Chemistry 211 Key 4 Fall 2023

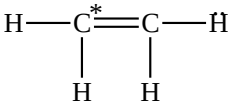
Multiple Choice: (4 points each. Put answers in left margin as capital letters.)
R = 0.0821 L•atm/mol•K

1. Which of the following species is isoelectronic to As^{+}?

   A) Br B) Br^{2+} C) Ga^{-} D) Kr E) Sb^{2-}

2. Which of the following sets of quantum numbers is not permissible? (n, ℓ, m_ℓ)

   A) 2, 1, 1 B) 3, 2, 0 C) 4, 1, -2 D) 4, 1, -1 E) 5, 4, -1

3. For the molecule:  What is the hybridization on the indicated atom?

   A) *sp* B) sp^2 C) sp^3 D) sp^3d E) does not hybridize

4. Which of the following is not true of **valence bond** theory?

   A) Hybridized orbitals can yield more stable bonds than atomic orbitals.
   B) π-Bonds occur between atomic orbitals, not hybrid orbitals.
   C) Sigma bonds result from the end-to-end overlap of atomic or hybrid orbitals.
   D) Hybridization involves the promotion of electrons and the mixing of atomic orbitals.
   E) Antibonding orbitals are higher in energy than bonding orbitals.

5. Paramagnetism occurs when

   A) a substance is magnetic at only low temperatures.
   B) an atom or molecule contains unpaired electrons.
   C) a substance is magnetic at only high temperatures.
   D) a substance is never magnetic.
   E) an atom or molecule contains no unpaired electrons.

6. Which of the following compounds would have the **most** exothermic lattice energy?

   A) CsBr B) CsCl C) CsF D) CsI

7. An ideal gas in a sealed container has an initial volume of 2.65 L. At constant pressure, it is cooled to 16.00 ºC, where its final volume is 1.75 L. What was the initial temperature?

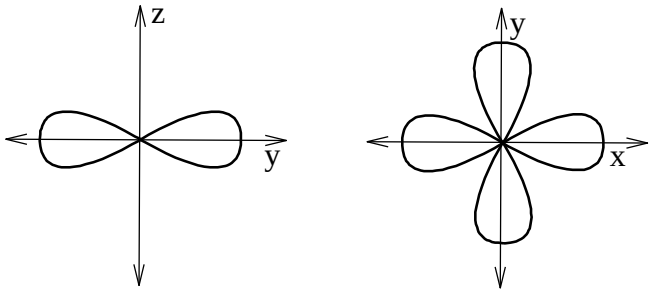
   A) -83 ºC B) 24 ºC C) 165 ºC D) 297 ºC E) 438 ºC

8. What is the total pressure of a gas mixture if one component gas has a pressure of 218 torr and represents 37.4% of the gas in the mixture?

   A) 81.5 torr B) 136 torr C) 348 torr D) 582 torr E) 760 torr

Discussion Questions: (You must show your work to receive credit.)

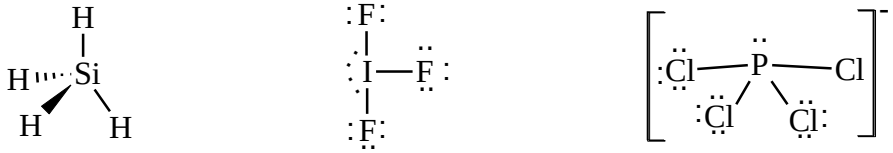
1. Sketch the shape and orientation of the p_y and d_{x2-y2} orbitals. (5 points)



2. Provide the electron configuration and number of unpaired electrons on Ir^{3+}. (5 points)

   [Xe] $4f^{14}\ 5d^6$, 4 unpaired electrons

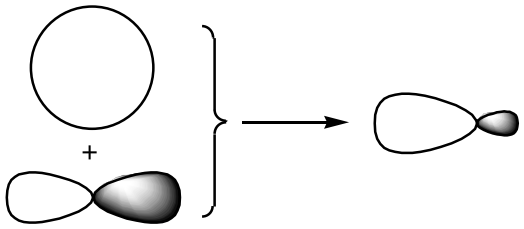
3. For each of the following molecules: 1) draw the correct Lewis structure, 2) what is the actual (molecular) shape, 3) what is the hybridization of the underlined atom and 4) write "polar" or "nonpolar" to indicate which is true of the first 2 molecules: $\underline{Si}H_4$, $\underline{I}F_3$, and $\underline{P}Cl_4^-$. (26 points)



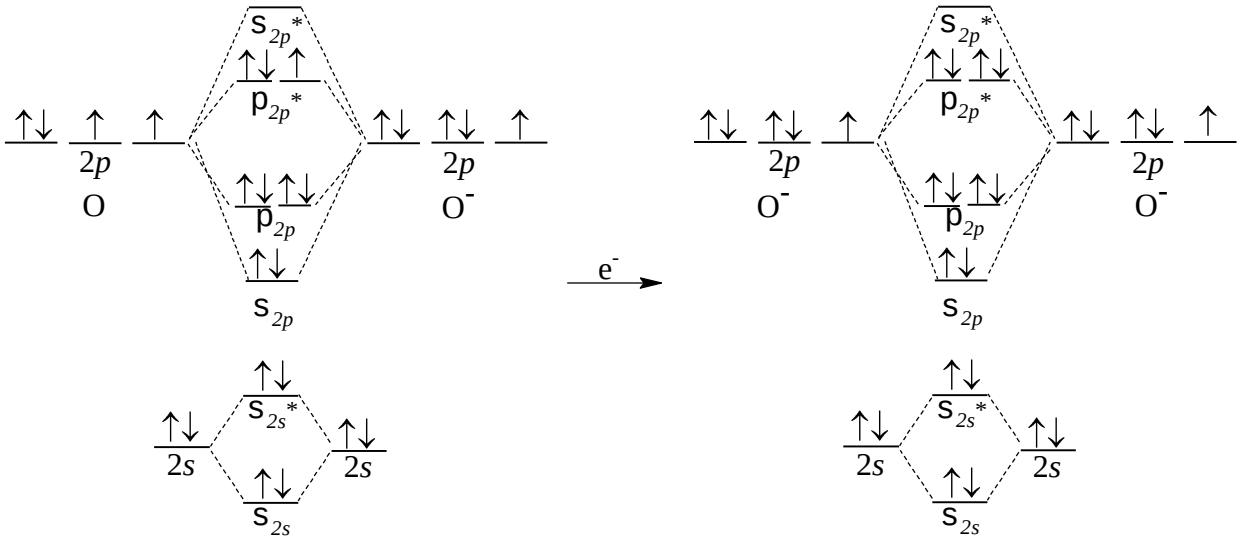
tetrahedral	T-shaped	seesaw
sp^3	sp^3d	sp^3d
nonpolar	polar	

4. Discuss the process of creating *sp* hybrid orbitals from their component atomic orbitals. Describe in both text and pictures. (10 points)

   sp Hybrid orbitals arise when an *s* orbital mixes with a *p* orbital. Two product orbitals form from this mixing. One lobe on each orbital is very large because the amplitudes of the wave functions are both positive and reinforce one another (constructive interference). The other lobe is small because the amplitudes are opposed and partly cancel each other (destructive interference).



5. Write out the molecular orbital diagram for O_2^-. Show only the n = 2 energy level. Would adding an electron increase or decrease the bond length and why? (12 points)



B.O. (O_2^-) = ½(8 – 5) = 1.5

B.O. (O_2^{2-}) = ½(8 – 6) = 1.0

The bond length shortens because the bond order decreases from 1.5 to 1.0.

6. What is the pressure of an unknown gas that occupies a volume of 413 mL at 122 ºC, if the sample contains 0.0467 mol. (5 points)
Remember to convert volume to liters and temperature to Kelvins.
PV = nRT
P(0.413L) = (0.0467 mol)(0.0821 L•atm/mol•K)(395 K)
P = 3.67 atm

7. A 2.65 g sample of an unknown gas at 67 ºC and 1.05 atm is stored in a 3.05 L flask. What is its molecular weight? (5 points)

T = 340 K
(1.05 atm)(3.05 L) = n(0.0821 L•atm/mol•K)(340 K)
n = 0.0115 mol

$$MW = \frac{2.65\ g}{0.0115\ mol} = 23.1\ g/mol$$