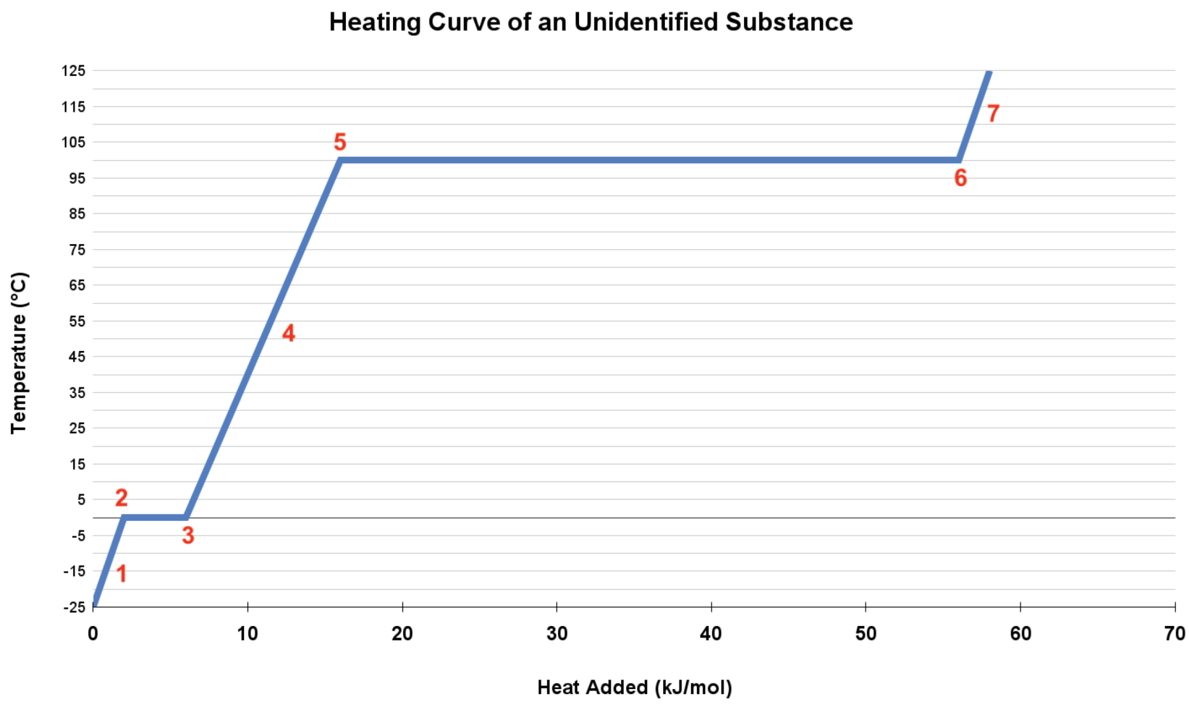
STUDENT CHECK FOR UNDERSTANDING

Concepts: Types of Phase Change, Melting/Freezing Point, Boiling/Condensation Point, Relative Energy of Phase Change, Breaking/Forming IMFs

DIRECTIONS:
Below is a simplified heating curve made for a substance **at a pressure of 1 atmosphere**. It shows the temperature changes that occur in a quantity of the substance as it is heated. Use the graph to answer the questions on the next page.



1. At which point is the average kinetic energy of the molecules the greatest? Explain your answer.

The average kinetic energy of the molecules is greatest at point 7. Temperature is a measure of the average kinetic energy of particles in a substance. Since the molecules have received a lot of heat by point 7, they will be moving more rapidly and thus have a greater kinetic energy than at any other point. This is best reflected in their higher temperature at point 7.

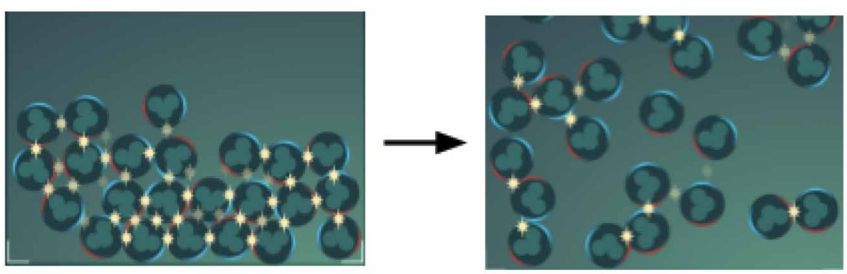
2. What is the condensation point of this substance at 1 atmosphere of pressure? How do you know?

The condensation point of this substance is at 100°C. One can tell by determining that the segment of the graph between point 5 and point 6 is the heat of vaporization—the energy required to convert the substance from a liquid to a gas. Accordingly, the temperature at which we see the heat of vaporization in this graph is the boiling point, which is the same as the condensation point.

3. In some instances, ALL added heat energy is going into the disruption of the intermolecular forces between particles. Identify two such areas in the heating curve (using adjacent points), and explain the visible evidence for your answer.

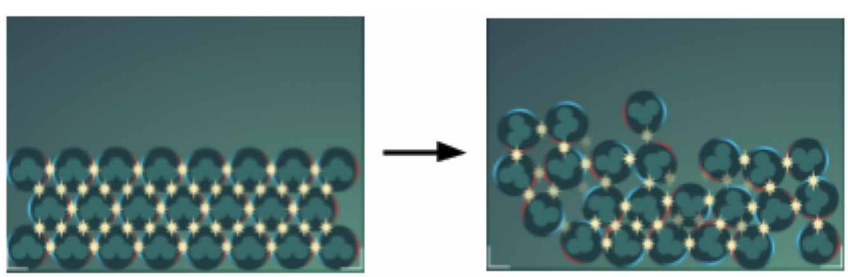
The graph between point 2 and point 3 and then again between point 5 and point 6 represents the energy needed to disrupt the intermolecular forces between particles. We know this because even though heat is being added, there is no change in temperature. The added heat is not increasing the average kinetic energy of the molecules (the temperature) because it is disrupting the intermolecular forces that keep the substance in a particular state of matter.

4. The image below represents a phase change occurring between two adjacent points on the heating curve. Identify the points at which this phase change occurs, and name the type of phase change.



Between Point 5 and Point 6→ boiling

5. The image below represents a phase change occurring between two adjacent points on the heating curve. Identify the points at which this phase change occurs, and name the type of phase change.



Between Point 2 and Point 3→ melting

6. The substance in the heating curve is capable of hydrogen bonding. Explain **two ways** that the positions of points **2** and **3** as well as points **5** and **6** would be different in a molecule of a similar size but with only London dispersion forces.

1. **The temperature at which those points occur would likely be much lower. Point 2 to point 3 represents melting and point 5 to point 6 represents boiling. Hydrogen bonding generally increases melting and boiling points, so you would expect those points to be at a lower temperature with London dispersion forces as the IMF type.**

2. **The space between the points would be smaller. Since the space between the points represents the energy needed to disrupt the intermolecular forces between particles, a relatively strong intermolecular force like hydrogen bonding increases the distance between these two sets of points. In a substance with only LDF, the positions between points 2 and 3, and between 5 and 6 would be smaller due to an easier disruption of the IMF type.**

7. Considering points **1, 4**, and **7**, at what point is the substance showing the most resistance to a change in its temperature? Explain how you know.

The substance shows the greatest resistance to temperature change at point 4. This can be determined by briefly analyzing the slope of the curve at those points. The segment where point 1 is located shows a temperature increase of 25°C after the addition of only about 1 kJ/mol of energy. The segment where point 7 is located also shows a similar temperature increase after the addition of that same amount of energy. The segment where point 4 is located, however, takes about 7-8 kJ/mol of energy to raise the temperature 100°C. That represents an increase of only around 13°C per 1 kJ/mol of energy added as compared to the ~25°C in the other two segments.