Instructions: Show all work whenever a calculation is required! You will receive credit for ***how*** you worked each problem as well as for the correct answer. This exam is worth 50 points. BOX YOUR ANSWERS! Questions worth ONE point, unless noted.

1. (5 pts) True or False. Circle T or F:
   T F When a bond forms between two atoms, energy is released.
   T F The bond length corresponds to optimal distance between two nuclei.
   T F Bond energies have units of kJ/mol.
   T F Multiple bonds (double, triple) are longer than single bonds.
   T F Breaking a covalent bond is endothermic.

2. (6 pts) The following statements pertain to ionic substances, covalent substances, both or neither. Circle I, C, B or N to designate ionic, covalent, both or neither, respectively.
   I C B N Compounds are solids, liquids or gases at room temperature.
   I C B N Compounds are always solids at room temperature.
   I C B N Compounds may dissolve in water.
   I C B N When compounds dissolve in water, they conduct electricity.
   I C B N Large electronegativity differences (> 2) exist between two of the atoms.
   I C B N Compounds are the result of two metals bonding.

3. (2 pts) Circle the most polar bond in each pair.

   (a) B – N or B – O   (b) P – Se or S – As
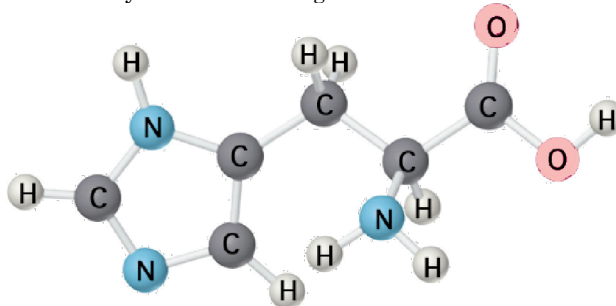
4. (3 pts) From the following list, circle all substances that are primarily ionic.

   NH_4NO_3 Li_2O SO_3 K_2SO_3

   $CaCl_2$ IF_5 CH_4 H_2O_2
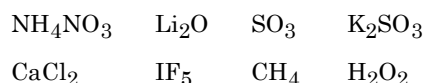
5. (1 pts) What does the following diagram represent?
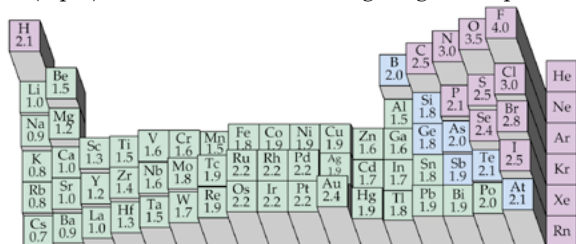
6. (2 pts) Add double bonds and electron pair groups as necessary for the following structure of histidine.

6(b) (1 pts) Referring to the picture of the histidine molecule, what is the hybridization of the carbon atom bonded to the two oxygen atoms?

6(c) (1 pts) Circle the sp^3 carbon atom(s) in the drawing.

7. (2 pts) Ozone, O_3, and sulfur dioxide have the same structure. Sketch the Lewis dot structure for ozone.

7(b) (1 pt) To your structure of ozone, assign formal charges.

7(c) (1 pt) To your structure, label the hybridization for each atom.

7(d) (1 pt) Does the molecule possess resonance? Circle: YES or NO

7(e) (1 pt) Estimate the bond angle for ozone.

8 (6 pts) Matching. Use the spaces provided in the following table to show whatever work you think is necessary to complete the matching that follows. (Suggest you draw Lewis structure and write ABE formula, however your drawings will not be graded.) Then match the structure with the geometry.

(A) CO_2	(B) SCl_2

(C) SO_3	(D) NH_4^+
(E) PH_3	(F) PF_5
(G) PF_6^-	(H) IF_5

Match the structures above with the descriptions below. Enter "A", "B" etc. Each used ONCE.
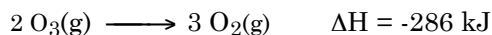
_____	1. octahedral
_____	2. linear
_____	3. tetrahedral
_____	4. trigonal pyramid
_____	5. square pyramid
_____	6. bent
_____	7. trigonal plane
_____	8. trigonal bipyramid

9. (3 pts) Inspect the hybridization drawing for C_2H_4.
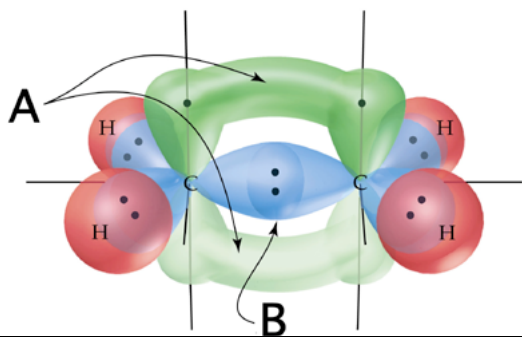
| |
|---|
| 9(a) What is the hybridization on the C atoms? |
| 9(b) Which bond is a π-bond? Circle: "A" or "B" |
| 9(c) What is the carbon—carbon bond order? |

10. Consider the reaction:

$$2\,O_3(g) \longrightarrow 3\,O_2(g) \qquad \Delta H = -286\ kJ$$

10(a) (1 pt) The reaction is [exothermic/endothermic]

10(b) (3 pts) Calculate q if 25 g ozone is converted into oxygen. *(continued next column)*

11. (3 pts) Sulfur trioxide reacts instantaneously with water to produce sulfuric acid. When 3.0 g sulfur trioxide is reacted with 100.0 g water in a coffee cup calorimeter, the temperature of the water rises from 25.0 °C to 41.6 °C. What is ΔH for the reaction as given below? You may assume that the solution has the same specific heat as pure water. [Given: specific heat of water is 4.184 J/g deg.]
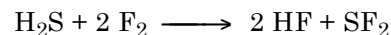
$$SO_3(g) + H_2O(l) \longrightarrow H_2SO_4(aq) \qquad \Delta H = ?$$
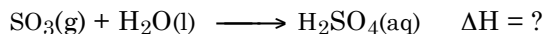
12. (3 pts) Calculate ΔH_{rxn} for the following reaction [Given: ΔH_f(kJ/mol): Ca_3P_2 = -504; $H_2O(l)$ = -286 CaO = -636; PH_3 = +5.4]

$$Ca_3P_2(s) + 2\,H_2O(l) \longrightarrow 3\,CaO(aq) + 2\,PH_3(g)$$
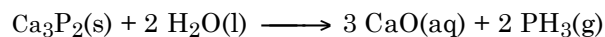
13. (3 pts) Estimate ΔH for this gas-phase reaction using bond energies.

kJ/mol	H	S	F
H	436	340	570
S	340	225	310
F	570	310	159

$$H_2S + 2\,F_2 \longrightarrow 2\,HF + SF_2$$

14. (1 point) Print your name here:

1. T T T F T

2. C I B I I N

3.
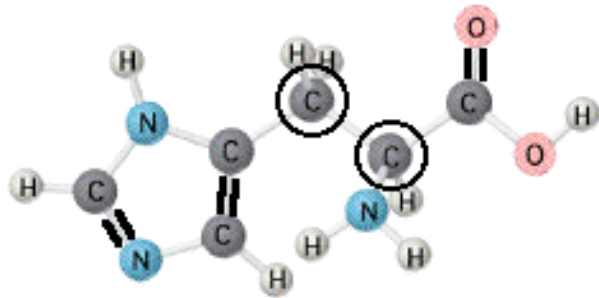(a) B – O   (b) S – As

4. NH_4NO_3 Li_2O K_2SO_3 $CaCl_2$

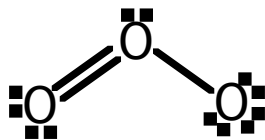5. periodic trends in electronegativity

6. (2 pts)

6(b) sp^2

6(c) see figure

7.

7(b) left O: 0
central O: +1
right O: -1
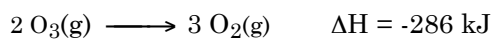
7(c) left O: sp^2
central O: sp^2
right O: sp^3

7(d) YES

7(e) < 120 degrees

8. G A D E H B C F

9. a. sp^2; b. A, c. 2

10. Consider the reaction:

2 O_3(g) $\longrightarrow$ 3 O_2(g)   ΔH = -286 kJ

10(a) exothermic

10(b) Calculate q = -74 kJ

11. ΔH = -191 kJ

12. ΔH_{rxn} = -821 kJ
13. ΔH = -762