NS C2 (pg 1 of 1) Calorimetry – Measuring Energy Lost and Gained When a Substance Changes Temperature

Calorimetry – The experimental measurement of heat movement from chemical and physical processes.

Calorimeter – An apparatus used to make the measurements necessary to measure heat transferred. In our lab, our "high-tech" calorimeter will be a foam coffee cup.

Every substance has an physical property known as ***specific heat capacity***, (symbolized by the letter c) which is the amount of energy required to raise (or lower) the temperature of 1 gram of that material (in a particular physical state – solid, liquid, or gas) by 1 degree Celsius. This is an *intensive* property, meaning it does not change for different amounts of the same substance. The specific heat capacity (**c**) of liquid water is 4.18 J/gºC. It is a different value for ice, and a different value for steam.

Heat capacity is the amount of energy required to change the temperature of some particular object (or amount of material) 1ºC. This of course depends on how large the object it. This property is an *extensive* physical property. The label on heat capacity will be Joules/ºC.

A substance will emit or absorb heat when it is near a substance that is at a different temperature. This emission or absorption of heat by the substance will of course causes the substance to change temperature.

The amount of energy gained or lost by a substance is dependent upon

- the temperature change that the substance experiences
- the substance's mass
- the type of material (and its physical state: solid, liquid, or gas)

We can calculate the quantity of heat a material loses or gains by using the SHC of that substance together with its measured mass and its temperature change. Observe the formula below:

$$\textbf{mass} \times \textbf{c} \times \Delta\textbf{T} = \boldsymbol{q} \quad \text{heat (lost or gained)}$$

When only one substance is changing temp.
Use this equation when you are asked to solve for heat or given heat (Joules) in the problem when there is a temperature change.

$$g \times \frac{J}{g^{\circ}C} \times {}^{\circ}C = J \quad \text{units for each item above}$$

be sure and notice that the units on the left side of the equation cancel out to equal the units on the right side of the equation.

Remember that heat is measured in Joules, mass is measured in grams, and temperature is measured in ºC. The symbol Δ (delta) means "change". Thus ΔT means change in temperature: $T_{final} - T_{initial}$

In our class, we will be measuring the temperature changes of substances as they are put in contact with another substance that is at a higher or lower temperature. The materials will change temperature until they both come to the same temperature which will be somewhere in between the high and the low temperature of the two materials. This temperature at which the two materials settle at is known as the *equilibrium temperature.* Since both materials will only stop changing temperature (heat will stop flowing) when they settle at the same temperature, this final temperature is also known as *thermal equilibrium*.

The Big Idea

In most of our calorimetry work, we will make the *big assumption* that the heat lost by the hot substance will equal the heat gained by the cold substance. This will allow us to use the equation above for the cold material gaining heat together with the hot material that is losing heat. Consider the equation below:

$$\begin{array}{ccc} -q & = & q \\ \text{heat lost} & = & \text{heat gained} \\ -(\textbf{mass} \times \textbf{c} \times \Delta\textbf{T}) & = & (\textbf{mass} \times \textbf{c} \times \Delta\textbf{T}) \end{array}$$

When two substance are changing temp
Use this equation when there are both hot and cold substances in the problem that are changing temperature.

As mentioned at the top, an apparatus that is used to measure the loss or gain of heat is called a *calorimeter*. The "high-tech" calorimeter that we will use to perform these heat lost / heat gained experiments will be a simple foam coffee cup. This is actually a very good instrument because foam has very low thermal conductivity (meaning it will hardly change temperature at all), which allows the assumption that the heat lost will equal the heat gained. Using a container other than foam would allow too much heat to be lost to the outside surroundings, which would invalidate our big assumption.