Chapter 17:Thermochemistry

Terms

- thermochemistry-the study of energy changes that occur during chemical reactions or changes of state.
- heat (represented by 'q') is energy that transfers from one object to another because of a temperature difference between them.

Heat ALWAYS flows from a warmer object to a cooler one until the temperature is equalized.

- exothermic-the 'system' loses heat as the surroundings heat up
- endothermic-the 'system' gains heat as the surroundings cool down

Units of Heat Measurement

Heat flow is measured in two common units, calorie or joule.

- calorie (cal) is defined as the quantity of heat (q) needed to raise the temperature of 1g of pure water 1° C.
- 1 dietary Calorie, is equivalent to 1 kilocalorie, 1000 calories
- the joule is the SI unit
- 1 J of heat raises the temperature of water 0.239 ° C

∴ 1 J = 0.239 cal 4.184 J = 1 cal

Heat Capacity and Specific Heat

Heat Capacity = the amount of heat required to raise the temperature of an object exactly 1℃

Specific Heat Capacity (represented by C)
-also called simply 'specific heat'
-the amount of heat required to raise 1g of a substance exactly 1℃

Table 17.1

Specific Heats of Some Common Substances

Substance	Specific Heat	
	J/(g•°C)	cal/(g•°C)
Water	4.18	1.00
Grain alcohol	2.4	0.58
Ice	2.1	0.50
Steam	1.7	0.40
Chloroform	0.96	0.23
Aluminum	0.90	0.21
Iron	0.46	0.11
Silver	0.24	0.057
Mercury	0.14	0.033

p. 508

Calculation of Specific Heat

$$C = \frac{q}{m \times \Delta T} = \frac{\text{heat (joules or calories)}}{\text{mass (g)} \times \text{change in temperature (°C)}}$$

Note!
$\Delta T = T_f - T_i$

Units are either

$\frac{J}{g℃}$ $\frac{cal}{g℃}$

SAMPLE PROBLEM 17.1

Calculating the Specific Heat of a Metal

The temperature of a 95.4-g piece of copper increases from 25.0°C to 48.0°C when the copper absorbs 849 J of heat. What is the specific heat of copper?

Hwk p. 510
#3,4
#9-11

Practice Problems

3. When 435 J of heat is added to 3.4 g of olive oil at 21°C, the temperature increases to 85°C. What is the specific heat of the olive oil?

4. How much heat is required to raise the temperature of 250.0 g of mercury 52°C?

Thermochemical Equations

- a thermochemical equation is simply a regular chemical equation that identifies the reactants and products, but includes the enthalpy change that occurs as a result of the reaction
- the terms 'heat' and 'enthalpy change' are used interchangeably
- this means that $q = \Delta H$

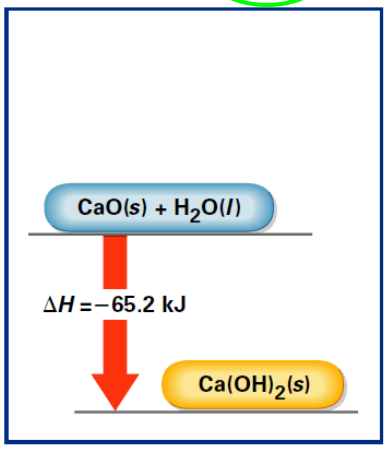
Example 1:

$CaO + H_2O(s) \rightarrow Ca(OH)_2(l) + 65.2kJ$

ΔH

Heat of Reaction

ΔH_{rxn}



a Exothermic Reaction

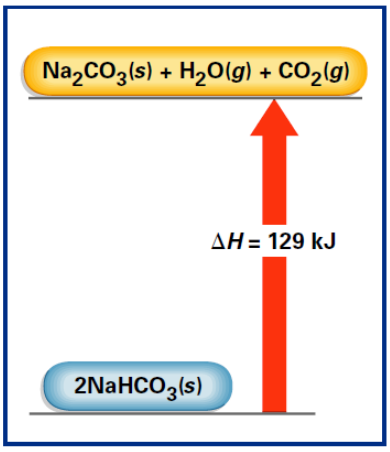
Example 2:

$2NaHCO_3(s) + 129kJ \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

ΔH

Heat of Reaction

ΔH_{rxn}



b Endothermic Reaction

ΔH for endothermic reactions is (+)

ΔH for exothermic reactions is (-)

SAMPLE PROBLEM 17.3

Using the Heat of Reaction to Calculate Enthalpy Change

Using the thermochemical equation in Figure 17.7b on page 515, calculate the amount of heat (in kJ) required to decompose 2.24 mol $NaHCO_3(s)$.

$2NaHCO_3(s) + 129kJ \rightarrow Na_2CO_3(s) + H_2O(g) + CO_2(g)$

2 moles of $NaHCO_3$ requires 129kJ of heat

2 moles NaHCO3 : 129kJ

$\therefore$ 2.24 moles NaHCO3 : *x kJ*

Cross Multiply

$(2.24)(129) = 2x$

$\therefore \quad x = \frac{(2.24)(129)}{2} = 144kJ$

Practice Problems

14. When carbon disulfide is formed from its elements, heat is absorbed. Calculate the amount of heat (in kJ) absorbed when 5.66 g of carbon disulfide is formed.

$$C(s) + 2S(s) \longrightarrow CS_2(l) \qquad \Delta H = 89.3 \text{ kJ}$$

15. The production of iron and carbon dioxide from iron(III) oxide and carbon monoxide is an exothermic reaction. How many kilojoules of heat are produced when 3.40 mol Fe_2O_3 reacts with an excess of CO?

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(s) + 3CO_2(g) + 26.3 \text{ kJ}$$