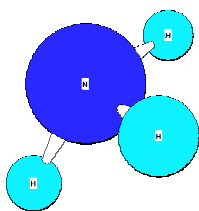


Sample Exam Three CHM 2045C

I. General Knowledge:

- The energy of sublimation is used to describe what physical process?
Conversion of a solid directly to a gas Write the equation using CO_2 as the substance $\text{CO}_{2(s)} \rightarrow \text{CO}_{2(g)}$
- Write the equation that demonstrates the second ionization of Ca. $\text{Ca}^+_{(g)} \rightarrow \text{Ca}^{+2}_{(g)} + e^-$
- As you read from left to right in a period, the ionization energy (**increases, decreases, or stays the same**). This is due to (**increased or decreased**) values of (**shielding or effective nuclear charge**)
- The cation of a metal is (**larger or smaller**) than its atomic state. This is because of reduced shielding, and often loss of one energy level
- (**True or False**) Lattice energy is the formation of gaseous ions from an ionic solid.
- Consider the structure shown at left. What is the hybridization on the central atom? sp^3
- (**True or False**) In resonance structures, atoms are rearranged to give the lowest formal charges. Only electron pairs are moved
- List the elements that usually do not obey the octet rule. H, He, and B
- Bond dissociation energies are average values in the chart. Explain why this is so. Bond strength varies with the electronegativities of other atoms
- A bond is polar if there is a difference in electronegativities. How would the polarity of an ionic bond compare to that of a covalent bond? Ionic Bonds are extremely polar. (difference in electronegativity > 2 units)
- When a reaction is temperature controlled, what condition exists. ΔH & ΔS have the same sign
- What defines a reaction's spontaneity? If the free energy is < 0



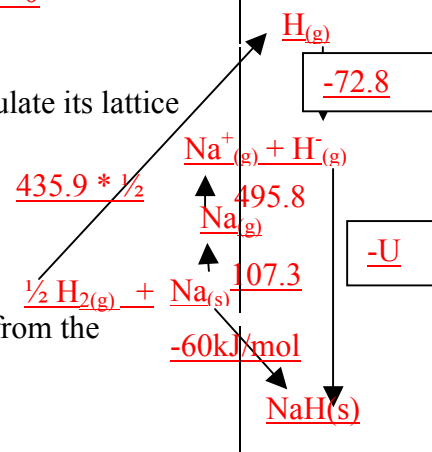
II. Born-Haber energetics $\text{Na}_{(s)} + \frac{1}{2} \text{H}_{2(g)} \rightarrow \text{NaH(s)}$

- Draw the Born Haber cycle for NaH, so that you can calculate its lattice energy:

- E_{ea} for H = -72.8 kJ/mol
- $E_{i,1}$ for Na = 495.8 kJ/mol
- $\Delta H_{\text{sublimation}}$ for Na = 107.3 kJ/mol
- D-D for H_2 = 435.9 kJ/mol
- $\Delta H_{\text{reaction}}$ for the reaction in which NaH is formed from the elements in their standard states: = -60 kJ/mol

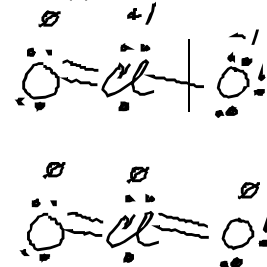
$$(435.9 * \frac{1}{2}) + 107.3 + 495.8 - 72.8 - U = -60$$

$$U = 808.3 \text{ kJ}$$

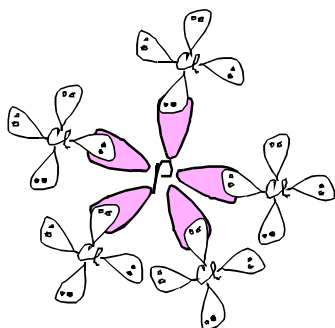


II. Lewis structures, VSEPR theory, hybridization, resonance and formal charges

- Free radical structures are those in which there is an unpaired electron. They are usually not stable. Consider the molecule ClO_2 . Draw the Lewis structure(s) and determine the formal charges on each atom.

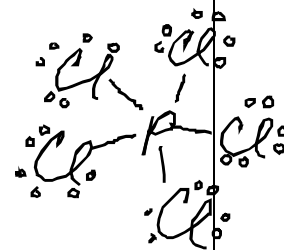


2. PCl_5 is a common expanded octet molecule. Draw its lewis structure, determine its geometry, and draw its valence bond hybrid structure.

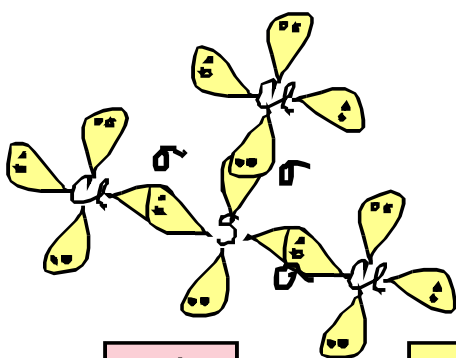


$3sp^3d$

sp^3

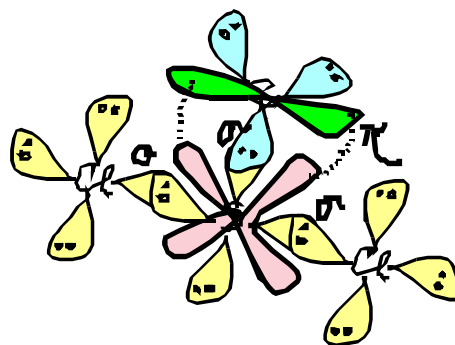


3. SOCl_2 has at least 2 resonance structures. Draw 2, and indicate that which is better. Explain your decision. Draw the hybridization diagram. Label all bonds according to whether they are sigma or pi type. The best is at right. Has zero formal charges on all atoms



d

sp^3



sp^2

p

III. Thermochemistry:

for the process: $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$

1. Calculate $\Delta H^0_{\text{reaction}}$, $\Delta S^0_{\text{reaction}}$, ΔG^0 at 25°C .

$$\Delta H^0_{\text{reaction}} = [1(-393.5) + 1(-635.1)] - [1(-1206.9)] = 178.3 \text{ kJ}$$

$$\Delta S^0_{\text{reaction}} = [1(213.6) + 1(39.7160.4)] - [1(92.9)] = 160.4 \text{ J/K}$$

$$\Delta G^0_{\text{reaction}} = 178.3 \text{ kJ} - (298.15 \text{ K}) * (.1604 \text{ kJ/K}) = 226.12 \text{ kJ}$$

2. Is the reaction spontaneous at this temperature? No. The Free energy > 0

4. Write the reaction that is associated with the $\Delta H^0_{\text{formation}}$ of $\text{CaCO}_3(\text{s})$



5. What quantity of heat is associated with the decomposition of 22g of CaCO_3 ?

$$(22 \text{g CaCO}_3) * (1 \text{ mol CaCO}_3 / 100.09 \text{g}) * (178.5 \text{ kJ/mol CaCO}_3) = +39.27 \text{ kJ}$$

6. Is this reaction exothermic or endothermic? Explain your answer. It is

endothermic. $\Delta H^0_{\text{reaction}} > 0$

7. $\text{C}_3\text{H}_8(\text{g}) + 5\text{O}_2(\text{g}) \rightarrow 3\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{g})$

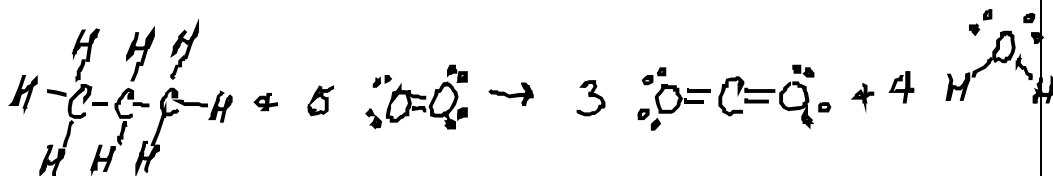
In gas phase reactions involving covalent molecules, the reaction enthalpy may be estimated using Bond dissociation energies. For this reaction, the enthalpy of the reaction is -2043 kJ/mol C_3H_8 combusted.

Given the following Dissociation energies (kJ/mol bond), find the dissociation energy of the C=O bond.

C-H 410 C-C 350 H-O 460 O=O 498

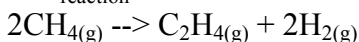
$$-2043 \text{ kJ} = \text{bonds broken} - \text{bonds made} = [8(410) + 2(350) + 5(498)] - [6(\text{C}=\text{O}) + 8(460)]$$

$$-12543 = -6(\text{C}=\text{O}); \text{ C}=\text{O} \text{ Dissociation energy} = 805.5 \text{ kJ}$$

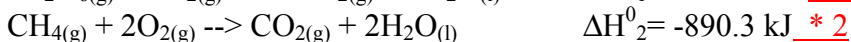
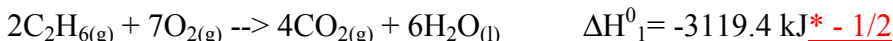


8. Hess's Law can be used to calculate reaction enthalpies for hypothetical processes that can't be carried out in the laboratory. Set up a Hess's Law cycle that will let you calculate

$\Delta H^0_{\text{reaction}}$ for the conversion of methane to ethylene:



reactions to use:



$$-1559.5 = \text{reaction energy}$$

9. When 0.187 g of benzene, C_6H_6 is burned in a bomb calorimeter, the surrounding water bath rises in temperature by 7.48°C . Assuming that the bath contains 250.0 g water

and that the calorimeter itself absorbs a negligible amount of heat, calculate the combustion enthalpy for benzene in kJ/mol. $C_6H_6(l) + 15/2 O_2(g) \rightarrow 6CO_2(g) + 3H_2O(l)$
 $Q_{rxn} + q_{surr} + q_{cal} = 0$ $Q_{rxn} = -q_{surr} = 7.48 * 250.0g * 4.18J/gC = -7816 J = -7.816kJ$
 $.187g \text{ Benzene} * (1mol/78.11g \text{ benzene}) = .002384mol$; $-7.816kJ / .002394mol = -3265 kJ/mol$
since only one mole benzene is used in the reaction, 1mol Benzene(-3265kJ/molbenzene)=-3265kJ/mol reaction

Short answer: Explain how a bomb calorimeter differs from coffee cup calorimeter. Include the quantities measured, and the specific application for which it is appropriate. Ccc used when no work occurs (no change in the number of moles of gas present. Since no work is present, the volume is constant and the pressure is constant. $Q = \Delta H = E$ Bomb calorimeter, however, is used when there would be work. By maintaining a constant volume, the work is converted to excess heat. Thus measure E, a combination of ΔH and work.

