Northern Arizona University **Quiz #5**
CHM 151, General Chemistry I Dr. Brandon Cruickshank
Section 4, Fall 2005 October 12, 2005

Name _____

1. In the CHM 151 lab, you are given a 25.00 mL sample of phosphoric acid, $H_3PO_4(aq)$, of unknown concentration. Your assignment is to determine the concentration of the phosphoric acid by titrating it with a 0.1015 *M* sodium hydroxide, NaOH(*aq*), solution. You use phenolphthalein as an indicator, and it takes 19.57 mL of sodium hydroxide to titrate to the end point of the titration. What is the **molarity** of the phosphoric acid solution? [5 pts]

$$H_3PO_4\,(aq) + 3\,NaOH\,(aq) \rightarrow 3\,H_2O\,(l) + Na_3PO_4\,(aq)$$

$$\frac{0.1015\text{ mol NaOH}}{1\text{ L}} \times 0.01957\text{ L} = 0.001986\text{ mol NaOH}$$

$$0.001986\text{ mol NaOH} \times \frac{1\text{ mol } H_3PO_4}{3\text{ mol NaOH}} = 6.620 \times 10^{-4}\text{ mol } H_3PO_4$$

$$M_{H_3PO_4} = \frac{\text{mol } H_3PO_4}{\text{L soln}} = \frac{6.620 \times 10^{-4}\text{ mol } H_3PO_4}{0.02500\text{ L}} = \mathbf{0.02648\ \textit{M}}$$

2. Given the three statements below, which answer is **correct**? [3 pts]

(1) In an endothermic reaction, heat is transferred from the surroundings to the system.
(2) The sign of ΔH for an endothermic reaction is positive.
(3) An exothermic reaction releases heat.

a) 1 and 2 are true, 3 is false
b) 1 and 3 are true, 2 is false
c) 1, 2, and 3 are true
d) 1, 2, and 3 are false
e) 2 and 3 are true, 1 is false

3. **True or False** [2 pts each]

a) Temperature is the transfer of thermal energy between two bodies at different temperatures.

FALSE, heat is the transfer of thermal energy between two bodies at different temperatures.

b) The universe is composed of the surroundings and the system.

TRUE

c) Enthalpy is a measure of the heat flow in chemical changes at constant volume.

FALSE, enthalpy is a measure of the heat flow in chemical changes at constant **pressure**.

4. Pentaborane-9, B_5H_9, is a colorless, highly reactive liquid that will burst into flame or even explode when exposed to oxygen. The reaction is

$$2\,B_5H_9\,(l) + 12\,O_2\,(g) \rightarrow 5\,B_2O_3\,(s) + 9\,H_2O\,(l) \qquad \Delta H = -9036.6\text{ kJ}$$

Calculate $\boldsymbol{\Delta H^\circ}$ for the above process when a 10.0 g sample of B_5H_9 is burned at constant pressure. [4 pts]

$$10.0\text{ g } B_5H_9 \times \frac{1\text{ mol } B_5H_9}{63.12\text{ g } B_5H_9} = 0.1584\text{ mol } B_5H_9$$

$$0.1584\text{ mol } B_5H_9 \times \frac{-9036.6\text{ kJ}}{2\text{ mol } B_5H_9} = \mathbf{-715.7\text{ kJ}}$$

5. Consider the following reaction. What is the standard enthalpy of formation, ΔH_f°, of CO(*g*)? [2 pts]

$$2\ C\ (s) + O_2\ (g) \rightarrow 2\ CO\ (g) \qquad \Delta H^\circ = -221\ kJ$$

The standard enthalpy of formation is the enthalpy change when **one** mole of a compound is formed from its elements. The above reaction represents the formation of **two** moles of a compound from its elements.

$$\Delta H_f^\circ(CO) = \frac{-221\ kJ}{2\ mol} = \mathbf{-110.5\ kJ/mol}$$

6. Use the data given below to calculate the ***standard enthalpy change***, $\boldsymbol{\Delta H^\circ_{rxn}}$, for the following reaction: [4 pts]

$$Fe_2O_3\ (s) + 6\ HCl\ (g) \rightarrow 2\ FeCl_3\ (s) + 3\ H_2O\ (g)$$

$\Delta H_f^\circ\ [HCl(g)] = -92.3$ kJ/mol $\Delta H_f^\circ\ [FeCl_2(s)] = -341.8$ kJ/mol $\Delta H_f^\circ\ [Fe_2O_3(s)] = -822.2$ kJ/mol

$\Delta H_f^\circ\ [H_2O(l)] = -285.8$ kJ/mol $\Delta H_f^\circ\ [H_2O(g)] = -241.8$ kJ/mol $\Delta H_f^\circ\ [FeCl_3(s)] = -400.0$ kJ/mol

Circle the correct answer.

a) −281.4 kJ/mol **b) −149.4 kJ/mol** c) −1257 kJ/mol
d) +281.4 kJ/mol e) +149.4 kJ/mol

$\Delta H^\circ_{rxn} = \Sigma n\Delta H_f^\circ(\text{prod.}) - \Sigma n\Delta H_f^\circ(\text{reac.})$

$\Delta H^\circ_{rxn} = [(2)(-400.0\ kJ/mol) + (3)(-241.8\ kJ/mol)] - [(1)(-822.2\ kJ/mol) + (6)(-92.3\ kJ/mol)] = \mathbf{-149.4\ kJ/mol}$

7. Given the following data, [4 pts]

$N_2\ (g) + O_2\ (g) \rightarrow 2\ NO\ (g)$ $\Delta H^\circ_{rxn} = +180.7$ kJ

$2\ NO\ (g) + O_2\ (g) \rightarrow 2\ NO_2\ (g)$ $\Delta H^\circ_{rxn} = -113.1$ kJ

$2\ N_2O\ (g) \rightarrow 2\ N_2\ (g) + O_2\ (g)$ $\Delta H^\circ_{rxn} = -163.2$ kJ

use Hess's law to calculate $\boldsymbol{\Delta H}$ for the reaction:

$N_2O\ (g) + NO_2\ (g) \rightarrow 3\ NO\ (g)$ $\boldsymbol{\Delta H^\circ_{rxn}}$ **= ?**

$N_2O(g) \rightarrow N_2(g) + 1/2O_2(g)$	$\Delta H = \frac{1}{2}(-163.2\ kJ) = -81.6\ kJ$
$NO_2(g) \rightarrow NO(g) + 1/2O_2(g)$	$\Delta H = \frac{1}{2}(+113.1\ kJ) = 56.55\ kJ$
$N_2(g) + O_2(g) \rightarrow 2NO(g)$	$\Delta H = +180.7\ kJ$
$N_2O(g) + NO_2(g) \rightarrow 3NO(g)$	$\boldsymbol{\Delta H} = -81.6\ kJ + 56.55\ kJ + 180.7\ kJ =$ **155.7 kJ**

Potentially Useful Information

$\Delta H^\circ_{rxn} = \Sigma n\Delta H_f^\circ(\text{prod.}) - \Sigma n\Delta H_f^\circ(\text{reac.})$