

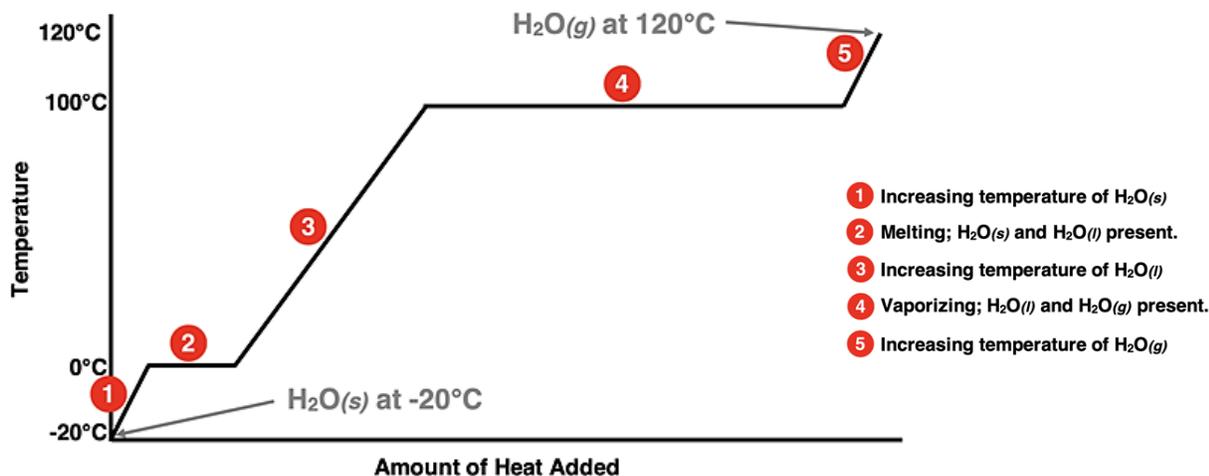
## Changes of State

Read from Lesson 2a: [Boiling and Melting](#) in the Chemistry Tutorial Section, Chapter 11 of The Physics Classroom.

## Phase Change Definitions

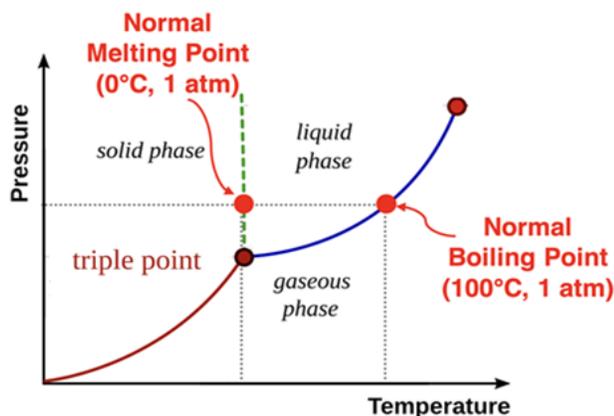
- **Melting:** Transition from a solid to a liquid as particles gain enough potential energy to overcome their rigid structure.
- **Freezing:** Opposite of melting; liquid becomes a solid as particles lose potential energy and form a fixed arrangement.
- **Vaporization:** Liquid changes to gas, either through boiling (entire liquid) or evaporation (surface level), as particles gain enough potential energy to escape the liquid state.
- **Condensation:** Gas cools down and transforms into a liquid as particles lose potential energy and come closer together.
- **Sublimation:** Solid turns directly into gas without passing through the liquid phase, like dry ice sublimating into CO<sub>2</sub> gas.
- **Deposition:** The reverse of sublimation; gas changes directly into a solid, as in frost forming on surfaces.

Heating Curves of Water (Graph representing temperature changes over time as heat energy is added)



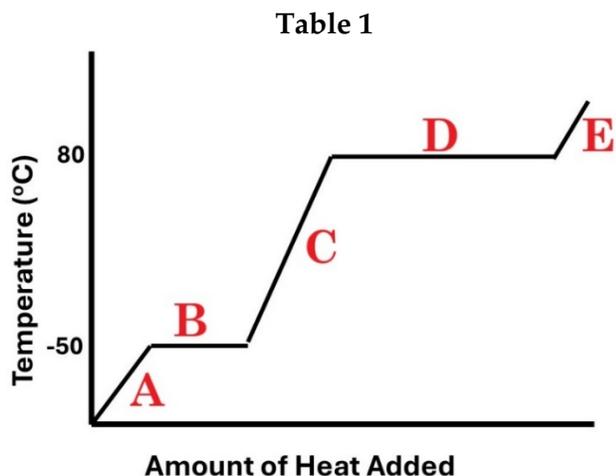
\*\*\*\*\* Remember that heating and cooling involve a gain or loss of kinetic energy (regions 1,3, and 5) and phase changes involve a gain or loss of potential energy (regions 2 and 4).

Phase Diagram of Water (Graph representing relationship between pressure, temperature, & states of matter)

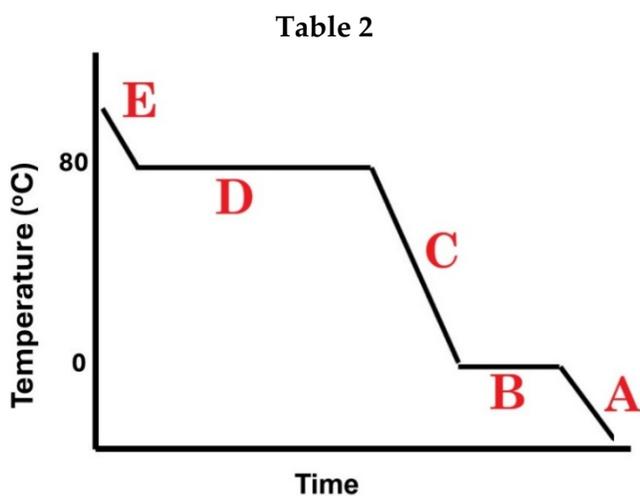


## Solids, Liquids, and Intermolecular Forces

**Part 1: Heating/Cooling Curve Questions** Use the heating curves shown below to answer the following questions.



1. In Table 1, what is the
  - a. melting point of the substance?
  - b. boiling point of the substance?
  - c. freezing point of the substance?
2. What is occurring during the area marked "D" on the heating curve?



3. In Table 2, what is the
  - a. condensation point of the substance?
  - b. melting point of the substance?
  - c. boiling point of the substance?
4. What is occurring during the area marked "C" on the cooling curve?

5. During which sections (A,B, C, D, or E) is kinetic energy changing? Potential energy changing?
6. Which sections (A,B, C, D, or E) involve the liquid phase? (There is more than one.)
7. Are any of these substances water? Explain your reasoning.
8. Are any of these substances a gas at room temperature? How do you know?

## Solids, Liquids, and Intermolecular Forces

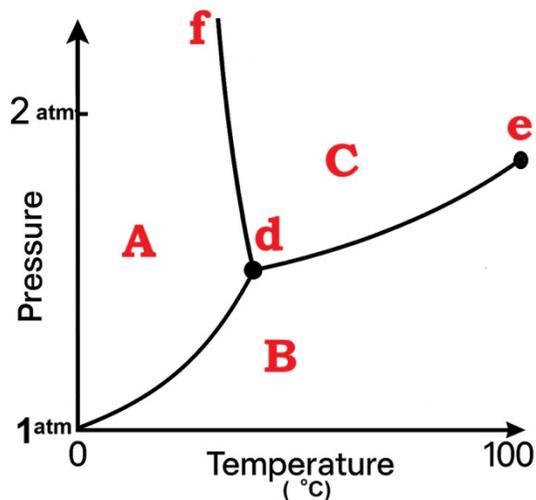
### Part 2: Phase Diagram Questions

Use the phase diagram shown below to answer the following questions.

Point **d** has the coordinates of  $35^{\circ}\text{C}$ ,  $1.5\text{ atm}$ .

Point **e** has the coordinates of  $100^{\circ}\text{C}$ ,  $1.8\text{ atm}$ .

Point **f** has the coordinates of  $30^{\circ}\text{C}$ ,  $2.4\text{ atm}$ .



1. What section represents the solid phase?
2. What section represents the liquid phase?
3. What section represents the gas phase?
4. What letter represents the triple point?
5. What letter represents the critical point?
6. At what temperature and pressure do all three phases coexist?
7. Above what temperature is it impossible to liquify this substance no matter what the pressure?
8. If this substance were at a pressure of  $2.0\text{ atm}$ , at what approximate temperature would it boil?
9. If this substance were at a pressure of  $2.0\text{ atm}$ , at what approximate temperature would it melt?
10. If this substance were initially at a temperature of  $50^{\circ}\text{C}$  and pressure of  $1.6\text{ atm}$ , and the pressure was lowered to  $1.0\text{ atm}$ , what phase change would occur?
11. If this substance were initially at a temperature of  $90^{\circ}\text{C}$  and pressure of  $1.2\text{ atm}$ , and the temperature was lowered to  $0^{\circ}\text{C}$ , what phase change would occur?
12. Is this a phase diagram for water? Explain your reasoning.