

# CH 05 AK

## Section 5.1:

- Identify the kind of energy change usually associated with each of the following:
  - Toaster-**electric energy to heat**
  - Radio-**electric energy to sound**
  - Automobile engine-**chemical energy to mechanical energy**
  - Automobile battery-**chemical energy to electric energy (and visa versa)**
  - Automobile generator-**kinetic energy to electric energy**
  - Model airplane engine-**chemical energy to electric energy, then potential energy**
  - Friction-**mechanical energy to heat**
  - Ski jump: **potential energy to kinetic energy**
  - Fluorescent lamp=**electric energy to light**
  - Photoelectric cell-**light to electric energy**
  - 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

- (6 points) For the following processes determine whether the process is endothermic or exothermic:
  - A piston is heated by adding 51 kJ of heat. It expands, doing 15 kJ of work on the atmosphere.  

$$+51 \text{ kJ} + -15 \text{ kJ} = +36 \text{ kJ}$$
  - A system releases 125 kJ of heat while 104kJ of work is done on it.  

$$-125 \text{ kJ} + +104 \text{ kJ} = -21 \text{ kJ}$$
  - A chemical reaction releases 5.75 kJ of heat and does no work on the surroundings.

$$-5.75 \text{ kJ}$$

	$\Delta E$	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**

$$+240\text{kJ} + -135\text{kJ} = 105 \text{ kJ } [1.1 \times 10^2 \text{kJ}]$$

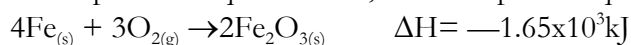
- b. A 50-g sample of iron metal is cooled from 100 °C to 90°C, thereby losing approximately 225 J of heat. **For this one, you don't need to do the math, the system is cooling, losing energy. The final temperature is lower than the initial temperature. This is an exothermic process.**

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

**See above, but this is an exothermic 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



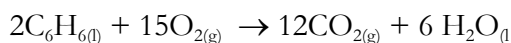
- a) How much heat is released when 0.250 kg of iron rusts?

0.250 kg Fe	1000 g Fe	1 mol Fe	-1.65x10 <sup>3</sup> kJ	-1.85x10 <sup>3</sup> kJ
	1 kg	55.845 g Fe	4 mol Fe	

- b) How much rust forms when 4.85 x 10<sup>3</sup> kJ of heat is released?

-4.85 x 10 <sup>3</sup> kJ	2 mol Fe <sub>2</sub> O <sub>3(s)</sub>	159.68 g Fe <sub>2</sub> O <sub>3(s)</sub>	939g Fe <sub>2</sub> O <sub>3(s)</sub>
	-1.65x10 <sup>3</sup> kJ	1 mol Fe <sub>2</sub> O <sub>3(s)</sub>	

6. **(4 points)** Benzene is an organic liquid that easily combusts in the presence of oxygen. The value of  $\Delta H$  for the following reaction is -6535kJ. How many kJ of heat will be evolved during the combustion of 16.0 g of C<sub>6</sub>H<sub>6(l)</sub>?



16.0 g C <sub>6</sub> H <sub>6(l)</sub>	1 mol C <sub>6</sub> H <sub>6(l)</sub>	-6535kJ	-670. kJ
	78.08 g C <sub>6</sub> H <sub>6(l)</sub>	2 mol C <sub>6</sub> H <sub>6(l)</sub>	

### 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  $C_p$  tin = 0.277J/g-K and the  $\Delta H_{\text{fus}}$  tin = 59.2J/g.

$$q(\text{total}) = q \text{ warm to melting point} + q \text{ to melt}$$

$$q(\text{total}) = C_p(\text{tin})(\text{mass tin})(\Delta T \text{ tin}) + \Delta H_{\text{fus}} \bullet \text{mass tin}$$

$$= 0.277\text{J/gK}(454\text{g})(231.9^\circ\text{C}-25^\circ\text{C}) + 59.2\text{J/g}(454\text{g}) = 52,896\text{J}, 53.0\text{kJ}$$

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?

$$q(\text{Cal}) = -q(\text{metal})$$

$$C_p \text{ water} \times \text{mass water} \times \Delta T \text{ water} = -C_p \text{ metal} \times \text{mass metal} \times \Delta T \text{ metal}$$

$$C_p \text{ metal} =$$

$$C_p \text{ water} \times \text{mass water} \times \Delta T \text{ water}$$

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$$- \text{mass metal} \times \Delta T \text{ metal}$$

$$C_p \text{ metal} =$$

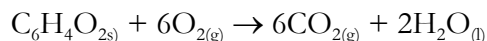
$$4.184\text{J/g}^\circ\text{C} \times 50.7\text{g water} \times (25.7^\circ\text{C}-22.0^\circ\text{C})$$

$$= 0.81\text{J/g}^\circ\text{C}$$

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$$-(20.0\text{g metal} \times (25.7^\circ\text{C}-100.0^\circ\text{C}))$$

9. **(8 points)** The Quinone,  $\text{C}_6\text{H}_4\text{O}_2$ , 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  $\Delta H$  (kJ/g of Quinone) for the combustion reaction of Quinone

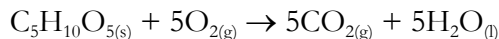


$$-q(\text{process}) = q \text{ calorimeter}$$

$$C_v \Delta T = 1.56\text{kJ/}^\circ\text{C} \times 3.200^\circ\text{C} = 4.992\text{kJ}$$

$\Delta H = -4.922\text{kJ}/0.1946\text{g quinone} = -25.65\text{kJ/g quinone}$ . However, since the  $C_v$  has 3 sf, actual answer is  $-25.7\text{kJ/g quinone}$ .

10. **(6 points)** The sugar arabinose,  $\text{C}_5\text{H}_{10}\text{O}_5$ , 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  $\Delta H$  (kJ/mole arabinose) for the combustion reaction per mole of arabinose.

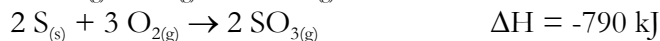
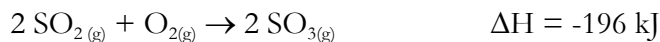
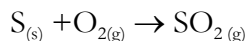


$$C_v \Delta T = 15.8\text{kJ/}^\circ\text{C} \times 0.54^\circ\text{C} = 8.532\text{kJ}$$

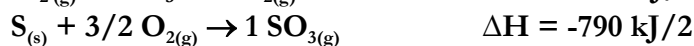
$\Delta H = -8.532 \text{ kJ}/0.548 \text{ g arabinose} = 15.57 \text{ kJ/g arabinose}$ . However, since the  $\Delta T$  2 sf, actual answer is  $-15.6 \text{ kJ/g arabinose}$ .

### Section 5.6:

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



**ANSWER**

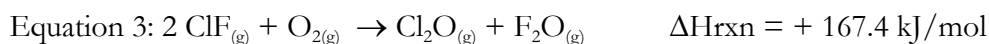
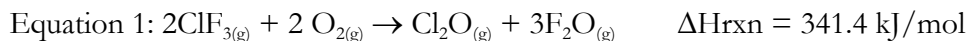


$$-297 \text{ kJ}$$

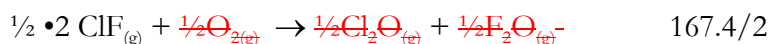
12. **(6 points)** What is the  $\Delta H_{\text{rxn}}$  at constant pressure for the reaction of interest?



Pathway reactions:



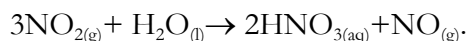
**ANSWER**



$\Delta H$  for the process is  **$-108.8 \text{ kJ}$**

### Section 5.7:

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



Heats of formation for the compounds are:  $\Delta H^\circ_f \text{NO}_{2(g)} = 33.84 \text{ kJ/mol}$ ,  $\Delta H^\circ_f \text{H}_2\text{O}_{(l)} = -285.83 \text{ kJ/mol}$ ,

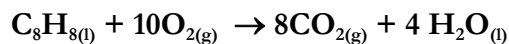
$\Delta H^\circ_f \text{HNO}_{3(aq)} = -206.6 \text{ kJ/mol}$ ,  $\Delta H^\circ_f \text{NO}_{(g)} = 90.37 \text{ kJ/mol}$

$$\Delta H_{\text{rxn}} = 3\Delta H_{(\text{HNO}_3)} + \Delta H_{(\text{NO})} - (3\Delta H_{(\text{NO}_2)} + \Delta H_{(\text{H}_2\text{O})})$$

$$2 \text{ mole } (-206.6 \text{ kJ/mol}) + 1 \text{ mole } (90.37 \text{ kJ/mol}) - [3 \text{ mol } (33.84 \text{ kJ/mol}) + 1 \text{ mol } (-285.83 \text{ kJ/mol})]$$

$$\Delta H_{\text{rxn}} = \mathbf{-138.52 \text{ kJ}}$$

14. Styrene is an organic liquid that easily combusts in the presence of oxygen. The  $\Delta H^\circ_{\text{rxn}}$  for the following reaction is  $-4395.0\text{ kJ}$ . Using the standard heats of formation listed on the formula page, calculate the heat of formation ( $\Delta H^\circ_f$ ) for styrene,  $\text{C}_8\text{H}_{8(l)}$ ?



$$\Delta H_{\text{rxn}} = \Delta H_{\text{products}} - \Delta H_{\text{reactants}}$$

$$\Delta H_{\text{rxn}} = 4\Delta H_{\text{H}_2\text{O}} + 8\Delta H_{\text{CO}_2} - \Delta H_{\text{styrene}}$$

$$-4395.0\text{ kJ} - 4\text{ mol}(-285.83\text{ kJ/mol}) - 8\text{ mol}(-393.5\text{ kJ/mol}) = 1\text{ mole} \times -\Delta H^\circ_{\text{styrene}}$$

$$\Delta H^\circ_{(\text{styrene})} = -103.7\text{ kJ/mol}$$

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  $\text{C}_{14}\text{H}_{18}\text{N}_2\text{O}_5(s)$ . Write the equation for the standard enthalpy of formation for 1 mole of aspartame. Include all phases, correct formulas, and coefficients.

