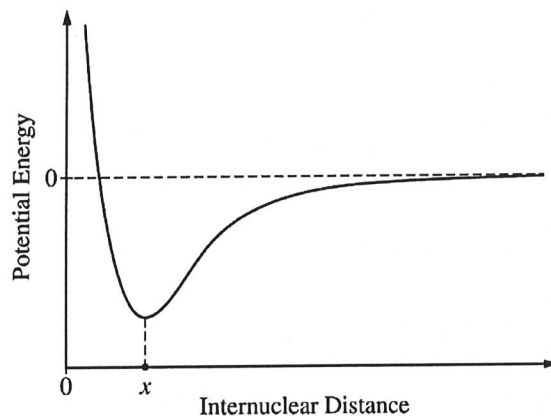


Unit 7 Chemical Bonding Practice Multiple Choice

Name(s):

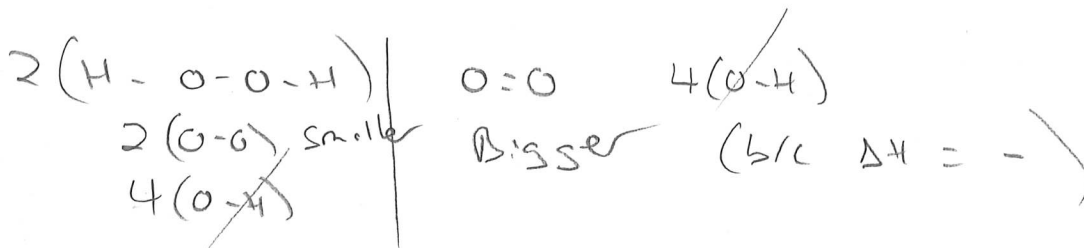
- Which of the following metals would produce a chloride compound with the lowest lattice energy?
A) Mg B) Ba C) Na **(D) Cs** *Large and also +1*
- Which of the following molecules would have the shortest bond length?
(A) N₂ *Triple bond* B) O₂ = C) Cl₂ - D) I₂ -
- The angle between sp hybridized orbitals is A) 45° B) 90° C) 109.5° D) 120° **(E) 180°**
- The Lewis dot structure of which of the following molecules shows only one unshared pair of electrons.
A) H₂ **(B) NH₃** C) H₂O D) CO *H-N-H*
- A molecule with the formula AB₂ can have _____ molecular shape.
(A) linear or bent B) trigonal planar C) linear or trigonal planar D) T-shaped
- Which of the following ions exhibit delocalized bonding? *(resonance)*
A) NO₂⁻ B) NH₄⁺ and NO₂⁻ **(C) N₃⁻ and NO₂⁻** D) N₃⁻
- For which of the following molecules is the molecular geometry the same as the electron domain geometry?
(i) PF₃ (ii) CF₄ (iii) XeF₄ (iv) SF₆
A) i and ii B) ii and iii C) iii and iv **(D) ii and iv** *(no lone pairs)*
- Which of the molecules in the previous question would have a dipole moment?
(A) i *lone pair* B) ii C) iii D) iv
- The potential energy of a system of two atoms as a function of their internuclear distance is shown in the diagram above. Which of the following is true regarding the forces between the atoms when their internuclear distance is x?
(A) The attractive and repulsive forces are balanced, so the atoms will maintain an average internuclear distance x.
B) There is a net repulsive force pushing the atoms apart, so the atoms will move further apart. *no*
C) There is a net attractive force pulling the atoms together, so the atoms will move closer together. *no*
D) It cannot be determined whether the forces between atoms are balanced, attractive, or repulsive, because the diagram shows only the potential energy. *lies*



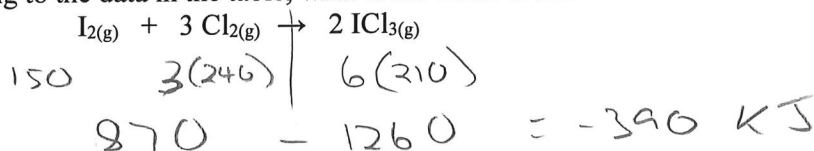
- The decomposition of hydrogen peroxide is represented by: $2\text{H}_2\text{O}_2(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + \text{O}_2(\text{g})$ $\Delta H^\circ = -196\text{kJ/molrxn}$
Assume that the bond enthalpies of the oxygen-hydrogen bonds in H₂O are not significantly different from those in H₂O₂. Based on the value of ΔH° of the reaction, which of the following could be the bond enthalpies (in kJ/mol) for the bonds broken and formed in the reaction?

	O—O in H ₂ O ₂	O=O in O ₂	O—H
A)	300	500	500
(B)	150	500	500
C)	500	300	150
D)	250	300	150

Broken - Formed



11) According to the data in the table, what is the value of ΔH° for the reaction below?



Bond	Average Bond Energy (kJ/mole)
I-I	150
Cl-Cl	240
I-Cl	210

- A) -870 kJ **B) -390 kJ** C) +390 kJ D) +1,260 kJ

12) The melting point of MgO is higher than that of NaF. Explanations for this observation include which of the following?

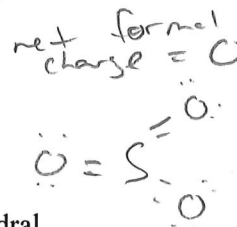
- I. Mg^{2+} is more positively charged than Na^+ ✓
 II. O^{2-} is more negatively charged than F^- ✓
 III. The O^{2-} ion is smaller than the F^- ion ✓

- A) II only B) I and II only C) I and III only **D) I, II, and III**

13) Of the following molecules, which has the largest dipole moment?

- A) CO B) CO_2 **C) HF** D) F_2

Handwritten note: F, enough said



14) The geometry of the SO_3 molecule is best described as...

- A) trigonal planar** B) trigonal pyramidal C) T-shaped D) tetrahedral

15) According to the VSEPR model, the progressive decrease in the bond angles in the series of molecules CH_4 , NH_3 , and H_2O is best accounted for by the...

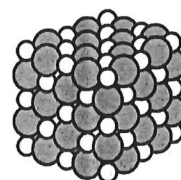
- A) decreasing repulsion between hydrogen atoms B) decreasing size of the central atom
 C) increasing electronegativity of the central atom **D) increasing number of unshared pairs of electrons**

16) Which of the following has the bonds arranged in order of decreasing polarity?

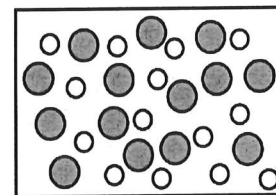
- A) $\text{H-F} > \text{N-F} > \text{F-F}$** B) $\text{H-I} > \text{H-Br} > \text{H-F}$ C) $\text{O-N} > \text{O-S} > \text{O-Te}$ D) $\text{Sb-I} > \text{Sb-Te} > \text{Sb-Cl}$

17) Based on the diagram, which of the following best helps to explain why $\text{MgO}(s)$ is not able to conduct electricity, but $\text{MgO}(l)$ is a good conductor of electricity?

- A) $\text{MgO}(s)$ does not contain free electrons, but $\text{MgO}(l)$ contains free electrons that can flow.
 B) $\text{MgO}(s)$ contains no water, but $\text{MgO}(l)$ contains water that can conduct electricity.
 C) $\text{MgO}(s)$ consists of separate Mg^{2+} ions and O^{2-} ions, but $\text{MgO}(l)$ contains MgO molecules that can conduct electricity.
D) $\text{MgO}(s)$ consists of separate Mg^{2+} ions and O^{2-} ions held in a fixed lattice, but in $\text{MgO}(l)$ the ions are free to move and conduct electricity.



Solid MgO

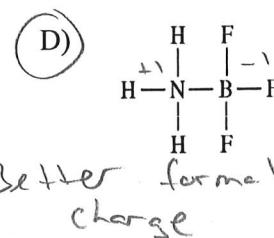
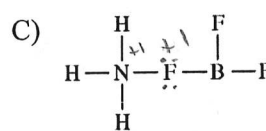
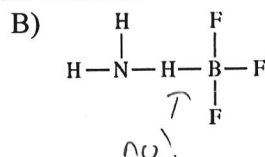
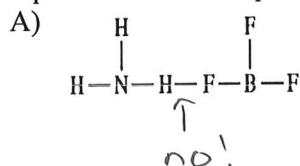


Liquid MgO

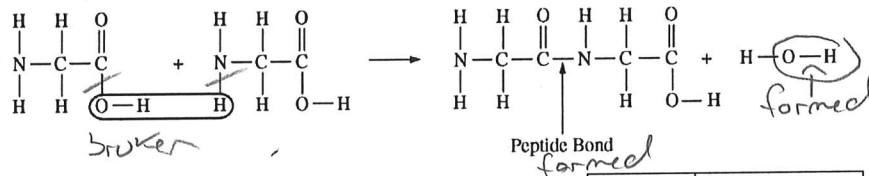
18) A student is given a sample of a pure, white crystalline substance. Which of the following would be most useful in providing data to determine if the substance is an ionic compound?

- A) Examining the crystals of the substance under a microscope
 B) Determining the density of the substance
 C) Testing the electrical conductivity of the crystals
D) Testing the electrical conductivity of an aqueous solution of the substance

19) NH_3 reacts with BF_3 to form a single species. Which of the following structural diagrams is the most likely representation of the product of the reaction?



Two molecules of the amino acid glycine join through the formation of a peptide bond, as shown. $\Delta H^\circ_{298} = +12 \text{ kJ/mol}_{rxn}$



20) Based on the bond energies listed in the table, which of the following is closest to the bond energy of the C-N bond?

- A) 200 kJ/mol B) 300 kJ/mol C) 400 kJ/mol D) 500 kJ/mol

$$12 = (360 + 390) - (x + 460)$$

$$12 = 750 - x - 460$$

$$12 = 290 - x \quad x = 278 \text{ kJ}$$

Bond	Bond Energy (kJ/mol)
C-O	360
N-H	390
O-H	460

21) The compound CCl_4 is nonflammable and was once commonly used in fire extinguishers. On the basis of the periodic properties, which of the following compounds can most likely be used as a fire-resistant chemical?

- A) BCl_3 B) CH_4 C) CBr_4 D) PbCl_2

Br is most similar to Cl, molecule is still nonpolar

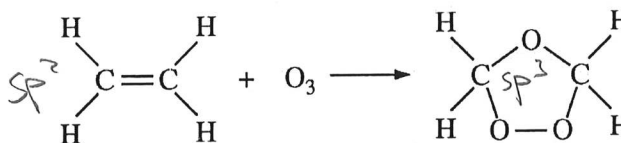
22) The exothermic process represented by the equation $2 \text{H}_2\text{O}_2(l) \rightarrow 2 \text{H}_2\text{O}(l) + \text{O}_2(g)$ is best classified as a

- A) physical change because a new phase appears in the products.
 B) physical change because $\text{O}_2(g)$ that was dissolved comes out of solution. } *common men!*
 C) chemical change because entropy increases as the process proceeds.
 D) chemical change because covalent bonds are broken and new covalent bonds are formed.

23) In the reaction represented below, what is the hybridization of the C atoms before and after the reaction occurs?

Before After

- A) sp sp^2
 B) sp sp^3
 C) sp^2 sp
 D) sp^2 sp^3

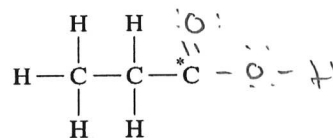


- 1) Propanoic acid, C_2H_5COOH , is an organic acid that is a liquid at room temperature.

2016 practice 6

- a) An incomplete Lewis diagram for the propanoic acid molecule is provided in the box. Complete the diagram, showing how the remaining atoms in the molecule are arranged around the carbon atom marked with an asterisk (*). Your structure should minimize formal charge and include any lone pairs of electrons.

(1pt)



- b) Identify the hybridization of the carbon atom marked with the asterisk. sp^2 (1pt)

- c) Propanoic acid has a lower boiling point than butanoic acid, C_3H_7COOH .

- i) Identify all the types of intermolecular forces present among the molecules in propanoic acid. (1pt)

LDF, H-bonding, Dipole - Dipole

- ii) Which of the types of intermolecular forces that you identified in part (c)(i) is most responsible for the difference in boiling points of the two acids? (1pt)

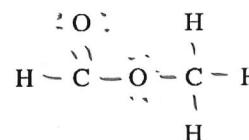
LDF (carbon chain is longer = stronger LDF's)

- 2) Answer the following about two isomers, methyl methanoate and ethanoic acid.

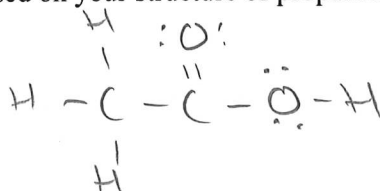
The molecular formula of the compounds is $C_2H_4O_2$.

(2015 Practice 5)

- a) Complete the Lewis electron-dot diagram of methyl methanoate in the box. Show all valence electrons. (1pt)



- b) Based on your structure of propanoic acid in #2a, draw the Lewis electron-dot structure for ethanoic acid. (1pt)



- c) Explain why methyl methanoate and ethanoic acid are isomers. (1pt)

Same formula - different structures

- d) Identify the geometry and approximate bond angles around the central atom of each structure. (1pt)

methyl methanoate bent - 104.5°

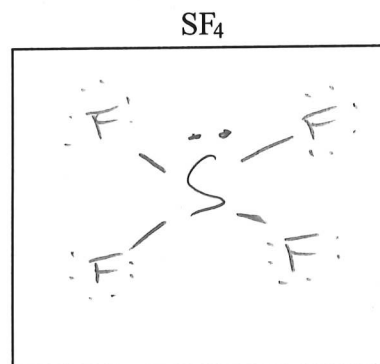
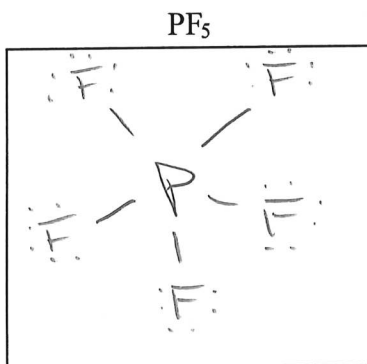
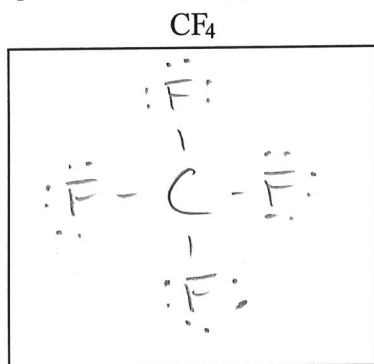
O

ethanoic acid Trig Planer $\sim 120^\circ$

C

Answer the following questions that relate to chemical bonding. 2005 6

- a) In the boxes provided, draw the complete Lewis structure (electron-dot diagram) for each of the three molecules represented below. (3pts)



- b) On the basis of the Lewis structures drawn above, answer the following questions about the particular molecule indicated.

i) What is the hybridization of the valence orbitals of C in CF₄? sp³ (1pt)

ii) What are the two different bond angles in PF₅? 90° and 120° (1pt) (Trig Bipyramidal)

iii) What is the geometric shape formed by the atoms in SF₄? see saw (1pt)

- c) Two Lewis structures can be drawn for the OPF₃ molecule, as shown.

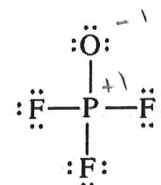
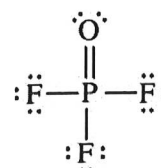
i) How many sigma bonds and how many pi bonds are in structure 1?

sigma 4 pi 1 (2pts)
3 single bonds + 1 from the double

ii) Which one of the two structures best represents a molecule of OPF₃?

Justify your answer in terms of formal charge.

Structure 1 - all atoms have a formal charge of 0



Answer the following questions about ozone.

2017 Practice 3a-c

- a) The O₃ molecule has a central oxygen atom bonded to two outer oxygen atoms that are not bonded to one another. Draw the Lewis electron-dot diagram of the O₃ molecule. Include all valid resonance structures. (2pts)



- b) Based on the diagram you drew in part (a), what is the shape of the ozone molecule? Bent (1pt)

Ozone decomposes according to the reaction represented by: $2 \text{O}_3(\text{g}) \rightarrow 3 \text{O}_2(\text{g}) \Delta H^\circ = -285 \text{ kJ/mol}_{\text{rxn}}$

- c) The bond enthalpy of the oxygen-oxygen bond in O₂ is 498 kJ/mol. Based on the enthalpy of the reaction represented above, what is the average bond enthalpy, in kJ/mol, of an oxygen-oxygen bond in O₃? (2pts)

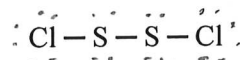
$-285 \text{ kJ} = \text{Broken} - \text{formed}$

$-285 = 4(x) - 3(498)$

$x = \boxed{302 \text{ kJ}}$

c) S_2Cl_2 is a product of the reaction: $\text{CS}_2(\text{g}) + 3 \text{Cl}_2(\text{g}) \rightarrow \text{CCl}_4(\text{g}) + \text{S}_2\text{Cl}_2(\text{g})$

i) Complete the Lewis electron-dot diagram for the S_2Cl_2 molecule by drawing in all of the electron pairs. (1pt) 2017 1c

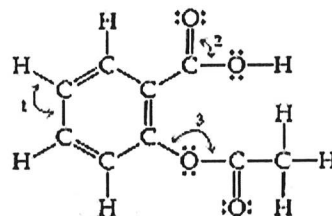
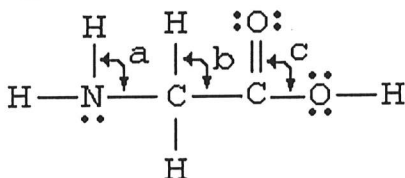


ii) What is the approximate value of the Cl-S-S bond angle in the S_2Cl_2 molecule that you drew in part (c)(i)? (If the two Cl-S-S bond angles are not equal, include both angles.) (1pt)

$\sim 104.5^\circ$ (bent)

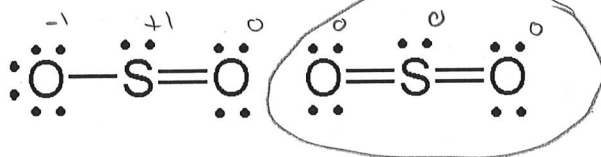
Identify the approximate bond angles marked (a), (b), and (c) in the molecule. Identify the hybridization producing the angles.

Angle	Hybridization
a) 107°	sp^3
b) 109.5°	sp^3
c) 120°	sp^2
1) 120°	sp^2
2) 120°	sp^2
3) 104.5°	sp^3



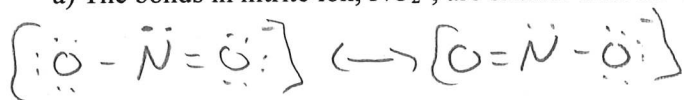
Two possible structures are shown for sulfur dioxide.

a) Calculate the formal charge for each and circle the structure which is more likely. (1pt)



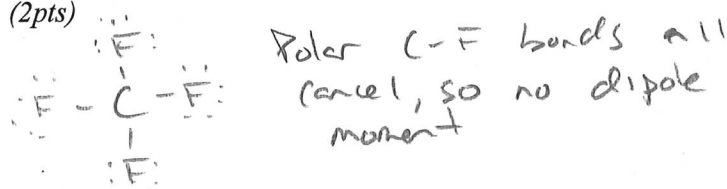
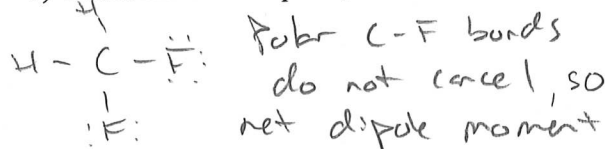
Using principles of chemical bonding and molecular geometry, explain each of the following observations. *Lewis electron-dot diagrams and sketches of molecules may be helpful as part of your explanations.* For each observation, your answer must include references to both substances. 2002 6

a) The bonds in nitrite ion, NO_2^- , are shorter than the bonds in nitrate ion, NO_3^- . (2pts)

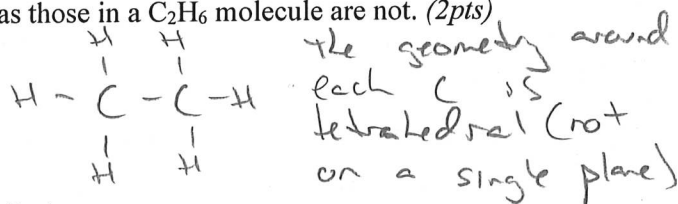
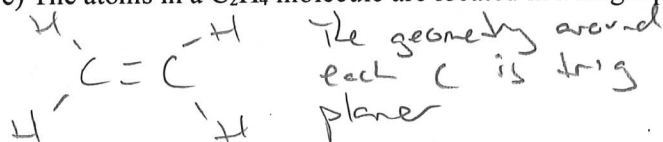


1.5 bonds due to electron delocalization = shorter 1.33 bonds due to delocalization

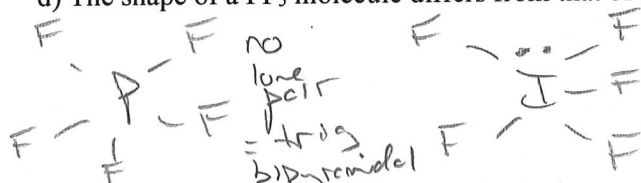
b) CH_2F_2 molecule is polar, whereas the CF_4 molecule is not. (2pts)



c) The atoms in a C_2H_4 molecule are located in a single plane, whereas those in a C_2H_6 molecule are not. (2pts)

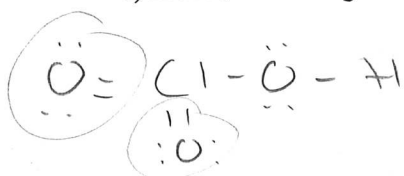


d) The shape of a PF_5 molecule differs from that of an IF_5 molecule. (1pt)



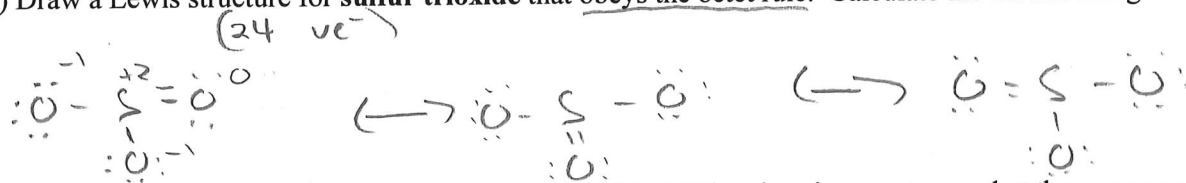
lone pair = square pyramidal

e) HClO_3 is a stronger acid than HClO . (1pt)



two additional O's in HClO_3 pull e^- away from the O-H bond and weakens it. This makes it easier for the H to be ionized.

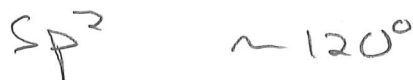
6) Draw a Lewis structure for **sulfur trioxide** that obeys the octet rule. Calculate the formal charges for each atom.



a) How many total resonance structures are possible? What does it mean to say that the π component of the double bond is **delocalized**? What orbitals are involved?

3 - The π bond is not confined to a single O. It is at all 3 oxygens which forms a 1.33 bond. The p orbitals form a π bond.

b) What is the hybridization of the sulfur atom? What are the bond angles?



c) What is the electron domain geometry and what is the molecular geometry?

Both are trigonal planar (no lone pairs on S)

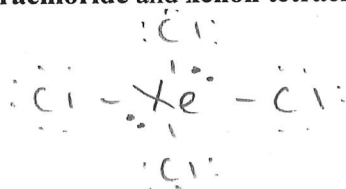
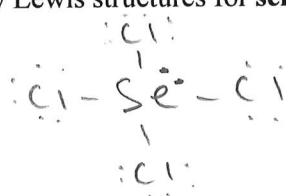
d) Is the structure polar or nonpolar?

Nonpolar - electronegativity difference is small + all three bonds cancel out.

e) Draw another structure for sulfur trioxide where the sulfur atom expands the octet until the formal charge on the sulfur goes to zero. What happens to the formal charges on the oxygens?



Draw Lewis structures for **selenium tetrachloride** and **xenon tetrachloride**.



* lone pairs on central atom give each O formal charge

a) Identify the **electron domain geometry** and **molecular geometry** for each.

$SeCl_4$ - Trig Bipyramidal / See saw | $XeCl_4$ - Octahedral / Square Planar

b) Indicate the bond angles in each structure.

$SeCl_4 \sim 90^\circ$ and $\sim 120^\circ$ | $XeCl_4 \sim 90^\circ$

c) Both molecules contain polar bonds. Indicate if each molecule is polar or nonpolar.

$SeCl_4$ = polar (lone pair) | $XeCl_4$ = nonpolar (all cancel)

d) Determine the hybridization of the central atom in each molecule.

$SeCl_4 - sp^3d$ | $XeCl_4 - sp^3d^2$ *NOT on AP test

e) Briefly explain why oxygen tetrachloride cannot exist.

Octet rule can not be followed
O can't use d orbitals for bonding (2d doesn't exist)