Northern Arizona University **Quiz #5**
CHM 151, General Chemistry I Dr. Brandon Cruickshank
Section 6, Fall 2008 October 9, 2008

Name (PRINT) **KEY** **(28 points total)**

1. In the CHM 151 lab, you are given a NaOH solution of unknown concentration, and you are asked to find its molar concentration (molarity). You start with 25.00 mL of the NaOH solution and titrate it with 1.500 *M* H_3PO_4. It takes 15.53 mL of H_3PO_4 to reach the equivalence point of the titration. What is the **molarity** of the NaOH solution? [5 pts]

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

$$\text{mol } H_3PO_4 = \frac{1.500\ \text{mol}}{1\ \text{L}} \times (15.53 \times 10^{-3}\ \text{L}) = 0.02330\ \text{mol } H_3PO_4$$

$$\text{mol NaOH} = 0.02330\ \text{mol } H_3PO_4 \times \frac{3\ \text{mol NaOH}}{1\ \text{mol } H_3PO_4} = 0.06990\ \text{mol NaOH}$$

$$M\ (\text{NaOH}) = \frac{\text{mol}}{\text{L}} = \frac{0.06990\ \text{mol NaOH}}{25.00 \times 10^{-3}\ \text{L}} = \mathbf{2.796\ \textit{M}}$$

2. In an endothermic process, heat is transferred from the **surroundings** to the **system**. [2 pts]

3. Which of the following is **exothermic**? [3 pts]

a) Water condenses on a cold pipe * b) Dry ice (CO_2) sublimes (solid → gas)
c) An icicle melts d) Liquid nitrogen boils
e) All of these are exothermic

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

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

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

5. Given the thermochemical equation:

$$2\ SO_2\ (g)\ +\ O_2\ (g)\ \rightarrow\ 2\ SO_3\ (g) \qquad \Delta H^\circ_{rxn} = -198\ \text{kJ}$$

What is the **enthalpy change** ($\Delta H°$) for the decomposition of six moles of SO_3? [3 pts]

$$6\ SO_3\ (g)\ \rightarrow\ 6\ SO_2\ (g)\ +\ 3\ O_2\ (g)$$

$$\frac{+198\ \text{kJ}}{2\ \text{mol } SO_3} \times 6.00\ \text{mol } SO_3 = \mathbf{+594\ kJ}$$

6. From the following heats of combustion,
[4 pts]

$CH_3OH\ (l)\ +\ 3/2\ O_2\ (g)\ \rightarrow\ CO_2\ (g)\ +\ 2\ H_2O\ (l)$ $\qquad \Delta H^\circ_{rxn} = -726.4$ kJ

$C\ (\text{graphite})\ +\ O_2\ (g)\ \rightarrow\ CO_2\ (g)$ $\qquad \Delta H^\circ_{rxn} = -393.5$ kJ

$H_2\ (g)\ +\ 1/2\ O_2\ (g)\ \rightarrow\ H_2O\ (l)$ $\qquad \Delta H^\circ_{rxn} = -285.8$ kJ

calculate the enthalpy of formation of methanol (CH_3OH) from its elements:

$C\ (\text{graphite})\ +\ 2\ H_2\ (g)\ +\ 1/2\ O_2\ (g)\ \rightarrow\ CH_3OH\ (l)$ $\qquad \boldsymbol{\Delta H^\circ_{rxn} = ?}$

$C\ (\text{graphite})\ +\ O_2\ (g)\ \rightarrow\ CO_2\ (g)$	$\Delta H^\circ_{rxn} = -393.5$ kJ
$2\ H_2\ (g)\ +\ O_2\ (g)\ \rightarrow\ 2\ H_2O\ (l)$	$\Delta H^\circ_{rxn} = 2(-285.8\ \text{kJ})$
$CO_2\ (g)\ +\ 2\ H_2O\ (l)\ \rightarrow\ CH_3OH\ (l)\ +\ 3/2\ O_2\ (g)$	$\Delta H^\circ_{rxn} = +726.4$ kJ
$C\ (\text{graphite})\ +\ 2\ H_2\ (g)\ +\ 1/2\ O_2\ (g)\ \rightarrow\ CH_3OH\ (l)$	$\boldsymbol{\Delta H^\circ_{rxn} = -238.7\ \text{kJ}}$

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

$$2\ B_5H_9\ (s)\ +\ 12\ O_2\ (g)\ \rightarrow\ 5\ B_2O_3\ (s)\ +\ 9\ H_2O\ (l)$$

$\Delta H^\circ_f\ [B_2O_3\ (s)] = -1{,}273.5$ kJ/mol, $\Delta H^\circ_f\ [B_5H_9\ (s)] = 73.2$ kJ/mol, $\Delta H^\circ_f\ [H_2O\ (l)] = -285.8$ kJ/mol
Circle the correct answer.

a) -2.55×10^3 kJ **b) $\boldsymbol{-9.09 \times 10^3}$ kJ** c) -3.63×10^4 kJ
d) -1.82×10^4 kJ e) -1.69×10^4 kJ

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

$\Delta H^\circ_{rxn} = (5\ \text{mol})\Delta H^\circ_{rxn}(B_2O_3) + (9\ \text{mol})\Delta H^\circ_{rxn}(H_2O) - [(2\ \text{mol})\Delta H^\circ_{rxn}(B_5H_9) + (12\ \text{mol})\Delta H^\circ_{rxn}(O_2)]$

$\Delta H^\circ_{rxn} = (5\ \text{mol})(-1273.5\ \text{kJ/mol}) + (9\ \text{mol})(-285.8\ \text{kJ/mol}) - [(2\ \text{mol})(73.2\ \text{kJ/mol}) + (12\ \text{mol})(0)]$

$\boldsymbol{\Delta H^\circ_{rxn} = -9.09 \times 10^3\ \text{kJ}}$

8. Given the thermochemical equation:

$$2\ SO_2\ (g)\ +\ O_2\ (g)\ \rightarrow\ 2\ SO_3\ (g) \qquad \Delta H^\circ_{rxn} = -198\ \text{kJ}$$

What is the **enthalpy change** ($\boldsymbol{\Delta H^\circ}$) for the combustion of 640.7 g of SO_2? [4 pts]

$$640.7\ \text{g}\ SO_2 \times \frac{1\ \text{mol}\ SO_2}{64.07\ \text{g}\ SO_2} = 10.00\ \text{mol}\ SO_2$$

$$\frac{-198\ \text{kJ}}{2\ \text{mol}\ SO_2} \times 10.00\ \text{mol}\ SO_2 = \boldsymbol{-990\ \text{kJ}}$$

Potentially Useful Information

$$\text{Molarity} = \frac{\text{moles solute}}{\text{L of solution}} \qquad \Delta H^\circ_{rxn} = \Sigma n \Delta H_f^\circ(\text{prod.}) - \Sigma m \Delta H_f^\circ(\text{reac.})$$

molar masses: Na (22.99 g/mol), O (16.00 g/mol), H (1.008 g/mol), S (32.07 g/mol), P (30.97 g/mol)