Heating and Cooling Curves

Aim: To determine how energy influences phase changes during heating and cooling.

Oct 6-1:47 PM

Phase Changes

All phase changes occur at constant temperature. Therefore average kinetic energy remains constant.

During a phase change, the heat added (PE increases) or released (PE decreases) will allow the molecules to move apart or come together.

Nov 6-5:51 PM

Phase Changes

Fusion (melting): solid to a liquid

Boiling (vaporization): liquid to a gas

Sublimation: solid to a gas

Solidification (freezing): liquid to a solid

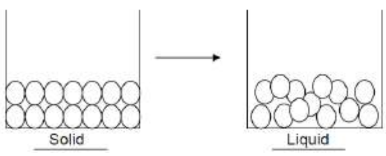
Condensation: gas to a liquid

Deposition: gas to a solid

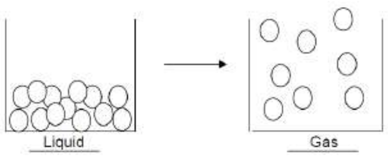
Nov 6-5:51 PM

Endothermic Phase Changes

1. Melting(fusion): s to l



2. Boiling(vaporization): l to g

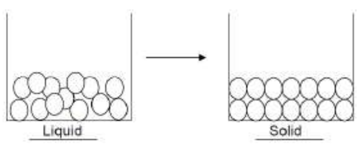


3. Sublimation: s to g

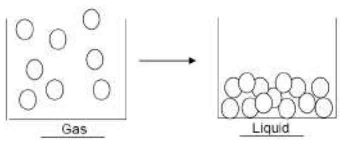
Heat absorbed causes the molecules to move farther apart by overcoming the intermolecular forces of attraction.

Exothermic Phase Changes

4. Freezing(solidification): l to s



5. Condensation: g to l



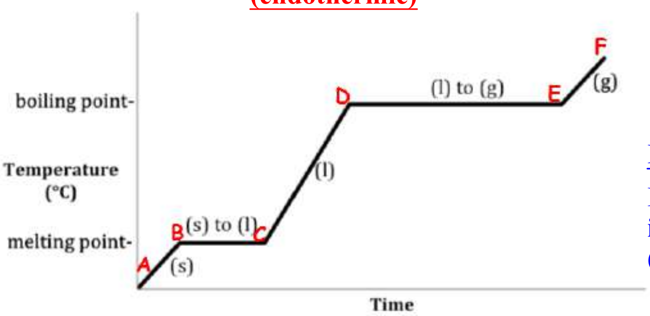
6. Deposition: g to s

Heat released allows the molecules to move closer together and the intermolecular forces of attraction become stronger.

Oct 6-1:49 PM

Nov 16-8:29 AM

Heating Curve
(endothermic)



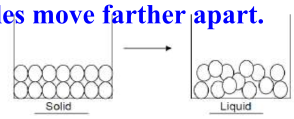
AB: phase= solid

Energy Changes= KE increases and particles move faster. PE remains constant.

Formula: Q=mcΔT to calculate the heat absorbed.

BC: phase= solid to liquid, fusion (melting)

Energy Changes= KE remains constant. PE increases and particles move farther apart. (IMF are overcome)



Formula: Q=mHf to calc. the heat absorbed.

CD: phase= liquid

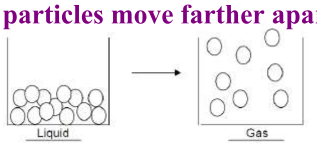
Energy Changes: KE increases and particles move faster while PE remains constant.

Formula: Q=mcΔT to calc. the heat absorbed.

DE: phase= liquid to gas, vaporization (boiling)

Energy Changes= KE remains constant while PE increases and particles move farther apart (IMF are overcome).

Formula: Q=mHv to calc. the heat absorbed.



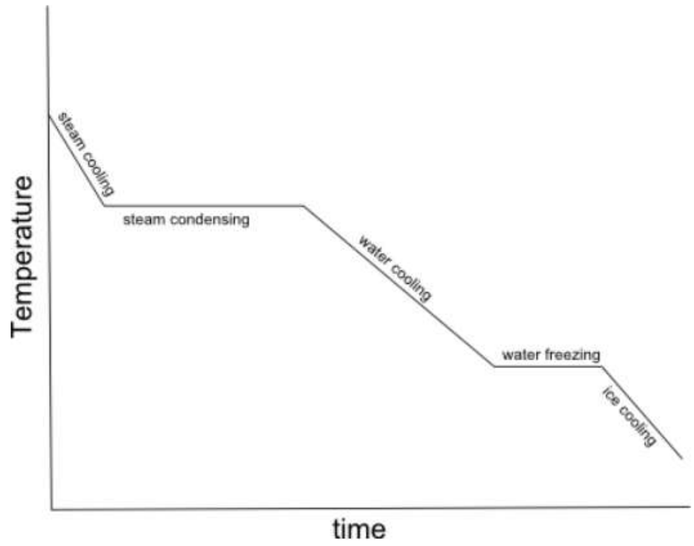
EF: phase= gas

Energy Changes= KE increases and particles move faster while PE remains constant.

Formula: Q=mcΔT to calc. the heat absorbed.

Oct 19-9:29 AM

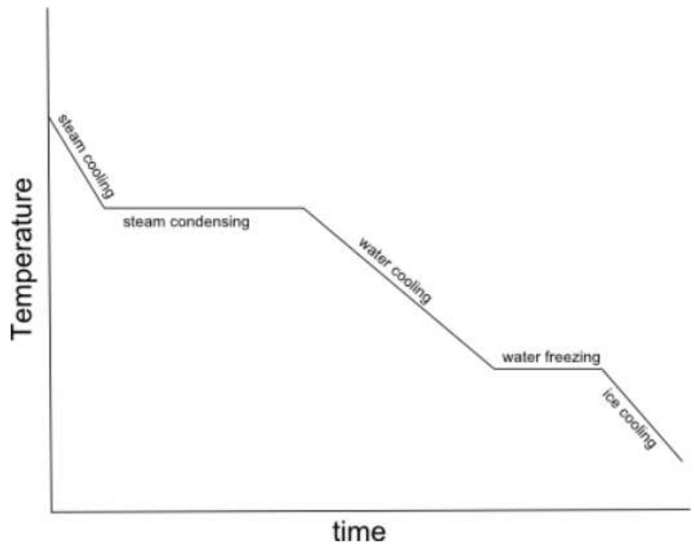
Heating Curve (endothermic)



During the phase changes of a heating curve the KE remains constant while PE increases (heat is absorbed during heating) to allow the molecules to move farther apart together and IMF are overcome.

Oct 19-11:43 AM

Cooling Curve (exothermic)



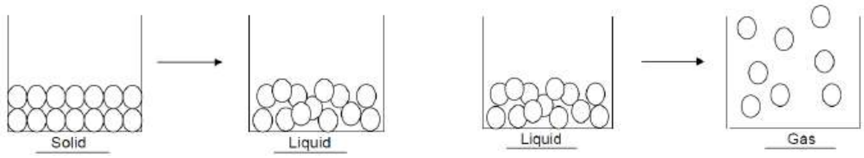
During the phase changes of a cooling curve the KE remains constant while PE decreases (heat is lost during cooling) to allow the molecules to move closer together and IMF increases.

Oct 19-11:43 AM

Heating and Cooling Curves

- Shows the temperature of each phase change when temperature is constant. (flat line)
- Shows the boiling point and melting point of a substance.
- Can be used to determine the phase of matter at a given temperature.
- Can be used to determine if the substance needs more energy to melt (fusion) or boil (vaporize).

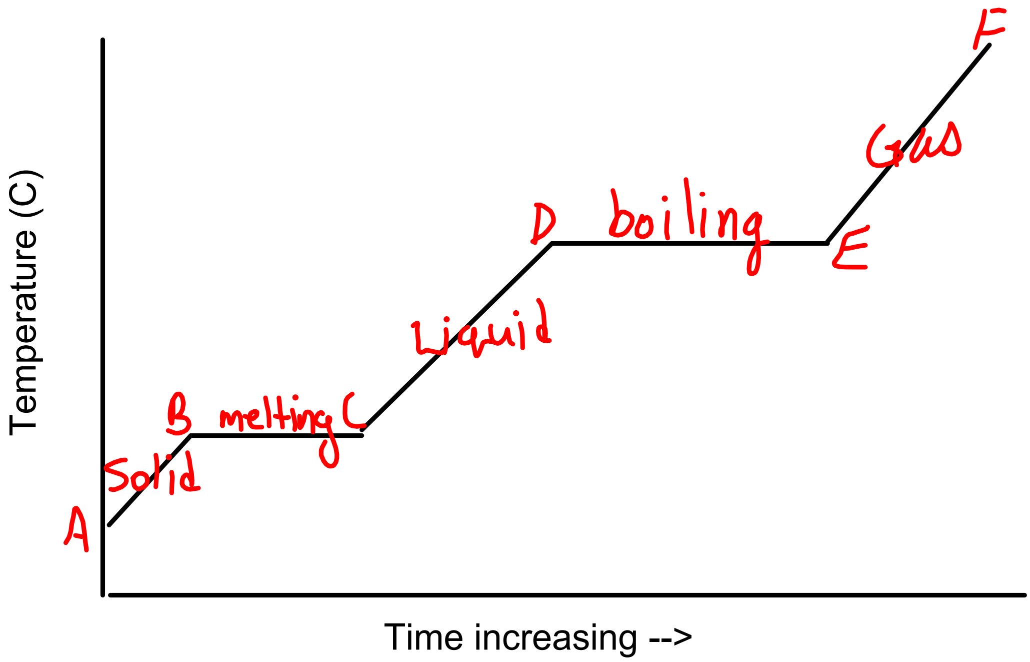
For water--> **Hf= 334 J/g** **Hv= 2260 J/g**



It takes more heat to vaporize water than to boil because more IMF must be overcome during vaporization than during melting. (more space between the molecules needed to form a gas than a liquid)

Oct 6-1:49 PM

Model 2: Temperature of a Substance as Heat is Added Over Time



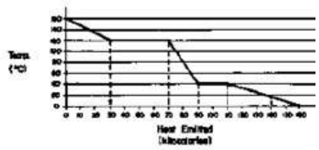
Oct 6-7:00 PM

1. At what temperature does the substance begin to melt?
2. What temperature does it boil?
3. At which section is the substance a solid? liquid? gas?
4. What sections of the graph have constant kinetic energy?
5. What sections of the graph have constant potential energy?

Oct 6-7:25 PM

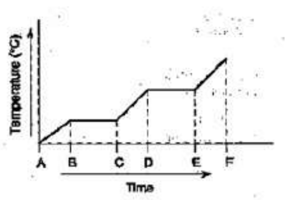
Practice Problems

1. The graph below represents the uniform cooling of a substance, starting as a gas at 160°C. At which temperature does a phase change occur for this substance?



A) 0°C
B) 40°C
C) 80°C
D) 140°C

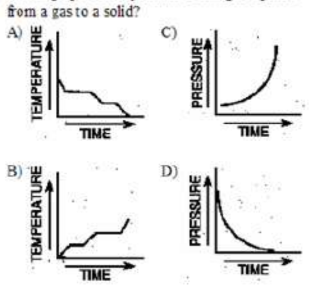
2. The diagram below represents the uniform heating of a substance that is a solid at Time *A*.



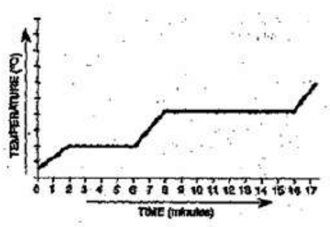
Between which times could the heat of fusion be determined?

A) *A* and *B*
B) *B* and *C*
C) *C* and *D*
D) *E* and *F*

3. Which graph best represents a change of phase from a gas to a solid?



4. The graph below was constructed by a student to show the relationship between temperature and time as heat was uniformly added to a solid below its melting point.



What is the total length of time that the solid phase was in equilibrium with the liquid phase?

A) 6 min
B) 10 min
C) 8 min
D) 4 min

Oct 6-5:25 PM

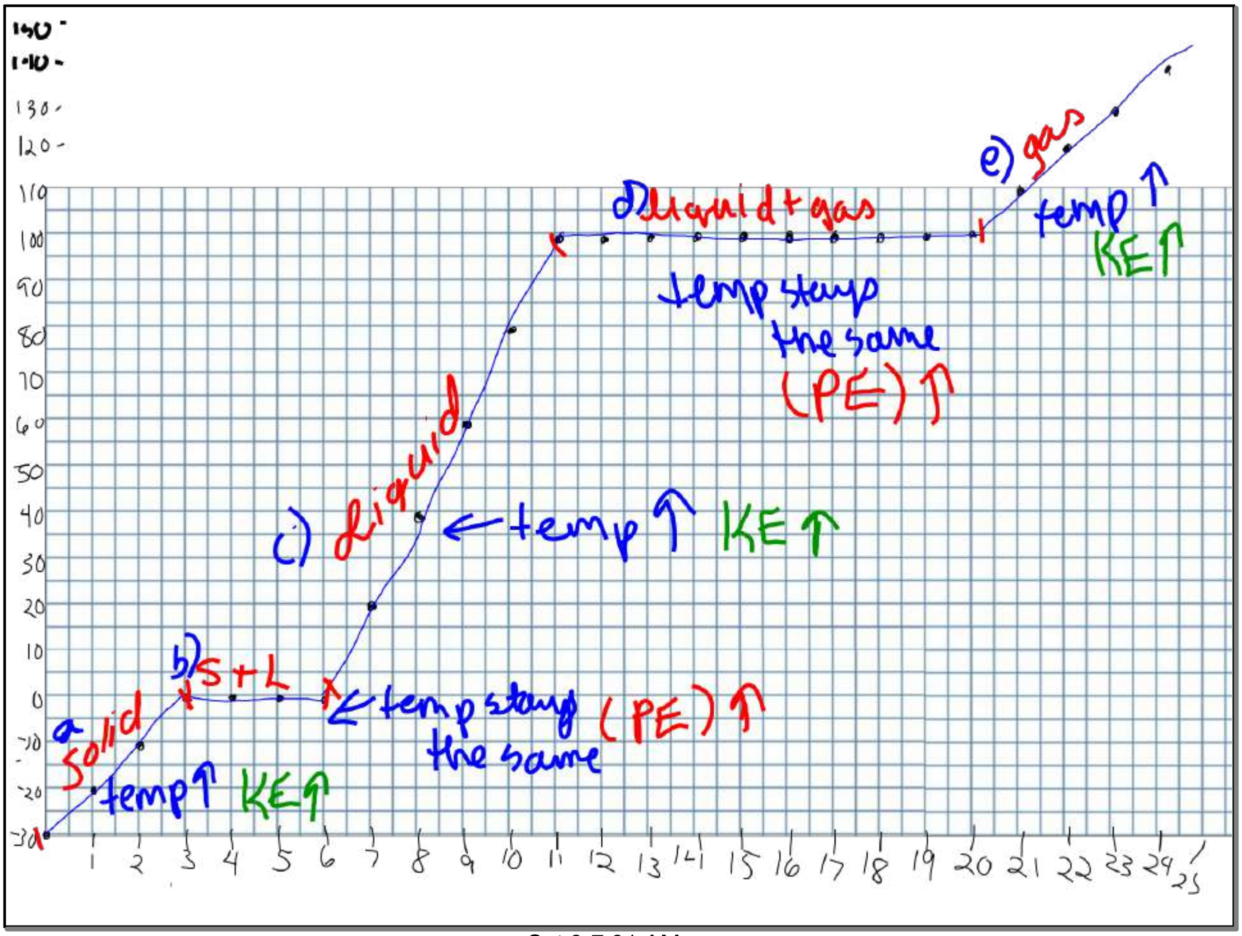
Practice Problems

5. At which point do a liquid and a solid exist at equilibrium?
   A) sublimation point C) boiling point
   B) vaporization point D) melting point

6. As water vapor condenses at 100°C, the potential energy of the molecules
   A) decreases C) remains the same
   B) increases

7. Which change of phase is exothermic?
   A) $H_2O(s) \rightarrow H_2O(g)$
   B) $CO_2(s) \rightarrow CO_2(\ell)$
   C) $H_2S(g) \rightarrow H_2S(\ell)$
   D) $NH_3(\ell) \rightarrow NH_3(g)$

Oct 6-5:26 PM



Oct 8-7:31 AM