Thermal Concepts

3.1.1 State that temperature is a property that determines the direction of thermal energy transfer between two bodies in thermal contact.

3.1.4 State that temperature is a measure of the average kinetic energy of the molecules of a substance.

3.1.5 State that the internal energy is the total potential and kinetic energy of molecules in a substance.

3.1.6 Explain and distinguish between the macroscopic concepts of temperature, internal energy and heat.

Temperature is something that we think about everyday. We ask what's the temperature? Is it hot? Are you cold? What does it really mean?

Try to define temperature. It's not so easy. It isn't heat. It isn't energy. What happens when you touch something with a lower temperature? Thermal energy flows out of you and into the colder object. The reverse happens when you touch something hot. Hot things make cold things warm. The heat flows from hot to cold, never the reserve. So it might be said that temperature determines which direction thermal energy flows. It can also be said that temperature is the measure of the average kinetic energy of molecules in a substance. Note: the terms average kinetic energy and mean kinetic energy are interchangeable.

What is thermal energy? Thermal energy represents the total internal energy of an object: the sum of its molecular kinetic and potential energies. Molecules have kinetic energy due to their motion, both vibrational and translational. Molecules have potential energy due to the intermolecular forces. A simple model for a molecule would be masses connected with springs.

How about heat? Heat is defined as the transfer or change in thermal energy that is due **only** to a difference of temperature. Heat is not something a object has, but something that a object gets or gives up. Units for heat are Joules (J) or calories (cal). 1 cal = 4.186 J.

3.1.2 Explain how a temperature scale is constructed

How do you decide whether to turn on the air conditioning or the heat? You need to know the outside temperature, or what you are really interested in is the temperature difference or which direction the head is going to flow. Its convenient to have a non-biased way of determining which direction the heat will flow, i.e. we'd like to put a number to it so we can predict which way the thermal energy will flow, so we can know whether the house is going to get colder or get hotter. To put it simply we need a temperature scale. So how do we construct a temperature scale?

To construct a scale we need some way to measure the temperature. Often different physical properties of materials are used to measure temperature. Thermal expansion of a material is frequently used as a way of measuring temperature. As temperature changes the volume of materials changes as well, if the change over a range of temperatures is linear then that material would make a good thermometer, or temperature measurer, over that range of temperatures.

We also need two reproducible temperatures, these two temperature form anchors for the scale. The Celsius scale was based on the freezing point (0°C) and the boiling point (100°C) of water at standard temperature and pressure. This range of temperatures was then broken into 100 equal portions, called degrees. The Fahrenheit scale was based on the freezing point of a salt water solution (0°F) and human body temperature (98.6°F). There are mixed reports as to how the number 98.6 was used. Some say it was originally 96, but there was experimental error, others say the temperature of a sick person (Fahrenheit's wife) was measured and thus the human body temperature was set at 100°F… It doesn't really matter, Fahrenheit sucks.

3.1.3 State the relationship between the Kelvin and Celsius scales of temperature.

Celsius scale is nice in that it is based on two easily reproducible temperatures. However there are plenty of things colder than frozen water. Which creates negative temperature, which is not a problem until put into an equation… If the volume of a material (gas) varies with temperature, say linearly as with the following equation:

(1)
$$V=kT$$

Then when the temperature is negative, the equation gives a negative volume, which doesn't make any sense. This is a problem with the math not with the physics…

It is convenient to have a scale with no negative values. Which is where the Kelvin scale comes in, zero degrees Kelvin is defined as absolute zero or when molecular motion is at a minimum. Absolute zero was first approximated using the volume and temperature relationship of gases. Different gases have different "k's" or constants but they are intersect at the same point (or roughly), of course gases would liquefy or even solidify before reaching absolute zero. The intersection point is absolute zero. This was calculated to be −273°C. This was later refined to be −273.16°C. In recent years absolute zero has been measured to more decimals places, but that doesn't really matter for this course… A degree Kelvin is the same as a degree Celsius, but the zero is different.

(2)

$$TK = TC + 273$$

For the purpose of this class, temperature in Celsius minus 273 is equal to temperature in Kelvin.

Note: When writing temperature in Kelvin no degree symbol is used, 10 K not 10°K.

It is vital when using absolute temperature in equations to use Kelvin, however when using temperature differences it does not matter whether Kelvin or Celsius is used since a degree Kelvin is equal to a degree Celsius.

3.1.7 Describe qualitatively the processes of conduction, convection and radiation.

3.1.8 Describe examples of conduction, convection and radiation.

Conduction is the process in which heat energy is transferred by adjacent molecular collisions throughout a material medium. The medium itself does not move. A simple example would be when you touch a cold piece of metal, thermal/heat energy flows out of your hand and into the metal, there is no net motion of matter, just heat flow.

Convection is the process by which heat is transferred by the actual mass motion of a fluid (gas or liquid). Most household heaters work this way. An object (a radiator) is heated the air around the object heats by conduction and then the air moves when it makes contact with a cooler object the heat energy is transferred.

Radiation is the process by which heat is transferred by electromagnetic waves. The sun is the best example of heat transferred by electromagnetic waves. There is no material or medium between the earth and the sun for the heat to be transferred through, so it must be done by electromagnetic waves which require no medium to propagate.

Source: http://ibphysicsstuff.wikidot.com/thermal-concepts