Name: _____

Quiz #8

CHEM 1411 — Spring 2019

Due Thursday, March 21 by 8:00 am

Late papers will not be accepted!

There is no clearer manifestation of pure evil than teachers giving assignments over holiday breaks. — *James Halloran*

Energy Changes

1. Change in energy: (10 pts)

a. Calculate the energy change, ΔE, when q = -47 kJ and w = +88 kJ.

b. Calculate the energy change, ΔE, when the system releases 125 kJ of heat while 104 kJ of work is done on the system.

Thermochemical Equations

2. When aluminum oxide, Al_2O_3, is heated to high temperatures, it decomposes to produce aluminum metal by the following thermochemical equation: (10 pts)

$$2Al_2O_3(s) \rightarrow 4Al(s) + 3O_2(g); \Delta H^\circ = +3352 \text{ kJ}$$

a. If 100.0 g of Al_2O_3 is to be decomposed, how much heat energy will be required?

b. How many grams of aluminum will be produced if 1680 kJ of heat energy is used?

3. The reaction $2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$ has $\Delta H° = -821.8$ kJ. What is the enthalpy change for the reactions shown below? (10 pts)

a. $Na(s) + \frac{1}{2}Cl_2(g) \rightarrow NaCl(s)$ _____

b. $4NaCl(s) \rightarrow 4Na(s) + 2Cl_2(g)$ _____

c. $NaCl(s) \rightarrow Na(s) + \frac{1}{2}Cl_2(g)$ _____

d. $6Na(s) + 3Cl_2(g) \rightarrow 6NaCl(s)$ _____

4. Write a **thermochemical equation** to represent the standard enthalpy of formation ($\Delta H_f°$) for the formation of NO(g) from its elements under standard conditions; this reaction absorbs 90.29 kJ of energy per mole of NO formed. (10 pts.)

5. Identify which of the reactions below has a value of $\Delta H°$ that corresponds to the enthalpy of formation, $\Delta H_f°$? (State "yes" if it does correspond to $\Delta H_f°$ and "no" if it does not.) (10 pts.)

a. $NO(l) + \frac{1}{2}O_2(g) \rightarrow NO_2(g)$ _____

b. $\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$ _____

c. $2H(g) + O(g) \rightarrow H_2O(l)$ _____

d. $2Fe(s) + \frac{3}{2}O_2(g) \rightarrow Fe_2O_3(s)$ _____

e. $6C(g) + 3H_2(g) \rightarrow C_6H_6(l)$ _____

Hess's Law

6. Use Hess's law to derive the enthalpy of the following reaction: (10 pts.)

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$$

Use the following thermochemical equations:

$$S(s) + O_2(g) \rightarrow SO_2(g); \Delta H° = -297 \text{ kJ}$$

$$SO_3(g) \rightarrow SO_2(g) + \tfrac{1}{2}O_2(g); \Delta H° = +99.0 \text{ kJ}$$

7. Use Hess's law to derive the enthalpy of the following reaction:

$$ClF(g) + F_2(g) \rightarrow ClF_3(g)$$

Use the following thermochemical equations: (10 pts)

$$2ClF(g) + O_2(g) \rightarrow Cl_2O(g) + F_2O(g); \Delta H° = +167.4 \text{ kJ}$$

$$2ClF_3(g) + 2O_2(g) \rightarrow Cl_2O(g) + 3F_2O(g); \Delta H° = +341.4 \text{ kJ}$$

$$2F_2(g) + O_2(g) \rightarrow 2F_2O(g); \Delta H° = -43.4 \text{ kJ}$$

Heats of Reaction

8. Calculate the energy change for the following reaction, using the enthalpies of formation provided below the equation. (10 pts.)

$$SO_2Cl_2(l) + 2H_2O(l) \rightarrow 2HCl(g) + H_2SO_4(l)$$

Substance	ΔH_f^o (kJ/mol)
$SO_2Cl_2(l)$	-394.1
$H_2O(l)$	-285.8
$HCl(g)$	-92.3
$H_2SO_4(l)$	-814.0

9. Calculate the energy change for the following reaction, using the enthalpies of formation provided below the equation. (10 pts)

$$MgO(s) + 2HCl(g) \rightarrow MgCl_2(s) + 2H_2O(l)$$

Substance	ΔH_f^o (kJ/mol)
$MgO(s)$	-601.7
$HCl(g)$	-92.3
$MgCl_2(s)$	-641.6
$H_2O(l)$	-285.8

10. The lunar module (LM) which was used to land on the surface of the moon during the *Apollo* missions used a mixture of hydrazine, N_2H_4, and nitrogen tetroxide, N_2O_4, as a fuel source. Calculate the energy change for the reaction of hydrazine with nitrogen tetroxide, shown below, using the enthalpies of formation provided below each compound. (10 pts)

$$2N_2H_4(l) + N_2O_4(l) \rightarrow 3N_2(g) + 4H_2O(g)$$

Substance	ΔH_f^o (kJ/mol)
$N_2H_4(l)$	+50.6
$N_2O_4(l)$	-19.4
$N_2(g)$	0
$H_2O(g)$	-241.8