# CH 05 AK

**Section 5.1:**

1. Identify the kind of energy change usually associated with each of the following:

(a) Toaster-**electric energy to heat**
(b) Radio-**electric energy to sound**
(c) Automobile engine-**chemical energy to mechanical energy**
(d) Automobile battery-**chemical energy to electric energy (and visa versa)**
(e) Automobile generator-**kinetic energy to electric energy**
(f) Model airplane engine-**chemical energy to electric energy, then potential energy**
(g) Friction-**mechanical energy to heat**
**(h)** Ski jump: **potential energy to kinetic energy**
(i) Fluorescent lamp=**electric energy to light**
(j) Photoelectric cell-**light to electric energy**
(k) Furnace-**chemical energy to heat**

2. Distinguish between a change of state and a phase change. Give an example of each.

Phase can be defined as matter having the same physical properties and is uniform. When matter changes phase, the physical properties change ( density is an example of this). Phase changes occur at specific temperatures and pressures. A state is more general. In a state of matter, the material has defined values such as pressure and temperature, but when a change occurs, it does not necessarily changes phase. Also, the change of state is independent of the path to get to the final product.

**Section 5.2: & 5.3**

3. **(6 points)** For the following processes determine whether the process is endothermic or exothermic:

   a. A piston is heated by adding 51 kJ of heat. It expands, doing 15 kJ of work on the atmosphere.

   **+51 kJ + –15 kJ =+36 kJ**

   b. A system releases 125 kJ of heat while 104kJ of work is done on it.

   **–125kJ + +104kJ = –21 kJ**

   c. A chemical reaction releases 5.75 kJ of heat and does no work on the surroundings.

   **–5.75kJ**

| | ΔE | Endo thermic | Exo thermic |
|---|---|---|---|
| A | +36kJ | X | |
| B | –21kJ | | X |
| C | -5.75 kJ | | x |

4. **(6 points)** For the following processes determine whether the process is endothermic or exothermic:

   a. A balloon is heated by adding 240J of heat. It expands, doing 135J of work on the atmosphere. **Endo thermic**

   **+240kJ+ –135Kj = 105 kJ [1.1x$10^2$kJ]**

   b. A 50-g sample of iron metal is cooled from 100 °C to 90°C, thereby losing approximately 225 J of heat. **For this one, you don't need to do the math, the system is cooling, losing energy. The final temperature is lower than the initial temperature. This is an exothermic process.**

   c. A chemical reaction releases 5.75 kJ of heat and does no work on the surroundings.

**See above, but this is an exthermic process because heat is released by the reaction and no work is being done on the system or by the system**

**Section 5.4:**

5. Deterioration of buildings, bridges, and other structures through iron rusting costs millions of dollars a day. The actual process requires water, but a simplified equation is

$$4Fe_{(s)} + 3O_{2(g)} \rightarrow 2Fe_2O_{3(s)} \qquad \Delta H = —1.65\text{x}10^3\text{kJ}$$

   a) How much heat is released when 0.250 kg of iron rusts?

| | | | | |
|---|---|---|---|---|
| **0.250 kg Fe** | **1000 g Fe** | **1 mol Fe** | **—1.65x$10^3$kJ** | **–1.85x$10^3$kJ** |
| | **1 kg** | **55.845 g Fe** | **4 mol Fe** | |

   b) How much rust forms when 4.85 x 103 kJ of heat is released?

| | | | |
|---|---|---|---|
| **–4.85 x $10^3$ kJ** | **2 mol$Fe_2O_{3(s)}$** | **159.68 g $Fe_2O_{3(s)}$** | **939g $Fe_2O_{3(s)}$** |
| | **—1.65x$10^3$kJ** | **1 mol $Fe_2O_{3(s)}$** | |

6. **(4 points)** Benzene is an organic liquid that easily combusts in the presence of oxygen. The value of ΔH for the following reaction is -6535kJ. How many kJ of heat will be evolved during the combustion of 16.0 g of $C_6H_{6(l)}$?

$$2C_6H_{6(l)} + 15O_{2(g)} \rightarrow 12CO_{2(g)} + 6\ H_2O_{(l}$$

| | | | |
|---|---|---|---|
| 16.0 g $C_6H_{6(l)}$ | **1 mol** $C_6H_{6(l)}$ | –6535kJ | **–670. kJ** |
| | **78.08 g** $C_6H_{6(l)}$ | 2 mol $C_6H_{6(l))}$ | |

**Section 5.5:**

7. **(combines with 11.4) (5 points)** What is the quantity of heat (in joules) needed to raise the temperature of 454 g of tin from room temperature (25.0°C) to its melting point, 231.9°C, and then melt the tin to form liquid tin? The Cp tin= 0.277J/g-K and the ΔHfus tin = 59.2J/g.

**q(total) = q warm to melting point + q to melt**

**q(total) = Cp(tin)(mass tin)(ΔT tin) + $\Delta H_{fus}$ •mass tin**

**=0.277J/gK(454g)(231.9°C–25°C) + 59.2J/g (454 g) = 52, 896J, 53.0 kJ**

8. **(6 points)** A 20.0 g piece of metal at 100.0 °C is placed in a calorimeter containing 50.7 g of water at 22.0 °C the final temperature of the mixture is 25.7 °C. What is the specific heat capacity of the metal?

**q(Cal) = –q(metal)**

**Cp water x mass water x ΔT water =– Cp metal x mass metal x ΔT metal**

$$\textbf{Cp metal} = \frac{\textbf{Cp water x mass water x } \Delta \textbf{T water}}{-\textbf{ mass metal x } \Delta \textbf{T metal}}$$

$$\textbf{Cp metal} = \frac{\textbf{4.184J/g°C x 50.7 g water x (25.7°C–22.0°C)}}{\textbf{–(20.0 g metal x (25.7°C–100.0°C))}} = \textbf{0.81J/g°C}$$

9. **(8 points)** The Quinone, $C_6H_4O_2$, is burned completely in oxygen in a bomb calorimeter. Burning a 0.1964-g sample caused the temperature of the calorimeter to rise 3.200°C. The heat capacity of the calorimeter and its contents (the bomb and the water) is 1.56kJ/C. Calculate the ΔH (kJ/g of Quinone) for the combustion reaction of Quinone

$$C_6H_4O_{2s)} + 6O_{2(g)} \rightarrow 6CO_{2(g)} + 2H_2O_{(l)}$$

– q(process) = q calorimeter

$C_v\Delta T$ = 1.56kJ/°C x 3.200°C = 4.992kJ

ΔH = –4.922 kJ/0.1946 g quinone = –25.65 kJ/g quinone. However, since the $C_v$ has 3 sf, actual answer is –25.7 kJ/g quinone.

10. **(6 points)** The sugar arabinose, $C_5H_{10}O_5$, is burned completely in oxygen in a bomb calorimeter. Burning a 0.548-g sample caused the temperature of the calorimeter to rise from 20.00°C to 20.54°C. The heat capacity of the calorimeter and its contents (the bomb and the water) is 15.8kJ/C. Calculate the ΔH (kJ/mole arabinose) for the combustion reaction per mole of arabinose.

$$C_5H_{10}O_{5(s)} + 5O_{2(g)} \rightarrow 5CO_{2(g)} + 5H_2O_{(l)}$$

$C_v\Delta T$ = 15.8kJ/°C x 0.54°C = 8.532 kJ

**$\Delta H$ = –8.532 kJ/0.548 g arabinose = 15.57 kJ/g arabinose. However, since the $\Delta T$ 2 sf, actual answer is –15.6 kJ/g arabinose.**

**Section 5.6:**

11. **(5 points)** From the following enthalpies of reaction (2 equations) listed below, calculate the $\Delta$Hrxn for the reaction of sulfur with oxygen gas:

$$S_{(s)} + O_{2(g)} \rightarrow SO_{2\,(g)}$$

$2\,SO_{2\,(g)} + O_{2(g)} \rightarrow 2\,SO_{3(g)}$ $\Delta H$ = -196 kJ

$2\,S_{(s)} + 3\,O_{2(g)} \rightarrow 2\,SO_{3(g)}$ $\Delta H$ = -790 kJ

**ANSWER**

**$SO_{2\,(g)} \rightarrow SO_3 + \frac{1}{2}\,O_{2(g)}$ $\Delta H$ = +196 kJ/2**

**$S_{(s)} + 3/2\,O_{2(g)} \rightarrow 1\,SO_{3(g)}$ $\Delta H$ = -790 kJ/2**

**–297 kJ**

12. **(6 points)** What is the $\Delta H_{RXN}$ at constant pressure for the reaction of interest?

Reaction of interest: $ClF_{(g)} + F_{2(g)} \rightarrow ClF_{3(g)}$

Pathway reactions:

Equation 1: $2ClF_{3(g)} + 2\,O_{2(g)} \rightarrow Cl_2O_{(g)} + 3F_2O_{(g)}$ $\Delta$Hrxn = 341.4 kJ/mol

Equation 2: $F_{2(g)} + 1/2\,O_{2(g)} \rightarrow F_2O_{(g)}$ $\Delta$Hrxn = –21.8 kJ/mol

Equation 3: $2\,ClF_{(g)} + O_{2(g)} \rightarrow Cl_2O_{(g)} + F_2O_{(g)}$ $\Delta$Hrxn = + 167.4 kJ/mol

**ANSWER**

~~$\frac{1}{2}\,Cl_2O_{(g)}$~~ + ~~$\frac{1}{2} \cdot 3F_2O_{(g)}$~~ $\rightarrow \frac{1}{2} \cdot 2ClF_{3(g)}$ + ~~$\frac{1}{2} \cdot 2\,O_{2(g)}$~~ –341.4/2

$F_{2(g)}$ + ~~$\frac{1}{2}\,O_{2(g)}$~~ $\rightarrow$ ~~$F_2O_{(g)}$~~ –21.8kJ

$\frac{1}{2} \cdot 2\,ClF_{(g)}$ + ~~$\frac{1}{2}O_{2(g)}$~~ $\rightarrow$ ~~$\frac{1}{2}Cl_2O_{(g)}$~~ + ~~$\frac{1}{2}F_2O_{(g)}$~~- 167.4/2

**$\Delta H$ for the process is –108.8 kJ**

**Section 5.7:**

13. **(5 points)** Calculate the $\Delta H^{\circ}_{rxn}$ for the reaction of

$$3NO_{2(g)} + H_2O_{(l)} \rightarrow 2HNO_{3(aq)} + NO_{(g)}.$$

Heats of formation for the compounds are: $\Delta H^{\circ} f_{NO2(g)}$ =33.84 kJ/mol, $\Delta H^{\circ} f_{H2O(l)}$=-285.83 kJ/mol, $\Delta H^{\circ} f_{HNO3(aq)}$= -206.6 kJ/mol, $\Delta H^{\circ} f_{NO(g)}$=90.37kJ/mol

$$\Delta H_{Rxn} = 3\Delta H_{(HNO3)} + \Delta H_{(NO)} - (3\Delta H_{(NO2)} + \Delta H_{(H2O)}$$

2 mole (–206.6 kJ/mol) + 1 mole (90.37 kJ/mol) – [3 mol (33.84 kJ/mol) +1 mol(–285.83 kJ/mol)]

$\Delta H_{Rxn}$=**–138.52kJ**

14. Styrene is an organic liquid that easily combusts in the presence of oxygen. The $\Delta H°_{rxn}$ for the following reaction is —4395.0kJ. Using the standard heats of formation listed on the formula page, calculate the heat of formation ($\Delta H°_f$) for styrene,$C_8H_{8(l)}$?

$$\mathbf{C_8H_{8(l)} + 10O_{2(g)} \rightarrow 8CO_{2(g)} + 4\ H_2O_{(l)}}$$

$$\mathbf{\Delta H_{\ rxn} = \Delta H\ products - \Delta H\ reactants}$$

$$\mathbf{\Delta H_{\ rxn} = 4\Delta H_{H2O} + 8\Delta H_{CO2} - \Delta H_{styrene}}$$

$$\mathbf{-4395.0kJ - 4\ mol(-285.83\ kJ/mol) - 8\ mol\ (-393.5\ kJ/mol) = 1\ mole\ x\ -\Delta H°\ styrene}$$

$$\mathbf{\Delta H°_{(styrene)} - 103.7\ kJ/mol}$$

15. **(6 points)** Aspartame is a white crystalline solid that was discovered in 1963 by accident in the lab. A careless chemist licked his dirty fingers and tasted sweetness. Aspartame has a molecular formula of $C_{14}H_{18}N_2O_{5(s)}$. Write the equation for the standard enthalpy of formation for 1 mole of aspartame. Include all phases, correct formulas, and coefficients.

$$\mathbf{14C_{(s)} + 9H_{2(g)} + N_{2(g)} + 5/2\ O_{2(g)} \rightarrow C_{14}H_{18}N_2O_{5(s)}.}$$