Changes of State ‘Enrichment’ document

When you heat a container that has only SOLID ice (no liquid water) in it, the temperature should be close to the “outside temperature”, in other words, below the melting point of ice. When you add heat, ASSUME all the energy goes into the ice; nothing goes into the air or the container. ASSUME\* that the atmospheric air pressure is that of SEA LEVEL. There is no loss of heat into heating the container and no heat is lost to the air. Say that the ice starts at minus 10.0 °C. Predict that the temperature of the steam generated is above 100°C.

There are five steps that will appear in the graph of the water as it changes state, they are:

1) the ice rises in temperature from -10.0 to 0.00 °C.

As we apply heat, the ice will rise in temperature until it arrives at its normal melting point of zero Celsius.

Once it arrives at zero, the change in temperature equals 10.0 °C. Here is an important point: THE ICE HAS NOT MELTED YET. At the end of this step we have SOLID ice at zero degrees. It has not melted yet. That's an important point.

2) the ice melts at 0.00 °C.

We continue to add energy and the ice begins to melt. However, the temperature DOES NOT CHANGE. It remains at zero during the time the ice melts. During this time, the energy being added is being used to overcome water molecules' attraction for each other, destroying the three-dimensional (crystal) structure of the ice. Water requires 334.16 Joules/gram of water to go from the solid to a liquid state. (1 Calorie = 4.184 Joules of energy). The energy being added (heat) to the sample then is used to change the state, NOT RAISE THE TEMPERATURE of the sample.

3) the liquid water then rises in temperature from zero to 100.0 °C.

Once the ice is totally melted, the temperature can now begin to rise again. It continues to go up until it reaches its normal boiling point of 100.0 °C. The change in temperature was 100 °C. Here is an important point: THE LIQUID HAS NOT BOILED YET, we have liquid water at 100 degrees. It has not turned to steam yet.

4) the liquid water then boils at 100.0 °C.

We continue to add energy and the water begins to boil. However, the temperature DOES NOT CHANGE. It remains at 100 °C during the time the water boils. During this time, the energy being added is being used to overcome water molecules' attraction for each other, allowing them to move from close together (liquid) to quite far apart (the gas state). Water requires 2261 J/g of energy to change from a liquid to a gas. We call this the "heat of vaporization".

5) the steam then rises in temperature from 100.0 to +100.0 °C

Once the water is completely changed to steam, the temperature can now begin to rise again. It continues to go up until we stop adding energy. Each gram of water requires a constant amount of energy to go up each degree Celsius. This amount of energy is called specific heat. There will be a different value needed, depending on the substance being in the solid, liquid or gas phase.

The Graph of the Change of State of Water (Solid, Liquid, Gas)



\*NOTE, As you increase your elevation, the boiling point of water drops as the molecules need to overcome a lower gas pressure in order to vaporize. The theoretically reduction in the boiling point of water is temperature;

At 600 m, the boiling point is about 98 °C. At 1500 m, the boiling point of (pure) water is about 95 °C.