NS C1 (pg 1 of 2)

Phase Changes

Name______________________Per____

What happens to a solid or liquid substance when it is heated? Assuming there is not a chemical reactions, one of two types of behavior are possible when a substance is heated: The substance can simply get hotter (that is, the temperature increases) or a phase change can occur. Either one or the other can occur, both do not occur at the same time. The transition from the solid phase to the liquid phase is an example of a phase change, which is often called melting. Vaporization, or boiling, is an example of a phase change from the liquid to the gas phase. Water evaporates, plastic melts, dry ice sublimes; all of these transformations are known as phase changes.

Melting

Every phase change is accompanied by a change in the energy of the system. In most solids, for example, the particles are in more or less fixed positions with respect to one another and closely arranged to each other. As the temperature of a solid increases, the particles of the solid vibrate about their fixed positions with increasingly energetic motion. When the solid melts, the particles that made up the solid are now free to move with respect to one another. The increased freedom of motion of the particles comes at an energy price. This energy used to melt (or freeze) is called the heat of fusion, symbolized as ΔH_{fusion}.

Boiling

As the temperature of the liquid phase increases, the molecules of the liquid move about with increasing energy. One effect of this increasing energy is that the amount of gas-phase molecules above the liquid increases with temperature. These molecules exert a pressure called the vapor pressure. We will explore vapor pressure later. For now we just need to understand that the vapor pressure increases with increasing temperature until the vapor pressure equals the external air pressure over the liquid. At this point the liquid boils, and the molecules of the liquid move into the gaseous state where they are widely separated. The energy required to cause boiling (or condensation) is called the heat of vaporization, symbolized as $\Delta H_{vaporization}$.

Why are ΔH_{fusion} and $\Delta H_{vaporization}$ so different in magnitude?

For all substances, the $\Delta H_{vaporization}$ is larger than the ΔH_{fusion} because in the transition from the liquid to the vapor state, the particles must essentially severe ***all*** of their interparticle attractive interactions and fly far apart from each other, whereas in melting, many of these attractive interactions remain as the particles are still touching each other.

EXO or ENDO ?

Recall that the term endothermic refers to any process in which energy is put into the system, and exothermic refers to any process in which energy is removed from the system. Interpret the diagram below that represents phase changes.

$-\Delta H_{fusion}$ freezing (exothermic) ← solid ← liquid; $-\Delta H_{vaporization}$ condensation (exothermic) ← liquid ← gas

solid **liquid** **gas**

solid → liquid: melting (endothermic) $+\Delta H_{fusion}$; liquid → gas: vaporization (endothermic) $+\Delta H_{vaporization}$

Exothermic indicated by a negative sign.
Endothermic indicated by a positive sign.

(or called evaporation when the phase change is occurring only at the surface of the liquid and below the boiling temperature)

Special Phase Changes

Some substance convert directly from solid to gas, skipping the liquid phase, or from liquid directly back into solid phase, again skipping the liquid phase. Carbon dioxide exhibits sublimation, and Iodine exhibits both sublimation and deposition.

solid $\xrightarrow{\text{sublimation}}$ **gas**

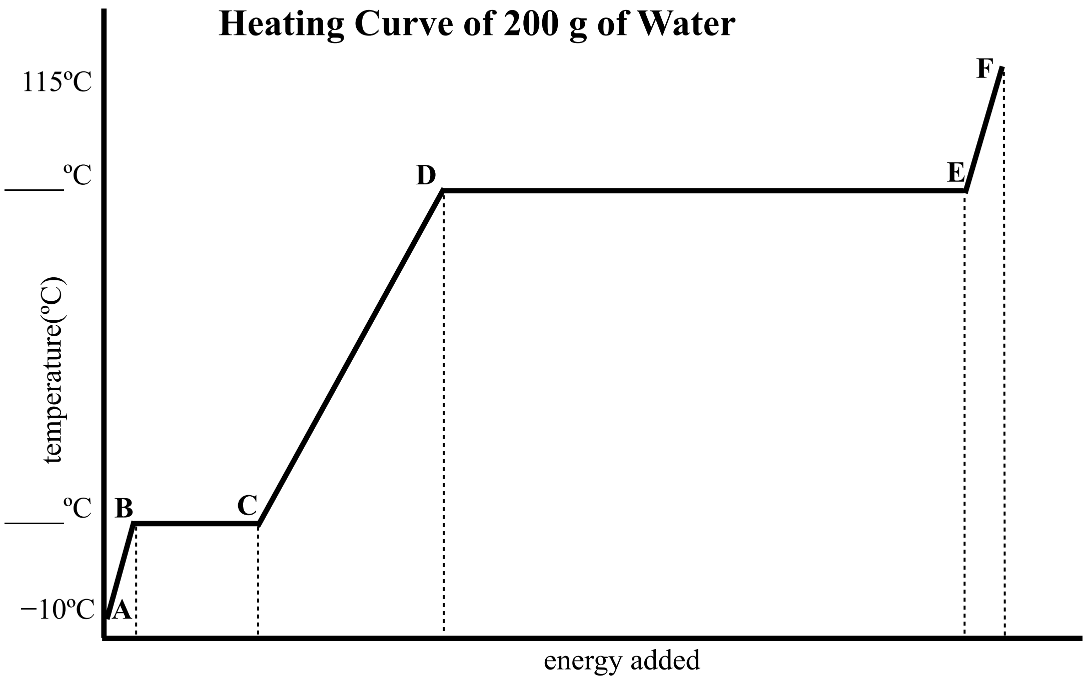
solid $\xleftarrow[\text{deposition}]{}$ **gas**

Just where do these phase changes show up in my daily life?

Phase changes of matter show up in important ways in our everyday experiences. We use ice cubes to cool our liquid drinks; the heat of fusion absorbed by the ice cools the liquid in which the ice is immersed. We feel cool when we step out of a swimming pool or a warm shower because the heat of vaporization is drawn from our bodies as the water evaporates from our skin. Our bodies use the evaporation of water from skin (sweat) to cool down body temperature, especially when we exercise vigorously in warm weather.

NS C1 (pg 2 of 2) Phase Changes and Temperature Changes

Consider the Heating Curve for Water shown below. Answer the following questions and label the graph as directed.



1. What phase change is occuring between point B and C?
2. What is the symbol for the energy of the B−C phase change?
3. What phase change is occuring between point D and E?
4. What is the symbol for the energy of this phase change?
5. Which phase change requires more energy? Suggest why.
6. Nanoscopically, what is happening between points C and D?
7. During what segments of the graph is the potential energy changing? How can you tell?
8. During what segments of the graph is the kinetic energy changing? How can you tell?
9. Is more energy require to heat up 200. g of liquid water or to melt 200. g of ice? How can you tell?
10. Do you suppose it take more energy per degree to heat liquid water of gaseous water? How can you tell?