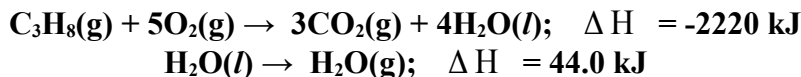


**CHM 110 – Heat – Practice Problems****Solve the problems.**

1) Find the mass of propane ( $C_3H_8$ , FW = 44.09 g/mol) required to heat 1.00 gal (3.78 L) of water from 25.0 °C to 100.0 °C. Then, find the mass of propane required to vaporize the water at 100.0 °C. Assume the density of water at 25.0 °C is 1.00 g/ml.

Complete solution

*This problem is essentially a stoichiometry problem involving heat. First, we calculate the energy requirement for heating the water to 100.0 °C using the formula for specific heat.*

$$Q = m \times C \times \Delta T = (3780 \text{ g}) \times \left(4.184 \frac{\text{J}}{\text{g} \cdot ^\circ\text{C}}\right) \times (100.0^\circ\text{C} - 25.0^\circ\text{C})$$

$$Q = 1186000 \text{ J} = 1186 \text{ kJ}$$

*Now, calculate the mass of propane required to heat the water. Keep in mind that the process is exothermic from the point of view of the propane!*

$$-1186 \text{ kJ} \times \frac{1 \text{ mol } C_3H_8}{-2220 \text{ kJ}} \times \frac{44.09 \text{ g } C_3H_8}{\text{mol } C_3H_8} = 23.55 \text{ g } C_3H_8$$

*So, **23.6 g of  $C_3H_8$**  are required to heat the water to 100.0 °C.*

*Next, we calculate the amount of heat required to boil (vaporize) the same quantity of water.*

$$3780 \text{ g } H_2O \times \frac{\text{mol } H_2O}{18.02 \text{ g } H_2O} \times \frac{44.0 \text{ kJ}}{\text{mol } H_2O} = 9230 \text{ kJ}$$

*Finally, we calculate the amount of propane required to provide this heat - just like we did previously. This process is exothermic from the point of view of the propane!*

$$-9230 \text{ kJ} \times \frac{1 \text{ mol } C_3H_8}{-2220 \text{ kJ}} \times \frac{44.09 \text{ g } C_3H_8}{\text{mol } C_3H_8} = 183.3 \text{ g } C_3H_8$$

***183 g of  $C_3H_8$**  of propane are required to vaporize the water.*

2) Sodium bicarbonate thermally decomposes to form sodium carbonate, water, and carbon dioxide.



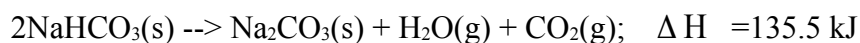
Calculate the enthalpy change of the decomposition of 42.5 g of solid  $\text{NaHCO}_3$ .

Complete solution

*First, find the enthalpy of the reaction as written. Using data tables, look up the heat of formation of each reactant and product, then use Hess's Law to find the enthalpy change of the reaction.*

Substance	$\Delta H_f$ (kJ/mol)
$\text{Na}_2\text{CO}_3(\text{s})$	-1130.8
$\text{H}_2\text{O}(\text{g})$	-241.8
$\text{CO}_2(\text{g})$	-393.5
$\text{NaHCO}_3(\text{s})$	-950.8

$$\Delta H = (1 \times -1130.8 + 1 \times -241.8 + 1 \times -393.5) - (2 \times -950.8) = 135.5 \text{ kJ}$$

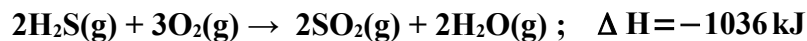


*Now, solve the problem by converting the mass of sodium bicarbonate to moles, then to enthalpy using the thermochemical equation.*

$$42.5 \text{ g NaHCO}_3 \times \frac{1 \text{ mol NaHCO}_3}{84.01 \text{ g NaHCO}_3} \times \frac{135.5 \text{ kJ}}{2 \text{ mol NaHCO}_3} = 34.3 \text{ kJ}$$

$\Delta H = 34.3 \text{ kJ}$  for the decomposition of 42.5 grams of sodium bicarbonate. The process is endothermic.

3) Calculate the enthalpy change for the combustion of 175 L of  $\text{H}_2\text{S}$  gas at  $25^\circ\text{C}$  and 1.00 atm pressure. The thermochemical equation for the process is given below.



### Complete solution

*To solve this problem, you will first have to calculate the number of moles of  $\text{H}_2\text{S}$  burned using the ideal gas equation. Then, you will need to find the enthalpy change using the thermochemical equation.*

*Find the number of moles. Remember to convert temperature to Kelvins.*

$$T = 25 + 273 = 298 \text{ K}$$

$$n = \frac{P \times V}{R \times T}$$

$$n = \frac{(1.00 \text{ atm}) \times (175 \text{ L})}{(0.08208 \frac{\text{L} \cdot \text{atm}}{\text{mol} \cdot \text{K}}) \times (298 \text{ K})} = 7.156 \text{ mol H}_2\text{S}$$

*Find the enthalpy change.*

$$\Delta H = 7.156 \text{ mol H}_2\text{S} \times \frac{-1036 \text{ kJ}}{2 \text{ mol H}_2\text{S}} = -3710 \text{ kJ}$$