Worksheet

2.c) $3NO_{2(g)} + H_2O_{(l)} \longrightarrow 2HNO_{3(l)} + NO_{(g)}$

$H_r = ?$

$\Delta H_r = ?$

$$\Delta H_r = \sum nH_{fp} - \sum nH_{fr}$$

$$\Delta H_r = \left[(2\,mol)\left(-174.1\,\frac{kJ}{mol}\right) + (1\,mol)\left(90.2\,\frac{kJ}{mol}\right)\right] - \left[(3\,mol)\left(33.2\,\frac{kJ}{mol}\right) + (1\,mol)\left(-285.8\,\frac{kJ}{mol}\right)\right]$$

$$\Delta H_r = (-258\,kJ) - (-186.2\,kJ)$$

$$\boxed{\Delta H_r = -71.8\,kJ}$$

$$\Delta H_r = nH_r$$

$$H_r = \frac{\Delta H_r}{n} = \frac{-71.8\,kJ}{3\,mol} = \boxed{-23.9\,kJ/mol}$$

Multi-Step Energy Calculations

Step 1: *Find H^o general*
-use Hess's law
-from equation
-use calorimetry

Step 2: *Find n (specific)*
-use mass (molar mass)
-use concentration
-use $n = \Delta H / H^o$

Step 3: Find unknown quantity
- often Δ*H (specific)*
use $\Delta H = nH^o$
- mass
- volume

Sample Problem

Ex. $2NaHCO_{3(s)} + 129.2kJ \longrightarrow Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(g)}$

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

Step 1: H_r(general)

$\Delta H_r = \sum nH_{fp} - \sum nH_{fr}$

$\Delta H_r = 129.2\,kJ$

$\Delta H_r = nH_r$

$H_r = \frac{\Delta H_r}{n} = \frac{129.2\,kJ}{2\,mol} = 64.6\,\frac{kJ}{mol}$

Step 2: n (specific)

$100\,000\,g\,NaHCO_3 \times \frac{1\,mol\,NaHCO_3}{84.01\,g\,NaHCO_3} = 1190.33\,mol\,NaHCO_3$

Step 3: ΔH_r (specific)

$\Delta H_r = nH_r$

$\Delta H_r = (1190.33\,mol)\left(64.6\,\frac{kJ}{mol}\right)$

$\Delta H_r = 76\,900\,kJ$

Sample Problem

Ex. $ZnS_{(s)} + 3/2O_{2(g)} \longrightarrow ZnO_{(s)} + SO_{2(g)}$

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

Step 1: Hr (general)

$\Delta H_r = \sum nH_{fp} - \sum nH_{fr}$

$\Delta H_r = \left[(1\,mol)(-350.5\,\frac{kJ}{mol}) + (1\,mol)(-296.8\,\frac{kJ}{mol})\right] - \left[(1\,mol)(-206.0\,\frac{kJ}{mol}) + (\frac{3}{2}\,mol)(0\,\frac{kJ}{mol})\right]$

$\Delta H_r = -441.3\,kJ$

$\Delta H_r = nH_r$

$H_r = \frac{\Delta H_r}{n} = \frac{-441.3\,kJ}{1\,mol} = -441.3\,\frac{kJ}{mol}$

Step 2: n (specific)

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

Step 3: ΔH_r (specific)

$\Delta H_r = nH_r$

$\Delta H_r = (513.136\,mol)(-441.3\,\frac{kJ}{mol})$

$\Delta H_r = -226\,000\,kJ$

Calculate the mass of methane combusted when 3700. kJ of energy is released according to the following reaction.

$$CH_{4(g)} + 2O_{2(g)} \Rightarrow CO_{2(g)} + 2H_2O_{(g)} + 802.7kJ$$