

## Multi-Step Energy Calculations

Step 1: *Find  $H^\circ$  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  $\Delta H$  (specific)*

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

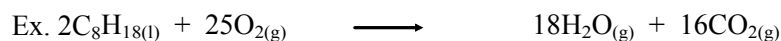
Multi-Step Energy Calculations can be used when energy produced in one chemical reaction is used to heat another substance. These calculations are very similar to calorimetry calculations.

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 -10.0°C to 70.0°C? The volumetric heat capacity of aqueous ethylene glycol is 3.7 kJ/L°C.



Step 1: H<sub>r</sub> (general)

$$H_r = \frac{\Delta H_r}{n}$$

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

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

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

$$\Delta H_r = n H_r$$

$$H_r = \frac{\Delta H_r}{n} = \frac{-10148.2 \text{ kJ}}{2 \text{ mol}} = \underline{\underline{-5074.1 \frac{\text{kJ}}{\text{mol}}}}$$

Step 2: n (specific)

$$\Delta H_r = -q$$

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

$$n \left( -5074.1 \frac{\text{kJ}}{\text{mol}} \right) = - (20. \text{L}) \left( 3.7 \frac{\text{kJ}}{\text{L}^\circ\text{C}} \right) (80.0^\circ\text{C})$$

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

$$M_m = \frac{m}{n}$$

$$\Delta H_r = n H_r$$

$$\Delta H_r = -q$$

Step 3: m (specific)

$$1.1667 \text{ mol} \times \frac{114.26 \text{ g}}{1 \text{ mol}} = \boxed{130 \text{ g}}$$

# Worksheet #1-5