**HEAT QUANTITIES**

**TEMPERATURE** is a measure of how hot or cold something is.

**HEAT** is thermal energy that flows between two objects because of their temperature difference.

* Its SI unit is the joule. Other units used for heat are the calorie (**1 cal = 4.1858 J**) and the British thermal unit (**1 Btu = 1054 J**). The “Calorie” used by nutritionists is called the “large calorie” and is actually a kilocalorie (**1Cal=1kcal=103cal**).

**THERMAL ENERGY** is the random kinetic energy of the particles (usually electrons, ions, atoms, and molecules) composing a system.

The **SPECIFIC HEAT** (or **SPECIFIC HEAT CAPACITY, c**) of a substance is the quantity of heat required to change the temperature of unit mass of the substance by one degree.

**c =**

In the SI, c has the unit J/kg-K, which is equivalent to J/kg °C. Also widely used is the unit cal/g.oC, where 1cal/g °C = 4184 J/kg °C.

For ***water, c = 4185.8 J/kg.°C = 1 cal/g °C.***

***Ice, c = 0.5cal/g.oC***

***Steam, c = 1.996 kJ/kg.oC = 0.4769 cal/g.oC***

The **HEAT GAINED (OR LOST)** by a body (whose phase does not change) as it undergoes a temperature change ΔT, is given by

**Q=mcΔT**

\****Qgained*** is ***(+); Qlost*** is ***(-)***

The **HEAT OF FUSION (Lf)** is the quantity of heat required to melt a unit mass of the solid at constant temperature. It is also equal to the quantity of heat given off by a unit mass of the molten solid as it crystallizes at this same temperature. The ***heat of fusion of water*** at 0°C is about ***335 kJ/kg or 80cal/g.***

**Q = mLf**

The **HEAT OF VAPORIZATION (Lv)** of a liquid is the quantity of heat required to vaporize a unit mass of the liquid at constant temperature. For ***water*** at 100°C, Lv is about ***2.26 MJ/kg or 540cal/g.***

**Q = mLv**

**CALORIMETRY** PROBLEMS involve the sharing of thermal energy among initially hot objects and cold objects. Since energy must be conserved, one can write the following equation:

**sum of heat changes for all objects = 0**

**Qgained + Qlost­ = 0**

Sample Problems:

1. (a) How much heat is required to raise the temperature of 2 mL of water from 20°C to 35°C? (b) How much heat is lost by the water as it cools back down to 20°C?
2. How much heat does 25g of aluminum give off as it cools from 100°C to 20°C? For aluminum, c = 880 J/kg.°C.
3. A certain amount of heat is added to a mass of aluminum (c = 0.22 cal/g °C), and its temperature is raised 57°C. Suppose that the same amount of heat is added to the same mass of copper (c = 0.093 cal/g.°C). How much does the temperature of the copper rise?
4. A thermos bottle contains 250g of coffee at 90°C. To this is added 20g of milk at 5°C. After equilibrium is established, what is the temperature of the liquid? Assume no heat loss to the thermos bottle. (Water, coffee, and milk all have the same value of c = 1 cal/g.oC)
5. An ice cube having a mass of 50g and an initial temperature of -20oC is placed in 400g of 30oC water. What is the final temperature of the mixture if the effects of the container can be neglected?
6. How much heat is given up when 20 g of steam at 100°C is condensed and cooled to 20 °C?
7. How much heat is required to change 10g of ice at exactly 0°C to steam at 100°C?