Name: ___________________________ Date: ___________ Class Notes Chemistry

Energy Transfer

When matter undergoes a physical or chemical change there is also a transfer of energy. Energy is either transferred from the **system** to the surroundings or from the surroundings to the system. The system is whatever is being studied or observed and everything else is the surroundings. This transfer of energy is defined as **heat (q)** and is measured in **calories** or **joules (J)**. A calorie is the amount of heat needed to raise 1 gram of water 1 degree Celsius. This is not the same calorie used to describe the energy content in food. Food calories are actually kilocalories equal to 1000 calories. A joule is a derived SI unit and one calorie equals 4.184 joules. Chemists use both the calorie and the joule to describe heat.

When energy is transferred from the system to the surroundings the process is called **exothermic.** If energy is transferred from the surroundings to the system the process is called **endothermic**. All chemical changes are either endothermic reactions or exothermic reactions. The burning of a match is an exothermic reaction and photosynthesis is an endothermic reaction. However, the transfer of energy in a chemical change does not just happen. Both exothermic and endothermic reactions require a minimum amount of energy to occur. This minimum amount of energy needed is referred to as the **activation energy** and without it chemical reactions will not happen. It's important to note that in an endothermic reaction the products contain more energy than the reactants, but in the exothermic reaction the products contain less energy than the reactants.

Physical changes also absorb or release energy. Any **phase change** in a substance results in an energy transfer. When ice melts, it is because the ice absorbed energy from the surroundings and homemade ice cream freezes because it lost energy to the surroundings. But neither case results in a new substance.

A device used to measure changes in heat transfer is called a **calorimeter**. A calorimeter is an insulated container that contains water and a thermometer to measure the heat released or absorbed during an energy transfer.

The amount of heat required to raise one gram of a substance one degree Celsius is called a substance's specific heat **(C_p)**. Since energy is conserved, a substance's specific heat can be calculated if the system is insulated.

Equation $\mathbf{q = m \times \Delta T \times C_p}$ $\mathbf{\Delta T = T_f - T_i}$

A calorimeter and the above equation can be used quantitatively to determine the amount of heat released or absorbed. This same process can also be used to determine the specific heat of an unknown metal. By placing the heated metal in water and measuring the change in the water's temperature and determining the water's mass the amount of heat transferred from the metal can be calculated. Then using this data we can calculate the metal's specific heat.

WATER has a specific heat of 4.184 J/g · °C.

Example Tell whether the following system is exothermic or endothermic. Then calculate the amount of heat released or absorbed.

40.0 g of water heated from 10.0°C to 30.0°C.

endothermic (the only way the water could reach 30.0°C is by absorbing heat)

$$q = 40.0\text{g x } (30.0 - 10.0)°\text{C x } 4.184 \text{ J/g} \cdot °\text{C} = \mathbf{3350\ J}$$

DETERMINE the amount of heat absorbed or released in each of the following.

__________________ 1. 25.0 g of water cooled from 85.0°C to 40.0°C

________________ 2. 100.0 g of ice melted, with no temperature change

________________ 3. 30.0 g of aluminum heated from 15.0°C to 35.0°C

________________ 4. 1.5 kg of copper heated from 5.5°C to 132.0°C

SOLVE the following specific heats.

________________ It takes 78.2 J to raise the temperature of 45.6 g of lead by 13.3°C. Calculate the specific heat.

________________ A 46.2 g sample of copper is heated to 95.4°C and then placed in a calorimeter containing 75.0 g water at 19.6°C. The final temperature of the metal and water is 21.8°C. Calculate the specific heat of copper, assuming that all the heat lost by the copper is gained by the water.

"It is not the mountain we conquer, but ourselves."

-- Edmund Hillary