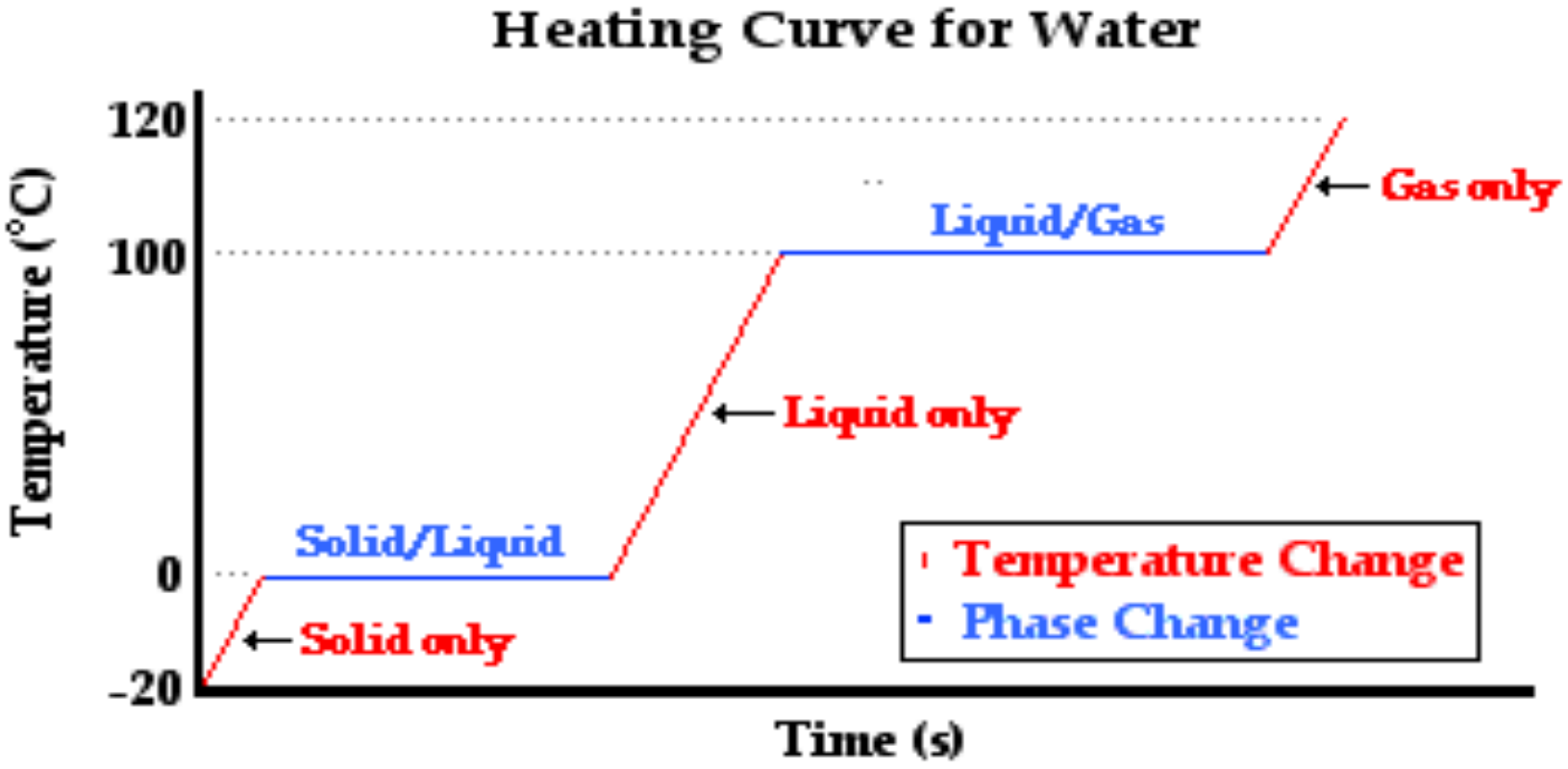
Heating and Cooling Curves

April 23, 2015

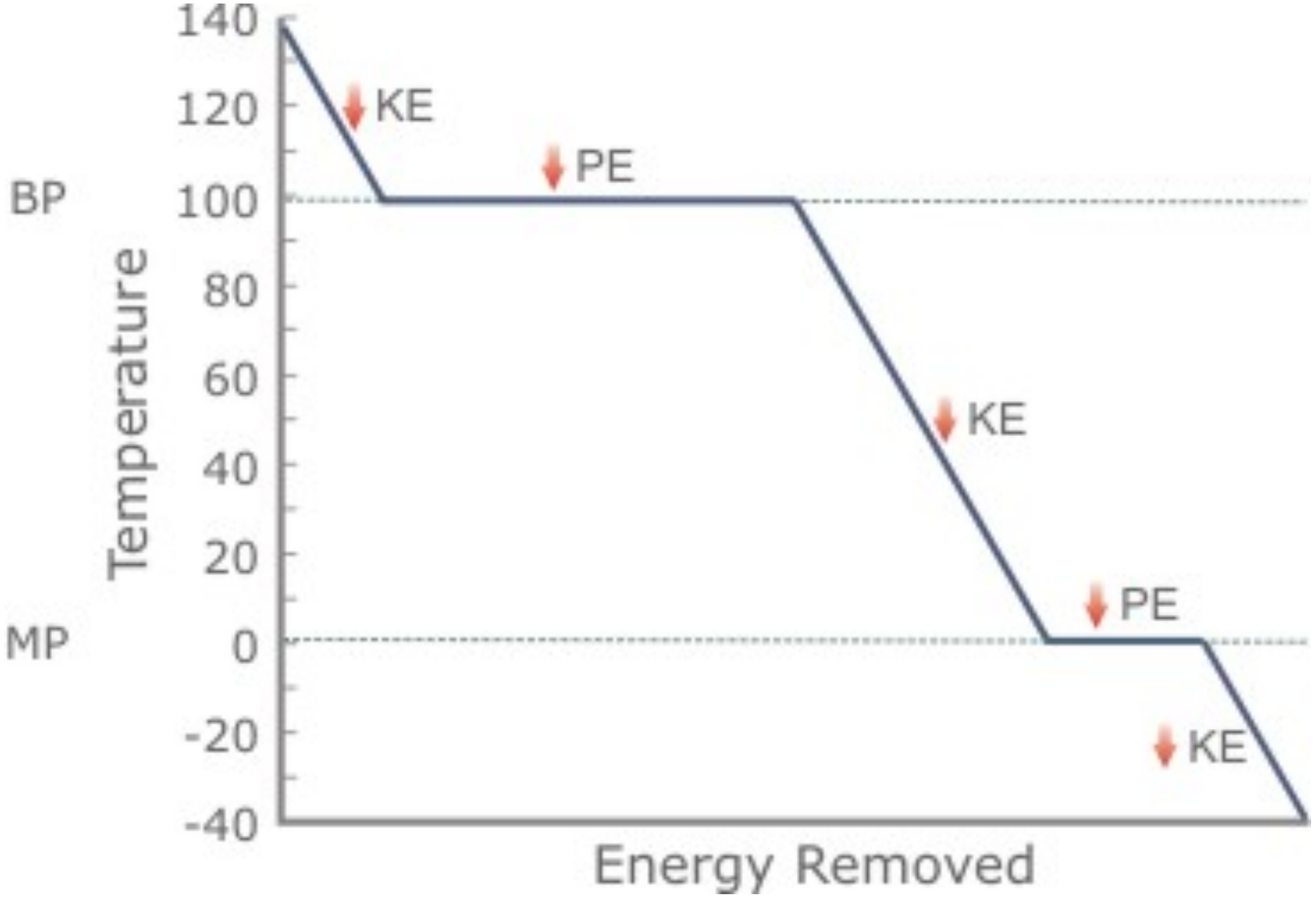
Chemistry CP

Heating/Cooling Curve Revisited

- **Potential Energy**: energy of position (stored energy)
  - During phases changes
- **Kinetic Energy:** energy of motion (temperature)
  - Increases as temperature increases



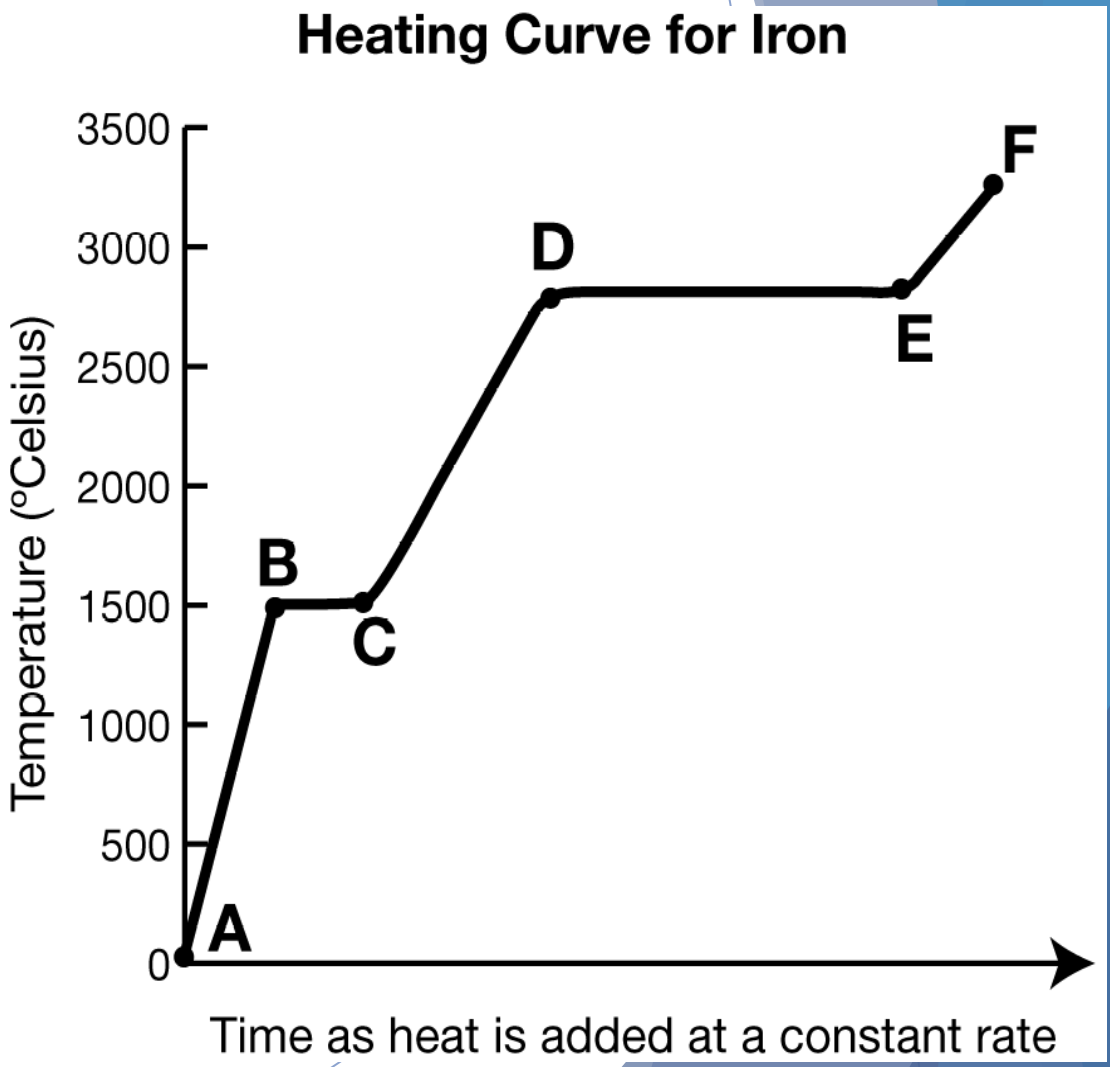
Cooling Curve for Water



Heating/Cooling Curve

PRACTICE

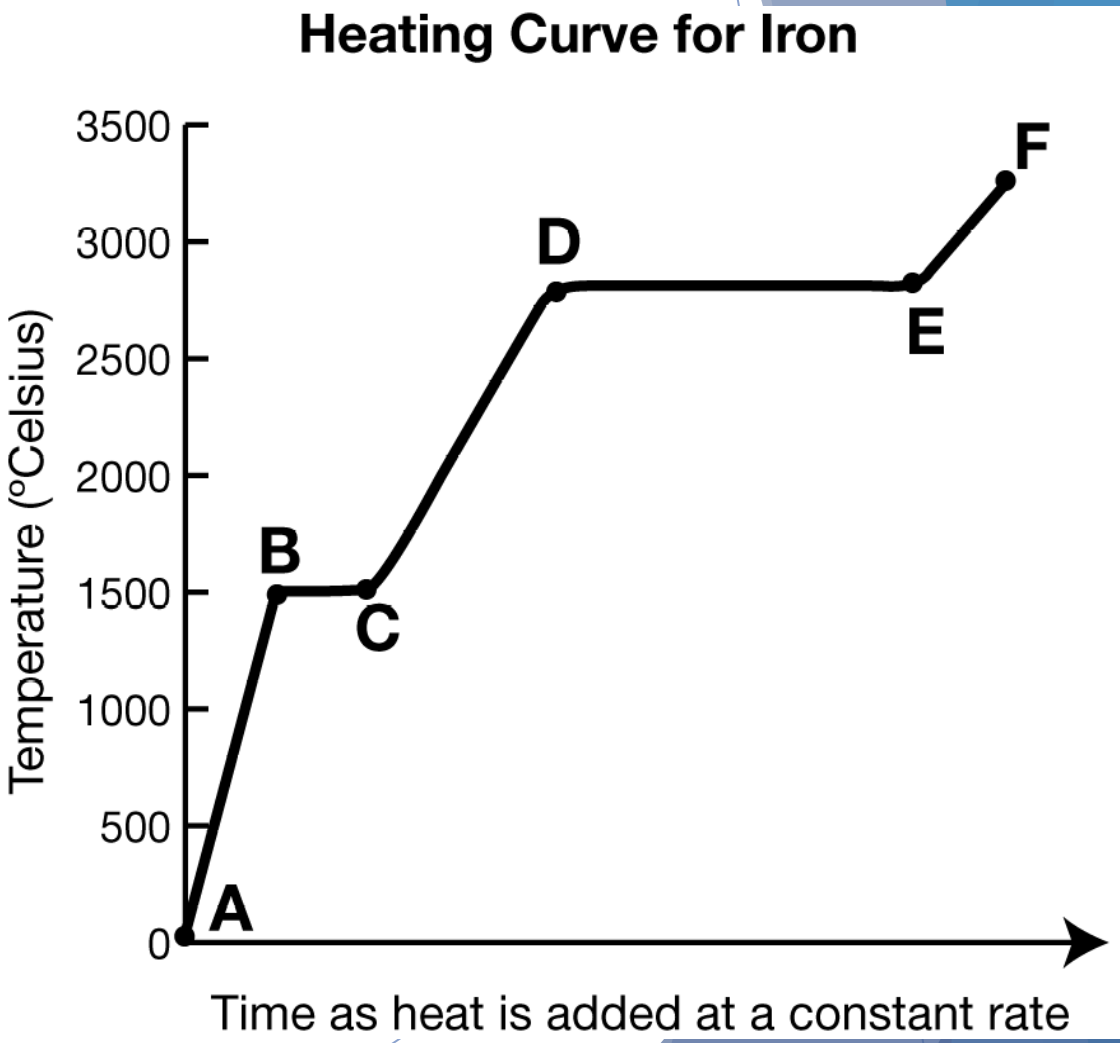
1. In the heating curve for iron, describe the phase change that occurred between points B and C on the graph.



Heating/Cooling Curve

PRACTICE

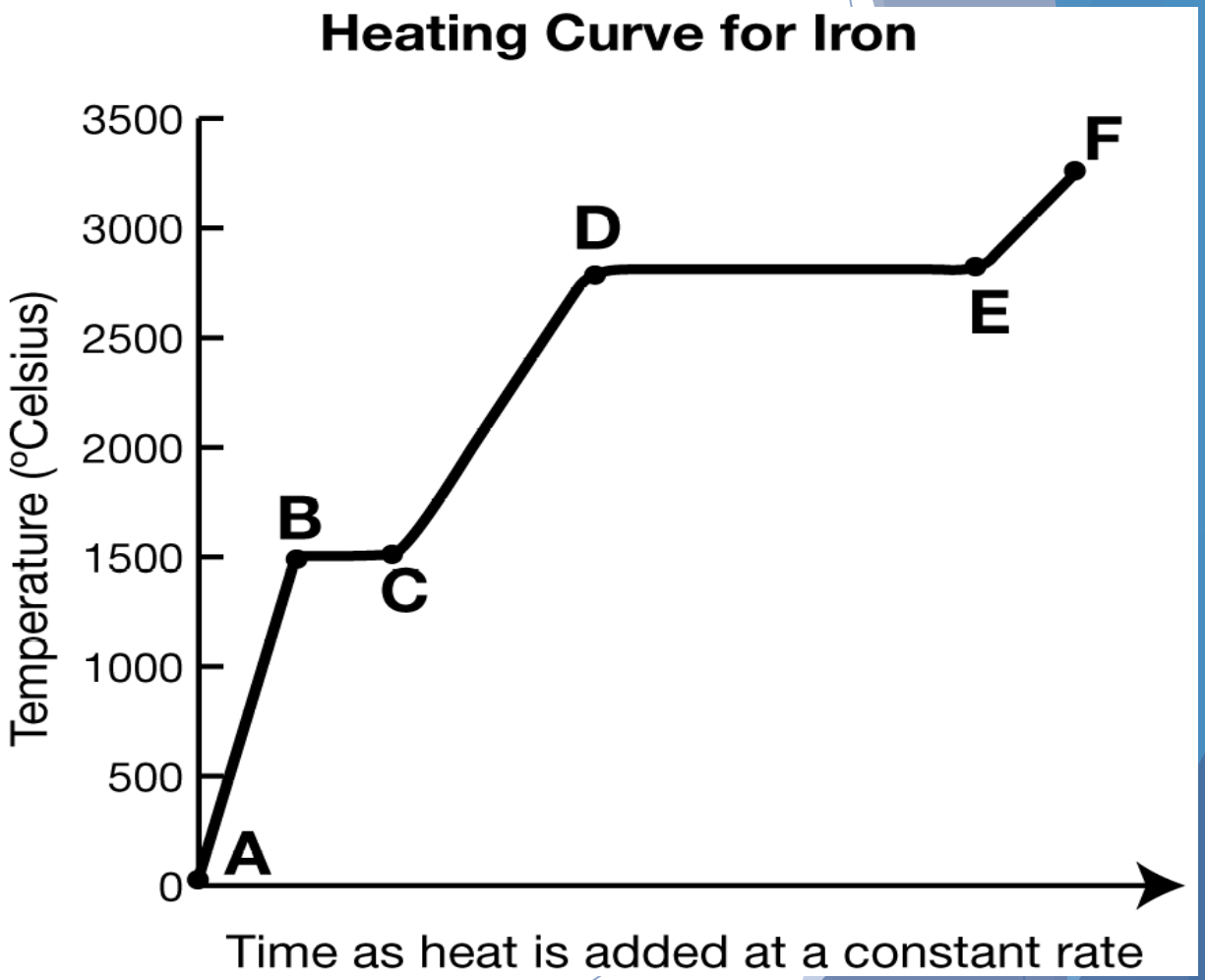
2. Explain why the temperature stayed constant between points B and C.



Heating/Cooling Curve

PRACTICE

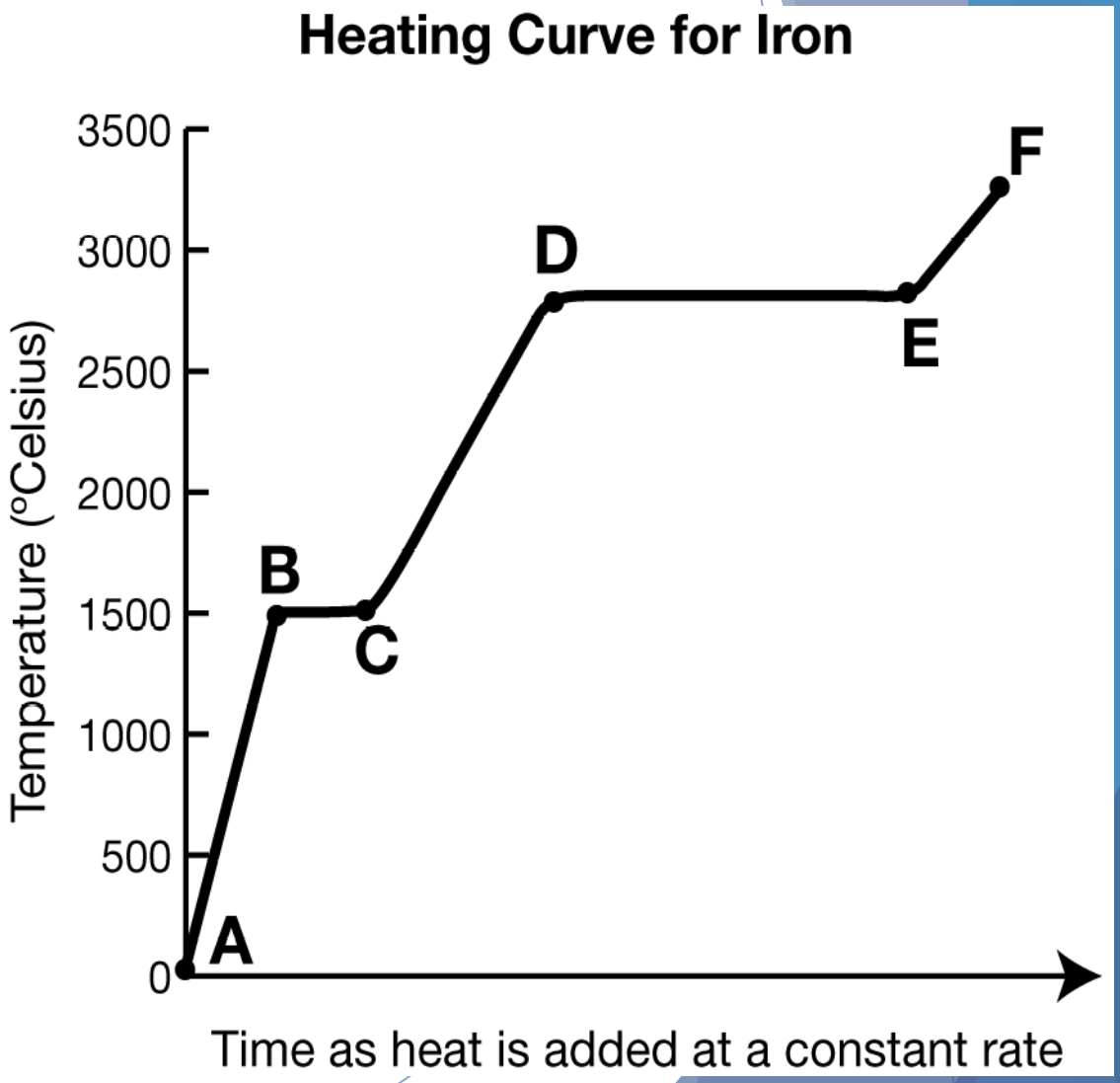
3. What is the melting temperature of iron?



Heating Cooling Curve

PRACTICE

4. What is the boiling temperature of iron?



Calculating Heat Involved in a Phase Change

- The energy required to melt one gram of a substance at its melting point is called the **heat of fusion** (ΔH_{fusion})
  - **It is different for each substance**
  - **The units are joules or calories per gram**
- To calculate the energy to melt a substance at its melting point we use the following formula: $Q = m \times \Delta H_{fus}$

Ex. Problem: Calculating Heat Involved in a Phase Change

- Calculate the energy necessary to melt 50 grams of water.
  Heat of fusion (H_{fusion}) of water = 334 J/g

- **$Q = m \times H_{fusion} = 50\ g \times 334 J/g = 16{,}700 J$**

Calculating Heat Involved in a Phase Change

- The energy required to boil one gram of a substance at it boiling point is called the **heat of vaporization** (ΔH_{vap})
  - **It is different for each substance**
  - **The units are joules or calories per gram**
- To calculate the energy to boil a substance at its melting point we use the following formula: $Q = m \times \Delta H_{vap}$

Ex. Problem: Calculating Heat Involved in a Phase Change

- Calculate the energy necessary to boil 150 g of water. Heat of vaporization (ΔH_{vap}) = 2260 J/g.

- **$Q = m \times \Delta H_{vap} = 150\ g \times 2260\ J/g$**
- **$Q = 339{,}000\ J$**

Calculating Energy Required to Make a Temperature and Phase Change

- How much energy is needed to raise the temperature of 250 grams of water from 25°C to it's boiling point and then boil it? The specific heat of water is 4.18 J/g°C and the heat of vaporization is 2260 J/g.

Let's Solve

Step 1: Calculate the energy necessary to raise the temperature from 25°C to 100°C

$$Q = m \times \Delta T \times Cp$$

$$Q = 250g \times (100^{o}C - 25^{o}C) \times 4.18J/g^{o}C$$

$$Q = 78,375\ J$$

Step 2 Calculate the energy necessary to boil the water

$$\Delta H_{vap} = m \times H_{vap}$$

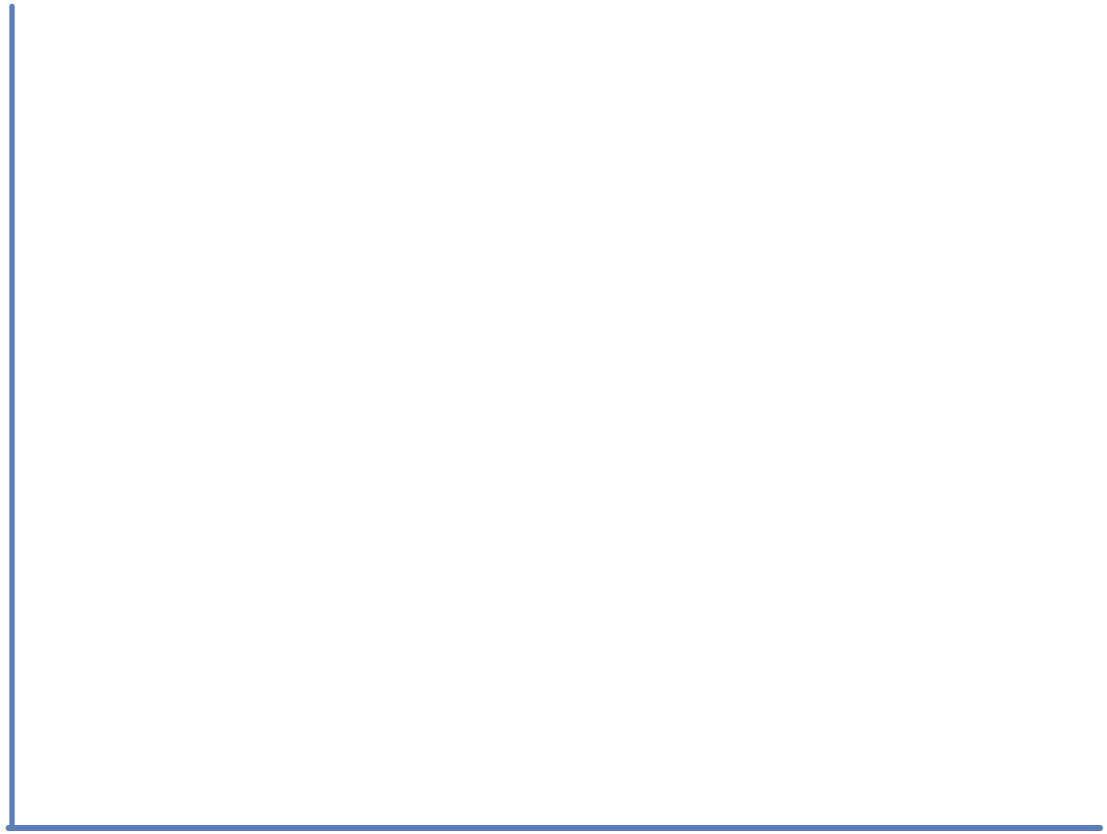
$$\Delta H_{vap} = 250g \times 2260\ J/g = 565,000\ J$$

Step 3 Add together the results of steps 1 and 2

$$78,375J + 565,000J = 643,375J$$

Five Step Problem for Water

Draw a heating curve for water, going from -20°C to 125°C on the axis below. Determine the heat needed to 15 g of ice at -20°C to 125°C.



Five Step Problem for Water

The data below are for water (H_2O)

Melting point	Boiling Point	Heat of Fusion	Heat of Vapor.	Cp (solid)	Cp liquid)	Cp (vapor)
0.0°C	**100.0°C**	**334 J/g**	**2260 J/ g**	**2.05 J/ g°C**	**4.18 J/ g°C**	**1.90 J/ g°C**

Determine the heat needed to 15 g of ice at -20°C to 125°C.

1. **Heat needed to raise the temperature of ice at -20°C to 0°C.**

Five Step Problem for Water

The data below are for water (H_2O)

Melting point	Boiling Point	Heat of Fusion	Heat of Vapor.	Cp (solid)	Cp liquid)	Cp (vapor)
0.0°C	**100.0°C**	**334 J/g**	**2260 J/ g**	**2.05 J/ g°C**	**4.18 J/ g°C**	**1.90 J/ g°C**

Determine the heat needed to 15 g of ice at -20°C to 125°C.

2. Heat needed to melt ice 0°C.

Five Step Problem for Water

The data below are for water (H_2O)

Melting point	Boiling Point	Heat of Fusion	Heat of Vapor.	Cp (solid)	Cp liquid)	Cp (vapor)
0.0°C	**100.0°C**	**334 J/g**	**2260 J/ g**	**2.05 J/ g°C**	**4.18 J/ g°C**	**1.90 J/ g°C**

Determine the heat needed to 15 g of ice at -20°C to 125°C.

3. Heat needed to raise temperature of water from 0°C to 100°C.

Five Step Problem for Water

The data below are for water (H_2O)

Melting point	Boiling Point	Heat of Fusion	Heat of Vapor.	Cp (solid)	Cp liquid)	Cp (vapor)
0.0°C	**100.0°C**	**334 J/g**	**2260 J/ g**	**2.05 J/ g°C**	**4.18 J/ g°C**	**1.90 J/ g°C**

Determine the heat needed to 15 g of ice at -20°C to 125°C.

4. Heat needed to vaporize water at 100°C.

Five Step Problem for Water

The data below are for water (H_2O)

Melting point	Boiling Point	Heat of Fusion	Heat of Vapor.	Cp (solid)	Cp liquid)	Cp (vapor)
0.0°C	**100.0°C**	**334 J/g**	**2260 J/ g**	**2.05 J/ g°C**	**4.18 J/ g°C**	**1.90 J/ g°C**

Determine the heat needed to 15 g of ice at -20°C to 125°C.

5. Heat needed to raise temperature of water from 100 to 125°C.

Five Step Problem for Water

The data below are for water (H_2O)

Melting point	Boiling Point	Heat of Fusion	Heat of Vapor.	Cp (solid)	Cp liquid)	Cp (vapor)
0.0°C	**100.0°C**	**334 J/g**	**2260 J/ g**	**2.05 J/ g°C**	**4.18 J/ g°C**	**1.90 J/ g°C**

Determine the heat needed to 15 g of ice at -20°C to 125°C.

TOTAL HEAT: ADD UP ALL VALUES FOR Q