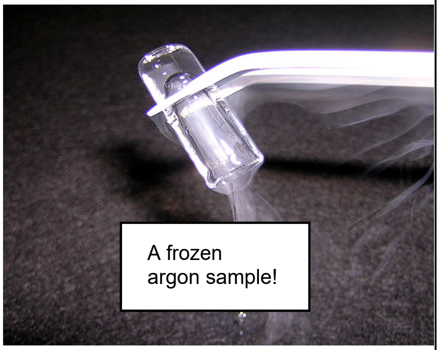
2.B.3 - Phase Changes and Latent Heat

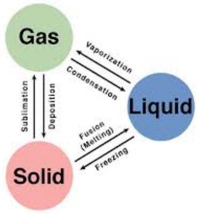


show triple point of cyclohexane video

Phases of Matter

Traditionally, there were three phases (states) of matter – solid, liquids, gases.
There is also a plasma state, in which nuclei are dissociated from their electrons. (Demo? Plasma in microwave!)
Adding enough heat to a solid melts it into a liquid; more heat converts it to gas.

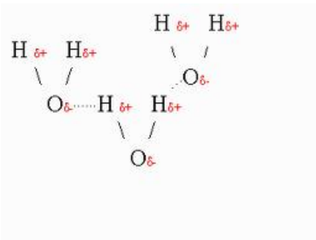
The reverse is true by removing heat.



Phases of Matter

Adding or removing heat in a substance makes its temperature change UNLESS it is undergoing a phase change.

During phase changes, energy alters intermolecular bonds, whether it's making or breaking them.



Latent Heat (Units = J/kg)

It takes a certain amount of energy per amount of mass to bring about a phase change.
Latent heat of fusion - L_f - (freezing/melting)
Latent heat of vaporization - L_v - (vaporizing/condensing)

L_f or $L_v = \frac{\lvert Q \rvert}{m}$	Q = Heat (J) m = mass (kg)

Latent is Latin for 'hidden'.

Latent Heat

See Table 2.B.2 in your resources. Notes
Another useful form of the equation is:

$$Q = \pm m \cdot (L_f \text{ or } L_v)$$

Note sign of heat when making computations - it is negative when the object is losing heat, and positive when it gains heat.

1. Latent Heat Example

How much ice (at the melting point) could a 415 W heater melt in 15.0 minutes?

Energy transferred: $\frac{415 J}{s} \bullet \frac{60 s}{\min} \bullet 15.0 \min = 373{,}500 J$

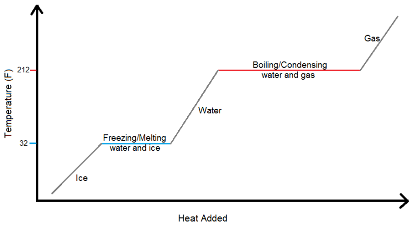
Mass: $Q = +m \bullet L_f$

$$m = \frac{Q}{L_f} = \frac{373{,}500 J}{3.33E5 J/kg} = \boxed{1.12 kg}$$

Cooling/Heating Curves

As a solid sample is heated, it will eventually melt.
During melting, its temperature is constant.
As the liquid heats up, it will eventually evaporate.
During boiling, temperature is constant.
As a vapor, heat added increases its temperature.

MP, and BP are areas of the graph where slope = 0.



Evaporation

Open containers of liquid will lose mass over time as evaporation occurs.

Sublimation is a process by which objects change phase from solid directly to gas. Water ice, dry ice, other materials sublimate.

(Iodine Demonstration).

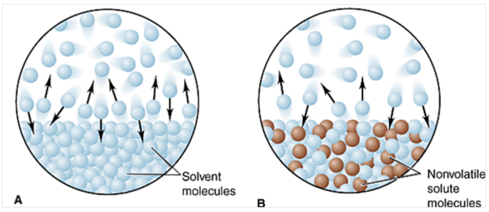
Witch's Brew: Dry Ice in Water

Evaporation

Molecules in a liquid move at different speeds.

Faster molecules escape from the surface of a liquid, leaving it completely if they have enough energy.

This is an energy losing process, called evaporative cooling.



Energy Example (6 Points)

How much heat does it require to increase the temperature of 1.00 kg of ice at - 10°C to steam at 110°C?

Five step process – calculate heat required to:

- 2. Raise the temperature of ice to the melting point
- 3. Melt the ice at 0°C
- 4. Raise the temperature of water to the boiling point
- 5. Convert the water to steam at 100°C
- 6. Raise the temperature of steam to 110°C

7. The **sum** of these steps equals total heat required.

Example

Final amount of heat will be the sum of these five calculations:

1. $Q = c_{ice} \cdot m \cdot \Delta T = 2100_{J/kg \cdot {}^\circ C} \cdot 1.0_{kg} \cdot 10.0_{{}^\circ C} = 21{,}000 J$
2. $Q = L_{f\ ice} \cdot m = 3.33\ E\ 5_{J/kg} \cdot 1.0_{kg} = 333{,}000\ J$
3. $Q = c_{water} \cdot m \cdot \Delta T = 4186_{J/kg \cdot {}^\circ C} \cdot 1.0_{kg} \cdot 100.0_{{}^\circ C} = 418{,}600 J$
4. $Q = L_{V\ water} \cdot m = 22.6\ E\ 5_{J/kg} \cdot 1.0_{kg} = 2{,}260{,}000\ J$
5. $Q = c_{steam} \cdot m \cdot \Delta T = 2000_{J/kg \cdot {}^\circ C} \cdot 1.0_{kg} \cdot 10.0_{{}^\circ C} = 20{,}000 J$

Total = 3,052,600 J - Round to 3.05 E 6 J

You will be quizzed on this process next week!

Homework

2.B.3 - Booklet Problems.
Due next class.

Demo Water's Phase Changes

Watch this! Snow/ice to water to steam.

Magic!