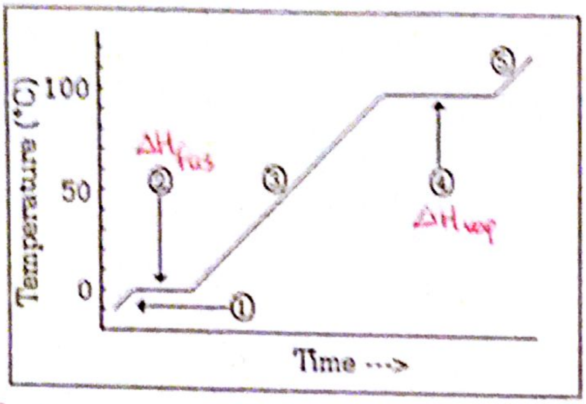
Culver City H.S. • AP Chemistry

Name KEY

Period __ Date __/__/__

6 • Thermochemistry

HEATING CURVE CALCULATIONS



In the heating and cooling curves tutorial (ChemTours, ch.5) we learned that energy is **absorbed** by a substance as it **warms up, melts** (fusion) or **boils** (vaporization) and energy is **released** from a substance as it **cools down, condenses, or freezes.**

Calorimetry ($q=mC\Delta T$) allows us to calculate the energy changes as a substance **warms or cools**. (1, 3, & 5)

The energies involved in **phase changes** (areas 2 & 4) are the **Heat of Vaporization** (liquid → gas) and the **Heat of Fusion** (solid → liquid). These energies will be used as conversion factors.

①③⑤ $q = mC\Delta T$

① C_{ice}

③ C_{water}

⑤ C_{steam}

Heat of Vaporization or Heat of Condensation of water	Heat of Fusion (melting) or Heat of Solidification of water
$H_{vap} = \frac{2330\text{ J}}{\text{gram}}$	$H_{fus} = \frac{335\text{ J}}{\text{gram}}$

Joules (J) are energy units. It takes 4.184 Joules of energy to heat 1 gram of water by 1 °C.

Examples:

Calculate the energy needed to vaporize 10.0 g of water.

$$10.0\text{ g } H_2O \times \frac{2330\text{ J}}{\text{gram}} = 23{,}000\text{ J} = 23.0\text{ kJ}$$

Calculate the energy released when 10.0 kg of water melts.

$$10.0\text{ kg } H_2O \times \frac{1000\text{ g}}{1\text{ kg}} \times \frac{335\text{ J}}{\text{gram}} = 3{,}350{,}000\text{ J} = 3{,}350\text{ kJ}$$

Do the following calculations. Show your equation for each problem. Box your answers.

1. Calculate the energy needed to vaporize…

a) 15.0 g of water $15.0\text{g } H_2O \times \frac{2330\text{J}}{1\text{g}} = 34950\text{J} = \boxed{3.50\times10^4\text{J or } 35.0\text{kJ}}$

b) 5.75 kg of water $5.75\text{kg} \times \frac{1000\text{g}}{1\text{kg}} \times \frac{2330\text{J}}{1\text{g}} = 13{,}397{,}500\text{J} = \boxed{13{,}400{,}000\text{J or } 13{,}400\text{kJ}}$

c) 3.88 moles of water $3.88\text{mol} \times \frac{18.016\text{g}}{1\text{mol}} \times \frac{2330\text{J}}{1\text{g}} = \boxed{163{,}000\text{J or } 163\text{kJ}}$

This is represented on the Heating Curve as Section 4.

2. Calculate the mass of water (in grams) that will be vaporized by…

a) 20.0 kJ of energy $20.0\,kJ \times \frac{1000\,J}{1\,kJ} \times \frac{1\,g}{2330\,J} = \boxed{8.58\,g}$

b) 175 kJ of energy $175\,kJ \times \frac{1000\,J}{1\,kJ} \times \frac{1\,g}{2330\,J} = \boxed{75.1\,g}$

c) 135 J of energy

$135\,J \times \frac{1\,g}{2330\,J} = \boxed{0.0579\,g}$

3. Calculate the energy needed to melt…

a) 23.0 g of water $23.0\,g\,H_2O \times \frac{335\,J}{1\,g} = \boxed{7710\,J \text{ or } 7.71\,kJ}$

b) 8.75 kg of water $8.75\,kg \times \frac{1000\,g}{1\,kg} \times \frac{335\,J}{1\,g} = \boxed{2{,}930{,}000\,J \text{ or } 2{,}930\,kJ}$

c) 3.25 moles of water $3.25\,mol \times \frac{18.016\,g}{1\,mol} \times \frac{335\,J}{1\,g} = \boxed{19{,}600\,J \text{ or } 19.6\,kJ}$

This is represented on the Heating Curve as Section 2.

4. Calculate the mass of water (in grams) that will be melted by…

a) 30.0 kJ of energy $30.0\,kJ \times \frac{1000\,J}{1\,kJ} \times \frac{1\,g}{335\,J} = \boxed{89.6\,g}$

b) 7.60 kJ of energy $7.60\,kJ \times \frac{1000\,J}{1\,kJ} \times \frac{1\,g}{335\,J} = \boxed{22.6\,g}$

c) 133 J of energy

$133\,J \times \frac{1\,g}{335\,J} = \boxed{0.397\,g}$

5. Calculate the energy…

a) absorbed by 35.8 g of ice melting $35.8\,g \times \frac{335\,J}{g} = 11{,}993\,J = \boxed{12.0 \times 10^3\,J \text{ or } 12.0\,kJ}$

b) released as 88.5 g of water vapor condenses $88.5\,g \times -\left(\frac{2330\,J}{g}\right) = \boxed{-206{,}000\,J \text{ or } -206\,kJ}$

c) released as 92.2 g of water freezes $92.2\,g \times -\left(\frac{335\,J}{g}\right) = \boxed{-30{,}900\,J = -30.9\,kJ}$

d) absorbed as 13.6 g of water vaporizes $13.6\,g \times \frac{2330\,J}{g} = \boxed{31{,}700\,J \text{ or } 31.7\,kJ}$

e) absorbed when 2.25 moles of ice melts $2.25\,mol \times \frac{18.016\,g}{1\,mol} \times \frac{335\,J}{1\,g} = \boxed{13{,}600\,J \text{ or } 13.6\,kJ}$

f) absorbed when 2.25 moles of water vaporizes

$2.25\,mol \times \frac{18.016\,g}{1\,mol} \times \frac{2330\,J}{1\,g} = \boxed{94{,}500\,J \text{ or } 94.5\,kJ}$

6. A 25.00 gram sample of ice at 0.0°C melts and then warms up to 20.0°C. How much energy is absorbed?

This problem is represented on the Heating Curve as Sections 2 & 3.

2 Steps

1) Melting: $25.00\,g \times \frac{335\,J}{g} = 8{,}375\,J$

2) Warming: $q = mc\Delta T$

$= (25.00\,g)(4.184\,\frac{J}{g^\circ C})(20.0^\circ C) = 2{,}092\,J$

Total $= \boxed{10{,}467\,J \text{ or } 10.467\,kJ}$