

Multi-Step Energy Calculations

Step 1: *Find H° general*

- use Hess's law
- from equation
- use calorimetry

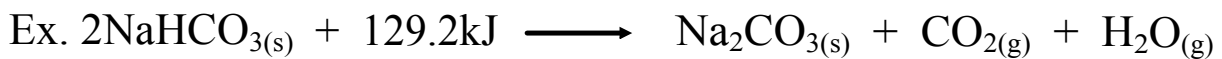
Step 2: *Find n (specific)*

- use mass (molar mass)
- use concentration
- use $n = \Delta H/H^\circ$

Step 3: *Find ΔH (specific)*

- use $\Delta H = nH^\circ$

Sample Problem



What quantity of energy, ΔH_r , is required to decompose 100. kg of $\text{NaHCO}_{3(s)}$?

Step 1: H_r (general)

$$\Delta H_r = n H_r$$

$$H_r = \frac{\Delta H_r}{n} = \frac{129.2 \text{ kJ}}{2 \text{ mol}} = \underline{\underline{64.6 \text{ kJ/mol}}}$$

Step 2: n (specific)

$$100\,000 \text{ g NaHCO}_3 \times \frac{1 \text{ mol NaHCO}_3}{84.01 \text{ g NaHCO}_3} = \underline{\underline{1190.334 \text{ mol}}}$$

Step 3: ΔH_r (specific)

$$\Delta H_r = n H_r$$

$$\Delta H_r = (1190.334 \text{ mol}) \left(64.6 \frac{\text{kJ}}{\text{mol}} \right)$$

$$\Delta H_r = 76\,900 \text{ kJ}$$

Sample Problem



What quantity of energy, ΔH_r , can be obtained from roasting of 50.0kg of zinc sulfide ore?

Step 1: H_r (general)

$$\Delta H_r = \sum n H_{fp} - \sum n H_{fr}$$

$$\Delta H_r = -853.3 \text{ kJ}$$

$$\Delta H_r = n H_r$$

$$(-853.3 \text{ kJ}) = (1 \text{ mol}) H_r$$

$$H_r = \underline{\underline{-853.3 \text{ kJ/mol}}}$$

Step 2: n (specific)

$$50\,000 \text{ g ZnS} \times \frac{1 \text{ mol ZnS}}{97.44 \text{ g ZnS}} = 513.136 \text{ mol ZnS}$$

Step 3: ΔH_r

$$\Delta H_r = n H_r$$

$$\Delta H_r = (513.136 \text{ mol}) \left(-853.3 \frac{\text{kJ}}{\text{mol}} \right)$$

$$\Delta H_r = \underline{\underline{-438\,000 \text{ kJ}}}$$

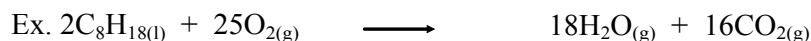
Multi-Step Energy Calculations can be used when energy produced in one chemical reaction is used to heat another substance. These calculations are very similar to calorimetry calculations.

total enthalpy change = quantity of heat

$$\Delta H_r = -q$$

Sample Problem

What mass of octane is completely burned during the heating of 20.L of aqueous ethylene glycol automobile coolant from -10°C to 70°C ? The volumetric heat capacity of aqueous ethylene glycol is $3.7 \text{ kJ/L}^{\circ}\text{C}$.



Step 1: H_r (general)

$$\Delta H_r = \sum n H_{f,p} - \sum n H_{f,r}$$

$$\Delta H_r = \left[(18 \text{ mol}) \left(-241.8 \frac{\text{kJ}}{\text{mol}} \right) + (16 \text{ mol}) \left(-393.5 \frac{\text{kJ}}{\text{mol}} \right) \right] - \left[(2 \text{ mol}) \left(-250.1 \frac{\text{kJ}}{\text{mol}} \right) + (25 \text{ mol}) \left(0 \frac{\text{kJ}}{\text{mol}} \right) \right]$$

$$\Delta H_r = -10148.2 \text{ kJ}$$

$$\Delta H_r = n H_r$$

$$(-10148.2 \text{ kJ}) = (2 \text{ mol}) H_r$$

$$H_r = \underline{\underline{-5074.1 \text{ kJ/mol}}}$$

Step 2: n (specific)

$$\Delta H_r = -q$$

$$n H_r = -v C \Delta T$$

$$n = \frac{-(20. \text{L}) (3.7 \frac{\text{kJ}}{\text{L}^{\circ}\text{C}}) (80. ^{\circ}\text{C})}{-5074.1 \frac{\text{kJ}}{\text{mol}}}$$

$$n = 1.1667 \text{ mol}$$

Step 3: m (specific)

$$1.1667 \text{ mol C}_8\text{H}_{18} \times \frac{114.26 \text{ g C}_8\text{H}_{18}}{1 \text{ mol C}_8\text{H}_{18}} = \boxed{130 \text{ g C}_8\text{H}_{18}}$$

Worksheet #1-5