ENERGY CHANGES IN CHEMICAL REACTIONS

1) **Heat** (*q*) is the transfer of energy from one substance to another.

2) **Temperature** (*T*) is a measure of the average kinetic energy of the particles in a sample of matter.

3) **Enthalpy** (*H*): The heat content of a substance; refers to how much energy is stored in the substance (in chemical bonds). Enthalpy is also known as **heat content**.

Units: We will be using two types of units for energy.
a) calorie (cal), kilocalorie (kcal):
One calorie is the quantity of heat required to raise the temperature of 1 gram of liquid water 1°C.

b) joule (J), kilojoule (kJ)
The joule is the energy required to exert a force of 1 Newton for 1 metre.
Therefore 1 Joule = 1 N·m = 1 $kg \cdot m^2/s^2$

When converting from one type of unit to the other, use the following relationships:
1 cal = 4.18 J or 1 kcal = 4.18 kJ

4) **Enthalpy Change** (Δ*H*): The enthalpy change refers to how much energy is released or absorbed when a reaction occurs. Enthalpy change is also referred to as the heat of reaction.

$$\Delta H = H_{(products)} - H_{(reactants)}$$

5) **Types of Reactions**: Reactions may be classified as endothermic or exothermic.

a) An **endothermic reaction** is one in which energy is absorbed.

eg. $C(s) + H_2O\,(g) + 131\ kJ \rightarrow CO\,(g) + H_2(g)$

With this type of reaction, *H* (products) **>** *H*(reactants). Thus, Δ*H* is always positive for an endothermic reaction. The above reaction may also be written in Δ*H* notation as:

eg. $C(s) + H_2O\,(g) \rightarrow CO\,(g) + H_2(g) \qquad \Delta H° = +131\ kJ/mol$

b) An **exothermic reaction** is one in which energy is released.

eg. $CO\,(g)\ +\tfrac{1}{2}O_2(g) \rightarrow CO_2(g)\ +393kJ$

With this type of reaction, *H*(products) **<** *H*(reactants). Thus, Δ*H* is always negative for an exothermic reaction. The above reaction may also be written in Δ*H* notation, as:

eg. $CO\,(g)\ +\tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \qquad \Delta H° = -393\ kJ/mol$

Notice that the Δ*H* term is negative since this is an exothermic reaction.

6) **<u>Energy-Mass Calculations:</u>** The following is an example of the type of energy-mass calculation that you would be expected to solve. You should approach this type of problem the same way that you would approach problems involving balanced equations during the review unit (similar to how you would approach a stoichiometry problem).

e.g. **.** Consider the combustion of the sugar sucrose ($C_{12}H_{22}O_{11}$):

$$C_{12}H_{22}O_{11}(s)\ +\ O_2(g)\ \rightarrow\ CO_2(g)\ +\ H_2O \qquad \Delta H° = -5644\ kJ/mol$$

How much energy would be released by the complete combustion of one gummy candy (mass = __________ g)?

Solution:

Types of Molar Enthalpies $(\Delta H°)$

- **Heat of Reaction** $(\Delta H°)$

- **Heat of Vapourization:**

  $H_2O(l) \rightarrow H_2O(g) \qquad \Delta H°_{vap} = +40.8\ kJ/mol$

- **Heat of Fusion:**

  $H_2O(s) \rightarrow H_2O(l) \qquad \Delta H°_{fus} = +6.03\ kJ/mol$

- **Heat of Combustion:**

  $CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(l) \qquad \Delta H°_{comb} = -892\ kJ/mol$

- **Heat of Formation:** The energy change in forming a compound from its elements.

  $H_2(g) + \frac{1}{2}\,O_2(g) \rightarrow H_2O(l) \qquad \Delta H°_f = -285.8\ kJ/mol$

  $H_2(g) + S\,(s) + 2\,O_2(g) \rightarrow H_2SO_4(l) \qquad \Delta H°_f = -811.7\ kJ/mol$