1. Rank the following in increasing bond polarity: CC, BO, NH, LiF

a. CC < NH < BO < LiF
b. BO < CC < LiF < NH
c. NH < BO < LiF < CC
d. CC < BO < NH < LiF

Homonuclear diatomic molecules are never polar.
BO: 3.5 -2 = 1.5
NH: 3 - 2.2 = .8
LiF: 4-1 = 3

2. Which of the following can be polar molecules:

I. CO_2
II. $Fe(CO)_5$
III. O_3

a. I
b. I, II, III
c. III
d. I, II

Carbon has double bonds with both oxygens and is therefore linear. The polarity of the bonds in CO_2 cancel out. $Fe(CO)_5$ has a trigonal bipyramidal geometry. The molecule is symmetric and there is no net dipole. The central oxygen in O_3 will have a positive dipole and the other two oxygens will have negative dipoles. Ozone has a bent molecular geometry and these dipoles do not cancel, making the molecule polar.

3. Which of the following molecules is nonpolar?

a. NH3
b. SO4 2-
c. SO2
d. BF2Cl

SO4 2- has two double bonds to two oxygens and single bonds with the other oxygens. The single oxygens carry the negative charges. Each of these bonds are polar but the molecule has a tetrahedral geometry and the dipoles cancel.

4. Determine the molecular geometry and bond angles of bromine pentafloride (BrF5)

a. Octahedral, 90, 120
b. Square Pyramidal, 90
c. Octahedral, 90
d. Square Pyramidal, 90, 120

VSPER says that BrF5 has an octahedral electronic geometry and a square pyramidal molecular geometry since Br has one lone pair.

5. Which hybrid orbitals are present in XeF4?

a. dsp3
b. d2sp3
c. d2sp2
d. sp3

Xe has four covalent bonds with F and two lone pairs. There are 6 regions of electrons around Xe so it will hybridize two d atomic orbitals, 1 s orbital, and 3 p orbitals to make 6 hybrid d2sp3 orbitals.

6. Determine the electronic geometry of ICl_2^-.

a. Trigonal pyramidal
b. Bent
c. Tetrahedral

d. Trigonal Bipyramidal

I has 3 lone pairs and two covalent bonds with Cl.

7. Determine the molecular geometry of the oxygen in CH3OH.

a. Tetrahedral
b. Bent
c. Linear
d. Seesaw

Oxygen has two covalent bonds and two lone pairs. It has a tetrahedral electronic geometry and a bent molecular geometry.

8. How many σ and π bonds are there in C_2H_2?

a. 4σ and 1π
b. 3σ and 2π
c. 2σ and 3π
d. 3σ and 1π

C_2H_2 has two single bonds and one triple bond. Every single bond is a sigma bond since the atomic or hybrid orbitals can directly overlap on the internuclear axis. Double bonds and triple bonds always have one sigma bond and one or two pi bonds respectively. The carbons are sp hybridized and these four hybrid orbitals are used in sigma bonding. The remaining four p orbitals are used in triple bonding.

9. What atomic orbitals are used in the bonding of NO?

a. 2s
b. 2s and 2p
c. 2p
d. 1s, 2s, 2p

The 1s and 2s orbitals do not contribute to bonding. The two π2p orbitals and the σ2p orbital are filled with electrons from the 2p electrons from nitrogen and oxygen. One electron remains and occupies a π2p* antibonding orbital.

10. Using molecular orbital theory determine which of the following molecules can exist and no be paramagnetic.

a. B_2
b. He_2
c. CO
d. NO

He2 cannot exist because it has a bond order of 0. CO has no unpaired electrons in its molecular orbitals. B2 has two unpaired electrons in the π2p orbitals. NO has one unpaired electron in its π2p* molecular orbital.

Miranda, Question Types 11-20.

11. What is the electronic configuration of B_2^-?

a. $(\sigma 2s)^2(\sigma 2s^*)^2(\pi 2p)^4$
b. $(\sigma 2s)^2(\sigma 2s^*)^2$
c. $(\sigma 2s)^2(\sigma 2s^*)^2(\pi 2p)2$
d. $(\sigma 2s)^2(\sigma 2s^*)^2(\sigma 2p)^2(\pi 2p)^2$

The filled MO for B_2^{2-}:

σ2p* ___
π2p*, π2p* ___ ___
σ2p ___
π2p, π2p ↑↓ ↑↓
σ2s* ↑↓

σ2s ⇅
σ1s* ⇅
σ1s ⇅

12. What are the bond orders for N_2^+, N_2, and N_2^-?
   a. 3.5; 3; 3.5
   b. 2; 3; 4
   c. 2.5; 3; 3.5
   d. 2.5; 3; 2.5

The filled MO for N_2:
σ2p* ___
π2p*, π2p* ___ ___
σ2p ⇅
π2p, π2p ⇅ ⇅
σ2s* ⇅
σ2s ⇅
σ1s* ⇅
σ1s ⇅
BO for N_2^+= (9 - 4) / 2 = 2.5
BO for N_2= (10 - 4) / 2 = 3
BO for N_2^-= (10 - 5) / 2 = 2.5

13. Which molecule is diamagnetic?
   a. B_2^{2-}
   b. C_2^{2+}
   c. O_2
   d. all are diamagnetic

The filled MO for B_2^{2-}:
σ2p* ___
π2p*, π2p* ___ ___
σ2p ___
π2p, π2p ⇅ ⇅
σ2s* ⇅
σ2s ⇅
σ1s* ⇅
σ1s ⇅
The filled MO for C_2^{2+}:
σ2p* ___
π2p*, π2p* ___ ___
σ2p ___
π2p, π2p ↑ ↑
σ2s* ⇅
σ2s ⇅
σ1s* ⇅
σ1s ⇅
The filled MO for O_2:
σ2p* ___
π2p*, π2p* ↑ ↑
π2p, π2p ⇅ ⇅
σ2p ⇅
σ2s* ⇅
σ2s ⇅
σ1s* ⇅

σ1s ⇅

14. Based on bond order, what is true about the difference between the bonds in Li_2 and C_2?

a. C_2 has a longer bond length and a higher bond energy than Li_2.
b. C_2 has a longer bond length and a lower bond energy than Li_2.
c. C_2 has a shorter bond length and a higher bond energy than Li_2.
d. C_2 has a shorter bond length and a lower bond energy than Li_2.

The bond order for C_2 is 2, and the bond order for Li_2 is 1. Bond length is inversely proportional to bond order, so C_2 has a shorter bond length than Li_2. Bond energy is directly proportional to bond order, so C_2 has a higher bond energy than Li_2.

15. Which of the following species does not exhibit resonance?

a. SO_3
b. PCl_5
c. HCO_2
d. C_6H_6

16. At constant temperature and pressure, the volume of a gas will increase as the number of moles increases. Who's law is this?

a. Pauli's
b. Charles's
c. Boyle's
d. Avogadro's

17. A gas is contained in a flexible, 4.7 L container. The temperature of the gas is increased from 25 ^{o}C to 50 ^{o}C, and the pressure is decreased from 760 Torr to 730 Torr. What is the new volume of the gas?

a. 5.3 L
b. 9.7 L
c. 5.8 L
d. 6.5 L

V1 = 4.7 L, V2 = ?
T1 = 25 + 273 = 298 K, T2 = 323 K
P1 = 760 Torr = 1 atm, P2 = 730 Torr = .96 atm
P1*V1/T1 = P2*V2/T2
V2 = (P1*V1*T2)/(T1*P2) = (1 atm * 4.7 L * 323 K)/(298 K * .96 atm) = 5.3 L

18. 3.5 grams of a gas is held in a 1.13 L container at 25 ^{o}C and 2 atm. What is the molecular weight of the gas? Which molecule could this gas be?

a. 40 g/mol; Ar
b. 70 g/mol; Cl_2
c. 4 g/mol; He
d. 38 g/mol; F_2

g = 3.5 g
V = 1.13 L
T = 298 K
P = 2 atm
MW = gRT/PV = (3.5 g * .082 Latm/Kmol * 298 K)/(2 atm * 1.13 L) = 37.8 g/mol

19. If the reaction goes to completion, what is the maximum number of moles that can be

obtained by reacting 5.00 L of $H_{2(g)}$ with 2.00 L of $N_{2(g)}$? Assume STP for the reactants and products.
$3 H_2 + N_2 \rightarrow 2 NH_3$

a. .178 mol
b. .149 mol
c. 1.63 mol
d. 1.95 mol

moles of H_2 = (1 atm * 5.00 L)/(.082 Latm/molK * 273 K) = .223 mol
moles of N_2 = (1 atm * 2.00 L)/(.082 Latm/molK * 273 K) = .089 mol
.223 mol of H_2 (2 mol NH_3/3 mol H_2) = .149 mol NH_3
.089 mol of N_2 (2 mol NH_3/1 mol of N_2) = .178 mol of NH_3
The maximum number of moles of NH_3 that can be obtained is .149 mol. All of the hydrogen will react, but there will be some remaining nitrogen gas.

20. If molecule A has a molecular weight of 127.5 g/mol and molecule B has a molecular weight of 120.2 g/mol, how many times faster will molecule B travel than molecule A?

a. 1.30
b. 1.03
c. .971
d. .943

$m_1v_1^2 = m_2v_2^2$
$v_1^2/v_2^2 = m_2/m_1$
$v_1/v_2 = (m_2/m_1)^{1/2} = (120.2/127.5)^{1/2} = .971$
$v_1 = .971\ v_2$
$v_2 = (1/.971)\ v_1 = 1.03\ v_1$

Travis (that's me), Question Types 21-30.
21. Ranking non-ideality of gases
Rank the following gases from most to least ideal in terms of the van der Waal coefficient b: CO, N_2O, HF, H_2O_2.

1. HF > CO > N_2O > H_2O_2
2. H_2O_2 > HF > CO > N_2O
3. HF > CO > H_2O_2 > N_2O
4. CO > HF > H_2O_2 > N_2O

The van der Waal coefficient b is the "excluded molar volume" of a gas - it is an empirically determined value that relates to the size of the gaseous particles. This should be ranked based on molecular weight. Keeping in mind that kinetic molecular theory assumes gases are infinitely small, the most ideal species will be the smallest.

22. Gas non-ideality theory
Which of the combinations of V, n and T below would behave the most ideally?

1. V = 2 L, n = 0.1 moles, T = 250 K
2. V = 2 L, n = 0.5 moles, T = 100 K
3. V = 10 L, n = 0.5 moles, T = 250 K
4. V = 10 L, n = 0.1 moles, T = 500 K
5. V = 2 L, n = 0.1 moles, T = 500 K

Conditions that favor ideality are low pressure, low density and high temperature.

23. IMF theory
Which of the following best explains all intermolecular forces?

1. Electrostatic attractions between opposite charges.
2. The capacity of molecules to form instantaneous dipoles.
3. The tendency of ions to arrange themselves in lattices.

4. The large charge density that occurs when hydrogen is bonded to a very electronegative atom.

Of all the various types of IMF, the thing they have in common is Coulombic attraction between regions of positive and negative charge.

24. Assigning IMF to molecules

Which of the following species exhibit hydrogen bonding?

I. CH_2O

II. CH_3OH

III. CH_3COOH

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

Species I (CH_2O, aka methanal aka formaldehyde), has no hydrogen atoms covalently bonded to a highly electronegative atom.

25. Assigning IMF to molecules

For which of the following species are London forces significant?

1. NH_3
2. CH_2F_2
3. O_3
4. SF_6

All of the species have London forces, but all except SF_6 also have some other stronger IMF, such as dipole-dipole or hydrogen bonding.

26. Defining physical properties

Which of the following describes a fluids ability to resist flow?

1. mucilage
2. viscosity
3. surface tension
4. capillary action
5. vapor pressure

Viscosity is a measure of a fluid's internal "friction," or the reluctance of individual molecules in the fluid to move past one another or away from one another.

27. Ranking physical properties by IMF

Rank the following species from highest to lowest vapor pressure: HF, H_2O, NH_3

1. $NH_3 > HF > H_2O$
2. $HF > H_2O > NH_3$
3. $H_2O > NH_3 > HF$
4. $NH_3 > H_2O > HF$

This is pure memorization. Ammonia has the weakest hydrogen bonding of the three species, and consequently the lowest boiling point and highest vapor pressure. Next is HF and finally water which is strongest.

28. Ranking physical properties by IMF

Rank the following species from least to greatest viscosity: CH_4, C_4H_{10}, CH_3F, CF_4.

1. $CH_4 < C_4H_{10} < CH_3F < CF_4$
2. $CH_4 < C_4H_{10} < CF_4 < CH_3F$
3. $C_4H_{10} < CH_4 < CH_3F < CF_4$

4. $CH_3F < C_4H_{10} < CH_4 < CF_4$
5. $C_4H_{10} < CH_4 < CF_4 < CH_3F$

Methane, butane and tetrafluoromethane area all non-polar and should be ranked according to size (molecular weight). Fluoromethane is polar.

29. Ranking physical properties by IMF

Rank the following species from highest to lowest boiling point: H_2Te, H_2S, H_2O, H_2Se

1. $H_2O > H_2S > H_2Se > H_2Te$
2. $H_2O > H_2Se > H_2Te > H_2S$
3. $H_2O > H_2Te > H_2S > H_2Se$
4. $H_2O > H_2Te > H_2Se > H_2S$

The greater polarizability and dispersion forces of large atoms such as Se and Te, leads to stronger intermolecular forces in the species above that contain them. Water is obviously the largest because of its strong hydrogen bonding.

30. Assigning type of solid to compounds

Which of the species below is not covalent network?

1. graphite
2. dry ice
3. diamond
4. quartz

Dry ice, solid carbon dioxide, is a molecular solid. Graphite and diamond are both covalent networks formed by carbon and quartz is a covalent network with a unit formula of SiO_2.