Calorimetry

OBJECTIVES:

--Use thermochemical equations to relate energy changes associated with heating or cooling a substance to heat capacity
--Use and manipulate thermochemical equations to relate the energy changes in a reaction to the amount of substance involved in the reaction.
--Calculate the heat transferred in a process using temperature measurements together with heat capacities or specific heats
--Define and identify how a calorimeter is used.

Calculating the heat of an increase (or decrease) in temperature:
Calorimetry Definition

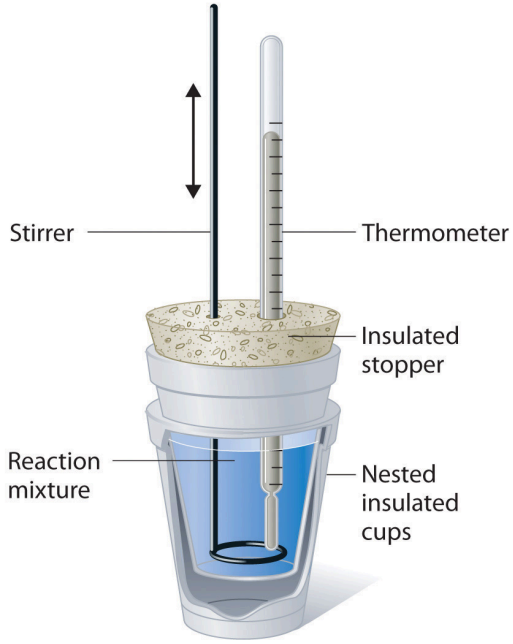
Specific Heat Equation:

Calculating ΔT

Sample Calorimetry Problem: How much heat must be added to change the temperature of 250g of water from 25° C to 60 ° C?

Enthalpy and Calorimetry:

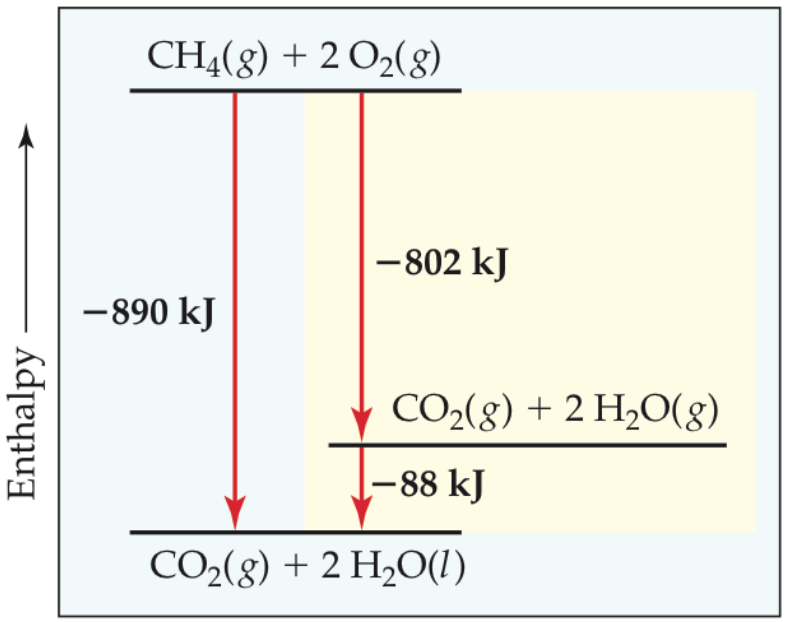
Coffee Cup Calorimeter



Sample Problem: A 100.0 g sample of water at 90°C is added to a 500.0 g sample of water at 10°C. Calculate the final temperature of the water.

HESS"S LAW
Objectives:
----Use Hess's law to determine enthalpy changes for reactions
---define enthalpy of formation and give examples

Using Hess's Law to calculate the enthalpy of a reaction:



▶ **Figure 5.20 Enthalpy diagram for combustion of 1 mol of methane.** The enthalpy change of the one-step reaction equals the sum of the enthalpy changes of the reaction run in two steps: −890 kJ = −802 kJ + (−88 kJ).

KEY POINT: Because enthalpy is a STATE function, the enthalpy of a reaction is the same whether the reaction takes place in one step or several steps.

Sample Problem: The enthalpy of reaction for the combustion of C to CO_2 is -393.5 kJ/mol C, and the enthalpy for the combustion of Co to CO_2 is -283.0 kJ/mol CO.

SAMPLE EXERCISE 5.9 Using Hess's Law to Calculate ΔH

The enthalpy of reaction for the combustion of C to CO_2 is -393.5 kJ/mol C, and the enthalpy for the combustion of CO to CO_2 is -283.0 kJ/mol CO:

(1) $C(s) + O_2(g) \longrightarrow CO_2(g) \qquad \Delta H = -393.5\ \text{kJ}$

(2) $CO(g) + \frac{1}{2}O_2(g) \longrightarrow CO_2(g) \qquad \Delta H = -283.0\ \text{kJ}$

Using these data, calculate the enthalpy for the combustion of C to CO:

(3) $C(s) + \frac{1}{2}O_2(g) \longrightarrow CO(g) \qquad \Delta H = ?$

Sample Problem 2:

SAMPLE EXERCISE 5.10 Using Three Equations with Hess's Law to Calculate ΔH

Calculate ΔH for the reaction

$$2\,C(s) + H_2(g) \longrightarrow C_2H_2(g)$$

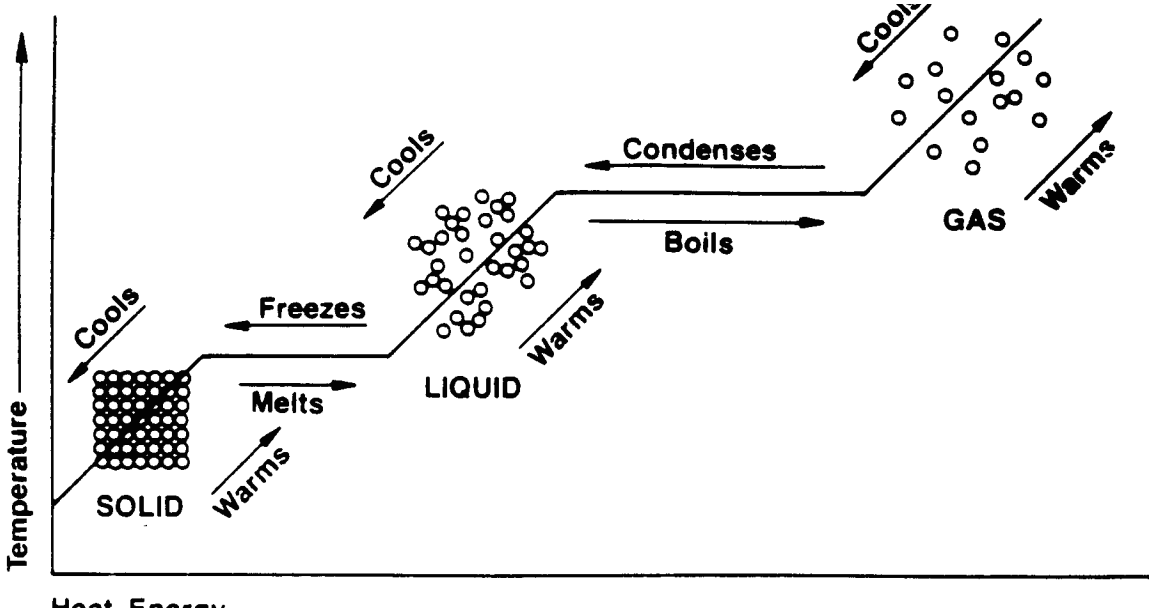
given the following chemical equations and their respective enthalpy changes:

$$C_2H_2(g) + \tfrac{5}{2}O_2(g) \longrightarrow 2\,CO_2(g) + H_2O(l) \qquad \Delta H = -1299.6\ \text{kJ}$$

$$C(s) + O_2(g) \longrightarrow CO_2(g) \qquad \Delta H = -393.5\ \text{kJ}$$

$$H_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow H_2O(l) \qquad \Delta H = -285.8\ \text{kJ}$$

Enthalpy of Phase Changes



Calculating the enthalpy of a phase change

HEAT OF FORMATION

Objectives:

--recognize equations that describing standard enthalpy of formation
--use standard enthalpies of formation to calculate ΔH° for reaction

Heat of Formation

Definitions:

Standard State

Standard Enthalpy Change

Standard Enthalpy of Formation

Sample Exercise: For which of thee reactions at 25°C does the enthalpy change represent a standard enthapy of formation? For each that does not, what changes are needed to make it an equation whose ΔH is an enthalpy of formation?

$2Na(s) + ½\ O_2\ (g) \rightarrow\ Na_2O\ (s)$

$2K\ (l)\ + Cl_2\ (g)\ ) \rightarrow\ 2KCl\ (s)$

$C_6H_{12}O_6\ (s)\ \rightarrow\ 6\ C\ (diamond) + 6H_2\ (g) + 3O_2\ (g)$

Using Enthalpies of Formation to Calculate Enthalpies of Reaction

$\Delta H°_{rxn} = \sum$

Sample Problem: (a) calculate the standard enthalpy change for the combustion of 1 mol of benzene, C_6H_6 *(l) to* CO_2 (g) and H_2O (l) (b) Compare the quantity of heat produced by combustion of 1.00 g propane (from the notes above) with that produced by 1.00 g benzene

Sample Problem: Calculate the enthalpy of formation using an enthalpy of reaction
The standard enthalpy change for the reaction $CaCO_3$ (s) → CaO (s) + CO_2 (g) is 178.1 kJ. Use this information and the table of heats of formation to calculate the standard enthalpy of formation of $CaCO_3$ (s).