Thermochemistry

Thermochemistry - the study of heat changes that occur during chemical reactions

We will be looking at

- heat changes in chemical reactions
- heat changes in physical reactions

Terms You Need to Know (write out definitions for the following terms, the last few are done for you)

- physical change -
- chemical change-
- kinetic energy (E_k) -
- potential energy (E_p)-
- temperature (T) -
- phase change-
- nuclear change-
- thermal-
- Law of Conservation of Energy (First Law of Thermodynamics)-
- endothermic reaction-
- exothermic reaction-

- heat (q) -

- Joule -

- heat capacity (C - measured in kJ/^{o}C) -

- specific heat capacity (c - measured in J/g^{o}C) -

- substance - the matter being discussed

- process - what happens to the substance (what changes)

- chemical system - classifying a substance or group of substances undergoing a physical or chemical change. A system consists of the substance (s) and the environment around (the surroundings)

Calculation of Heat Energy

For the temperature of an object to increase it must absorb energy/heat. The amount absorbed must depend upon the following criteria:

1. The type of material
2. The temperature of the material
3. The mass of the material

This translates into two useful formulas:

1. $q = C\Delta T$

Heat capacity formula, it stands for:
heat energy = heat capacity x change in temperature
(More later on when we talk about calorimetry)

2. $q = mc\Delta T$

Specific heat capacity formula, it stands for:
heat energy = mass of substance x specific heat capacity of substance x change in temperature

(You'll often use these two formulas as multiple choice questions when all the variables are

provided except one)

Examples of questions:

1. Calculate the amount of energy required to raise the temperature of a 25.6 g sample of Al 2.6°C. The specific heat capacity of Al is 0.900 J/g°C

Given: m = 25.6 g
$\Delta T = 2.6\ ^{o}C$
$c = 0.900\ J/g^{o}C$

$q = mc\Delta T$
$q = 25.6\ g \times 0.900\ J/g^{o}C \times 2.6^{o}C$
$= 6.0 \times 10\ J$

2. Calculate the change in temperature that results when a 38.7 g block of ice releases 18.6 kJ of heat. (Specific heat of ice is 2.10 J/g°C)

{Releases heat means it gives off heat - therefore negative}

m = 38.7 g
ΔT = ?
q = $-18.6\ kJ = -1.86 \times 10^{4}\ J$
$c = 2.10\ J/g^{o}C$

If $q = mc\Delta T$ Then $\Delta T = \frac{q}{mc}$

$= \frac{-1.86 \times 10^{4} J}{(38.7g)(2.01 J/g^{o}C)}$

$= -240\ ^{o}C$

Now try these and finish for homework:

1. Calculate the quantity of heat flowing into a 2.00L of water at 20.0 °C that is heated to 99.7 °C in an electric kettle. (Specific heat of liquid water is 4.18 J/g °C and you know how to translate from 1 L of water to its mass, right?)

2. When 435 J of energy are added to 3.5 g of oil at 21°C, the temperature increases to 85°C. What is the specific heat capacity of the oil ?

3. In an experiment a person determined that 1.50 kJ of heat flowed into a 500.0 mL sample of water in a beaker. If the specific heat capacity of water is 4.18 J/g °C, what was the temperature increase?

Types of Thermochemical Systems

1. A system that is open to the flow of energy, but closed to the flow of matter is called a **closed system**. For example, a gel filled freezer pack is a closed system. Heat can flow out of the pack when it is put into the freezer, or into the pack when it is placed in a portable cooler. The gel however, stays inside the plastic packaging. Other examples of closed systems are:

- a sealed bottle of soda cooling in a refrigerator
- a reaction taking place in an aqueous medium e.g. acid-base neutralization reaction
- nitrogen dioxide reacting to produce dinitrogen tetraoxide in a closed reaction vessel

2. A system that is open to the flow of energy and matter is called an **open system**. For example, a glass of cold water on a countertop is an open system because heat can enter the water from the air and water can evaporate into the air. Other examples:

- a burning log
- a burning candle
- water evaporating from a river

3. A system that is closed to the flow of energy and matter is an **isolated** or **insulated** system. For example, liquid nitrogen is kept at temperatures below -196°°C in a Dewar flask. The liquid nitrogen does not escape and energy does not enter this type of flask. (Dewar flasks are commonly known as Thermos bottles in the same way that snow machines are often called "Ski-Doo's".)