B_2 < O_2 = C_2 < N_2$ Correct**
2. $N_2 < C_2 = O_2 < B_2 = Li_2$
3. $Li_2 = B_2 < N_2 < O_2 = C_2$
4. $O_2 = C_2 < Li_2 = B_2 < N_2$
5. $O_2 = Li_2 = B_2 < C_2 = N_2$

Explanation: Bond energy is inversely proportional to bond length. Therefore, $N_2$ with the triple bond has the greatest bond energy, followed by $C_2$ and $O_2$ (double bonds), then $B_2$ and $Li_2$ (single bonds).

4. Choose the species below that exhibits delocalization.

I. **$SO_4^{2-}$ correct**
II. $CH_4$
III. KF
IV. $F_2$
V. $NH_3$

Explanation: KF is a salt, and thus has no covalent bonds of any sort in which to delocalize electrons. The species $CH_4$, $F_2$, and $NH_3$ all have only single ($\sigma$) bonds and localized electrons. The sulfate anion exhibits resonance which allows the delocalization of electrons.

5. Burning butane can be represented by this combustion reaction:

$2C_4H_{10}\,(l) + 13O_2\,(g) \rightarrow 8CO_2\,(g) + 10H_2O\,(g)$

If we completely combusted four moles of butane with twenty-six moles of oxygen at STP, what volume would it occupy? Assume the reaction goes to completion. Assume all gases behave ideally.

1. 92 L
2. 120,000 L
3. **810 L** **correct**
4. 8.35 L
5. 0.62 L

Explanation: We will use PV = nRT to answert his question. Solving for V we find V = nRT/P. We see from the reaction that we will produce 16 moles of carbon dioxide and 20 moles of water, which tells us that n = 36. We then simply plug in the values for STP (T = 273 K and P = 1 atm) and the gas constant R. So, V = (36 moles * 0.0821 L atm per mole per K * 273 K) / 1 atm = 807 L. It's always good to check and see your units cancel for this type of problem.

6. A rigid 5 L container holds 2 moles of ammonia gas (assume ideal gas) at room temperature (T = 25 C). The temperature is increased by 30 degrees. What is the final pressure?

1. 32 atm
2. 21.5 atm
3. 0.9 atm
4. 42.5 atm
5. **10.8 atm** **correct**

Explanation: First, solve for the initial pressure using PV = nRT. Plugging in, P = (2 moles * 0.0821 L atm per mole per K * 298 K / 5 L ) = 9.786 atm. Next, we are told there is a change in the temperature and we want to know the new pressure. Notice that n and V stay constant because no new gas has been added or reacted away and the container is rigid so the volume doesn't change). Therefore, $P_1/T_1 = P_2/T_2$. Solving, $P_2 = P_1T_2/T_1$ = 9.786 atm * 328 K / 298 K = 10.77 atm. Make sure you are always converting to Kelvin for these problems – using Celsius will give you the wrong answer.

7. Which of the following statements is/are true?

I. Increasing gas speed results in increased diffusion speed but lowered effusion speed.
II. Given the same kinetic energy, a larger molecule will move slower than a smaller molecule.
III. Regardless of identity, gas molecules move at the same speed if they have the same kinetic energy.
IV. Effusion is the process of molecules flowing through a hole.
V. Diffusion is faster than gas speeds because collisions push the molecules in a particular direction, whereas individual gas molecules may be moving against diffusion.

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

Explanation: Higher gas speeds result in faster diffusion AND faster effusion, as should be intuitively obvious. Because gas molecules obey $E = (1/2)mv^2$ we can see that if E is the same but the masses are different, the velocities must be different to compensate. In other words, we can see that molecule with a large mass must move slower than those with smaller masses. Therefore gas molecules do NOT move at the same speed regardless of identity for a given kinetic energy because different molecules will have different masses. Effusion IS the process of molecules flowing through a hole. Diffusion is SLOWER than gas speed because collisions actually slow the travel of a gas.

8. Rank the following gases in terms of decreasing ideality: $CH_4$, $C_2H_6$, $C_3H_8$, $C_4H_{10}$

1. **$CH_4 > C_2H_6 > C_3H_8 > C_4H_{10}$** **correct**

2. $CH_4 > C_2H_6 > C_4H_{10} > C_3H_8$
3. $CH_4 > C_3H_8 > C_2H_6 > C_4H_{10}$
4. $CH_4 > C_3H_8 > C_4H_{10} > C_2H_6$
5. $CH_4 > C_4H_{10} > C_3H_8 > C_2H_6$
6. $CH_4 > C_4H_{10} > C_2H_6 > C_3H_8$

Explanation: Because all of the gases are non-polar, the only consideration for non-ideality is the size. Larger molecules, evaluated by atomic mass, are less ideal.