Heating Curves

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YALE UNIVERSITY
CHEMISTRY 161
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A Guided Example

Say we have a 5.00 g block ice at -10.0 °C.

How much heat does it take to convert this entire mass of ice into water vapor at 125.0 °C?

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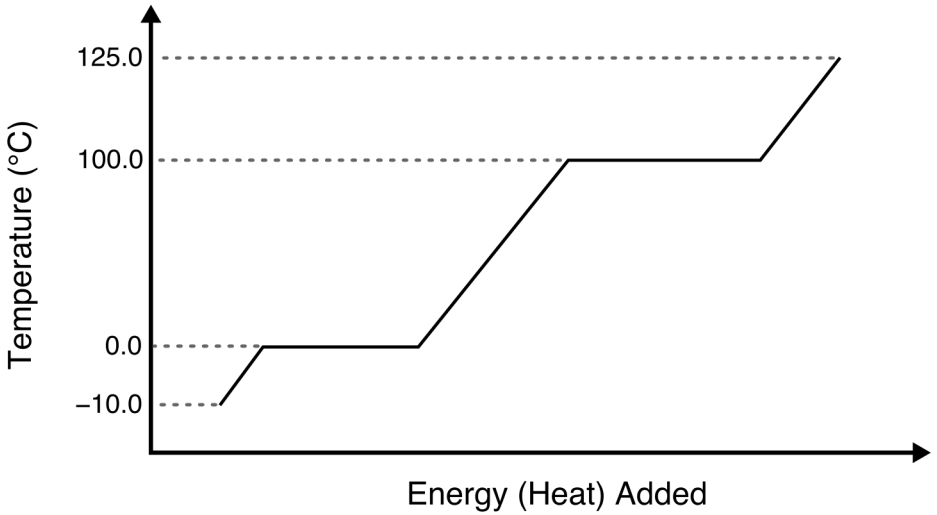

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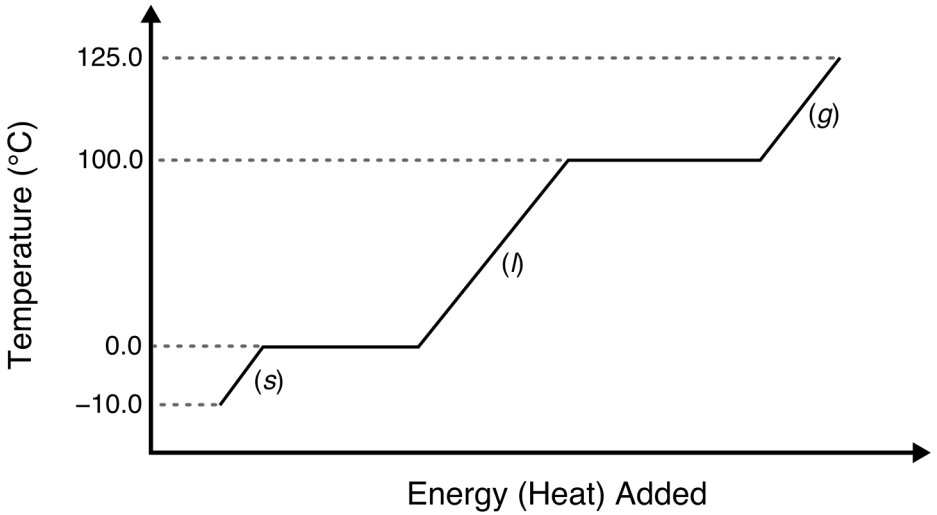

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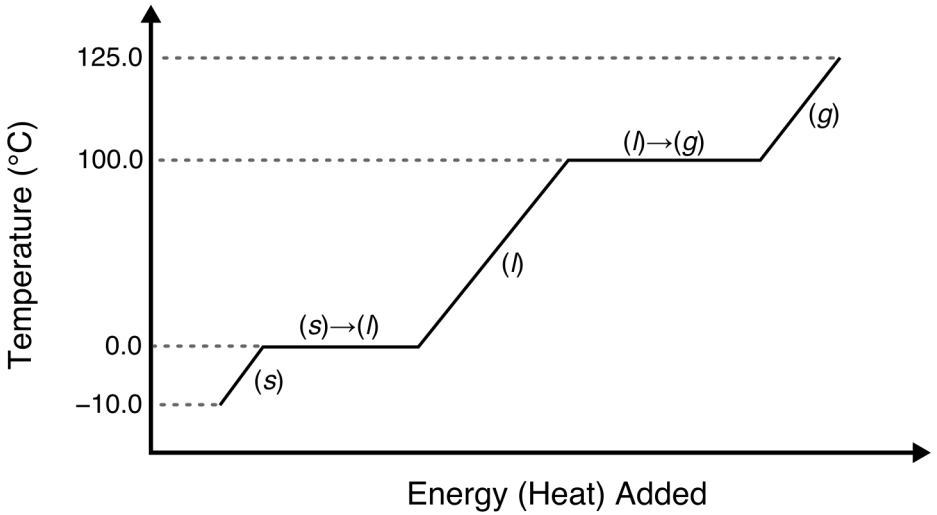

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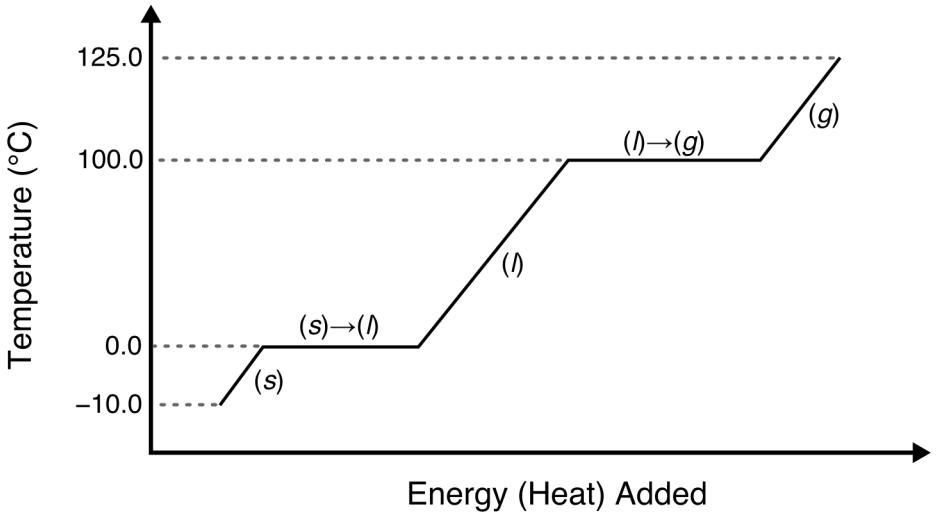

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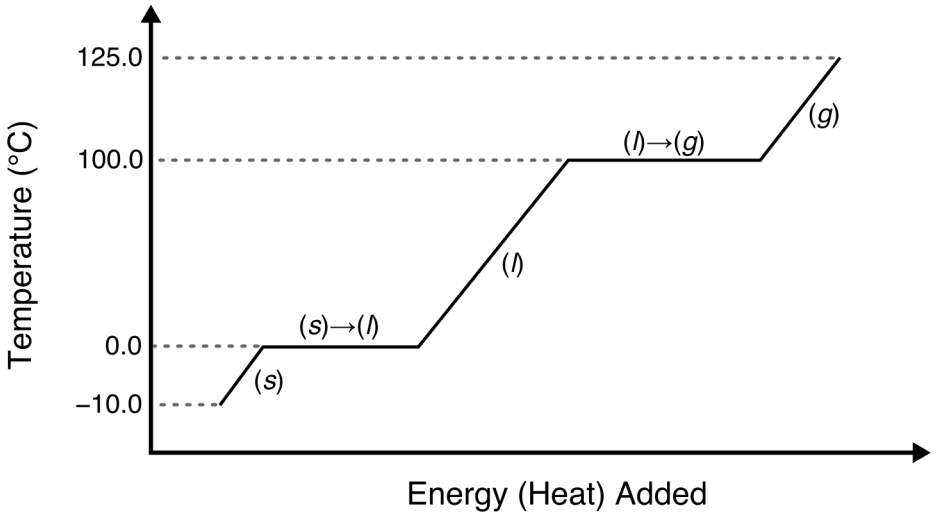

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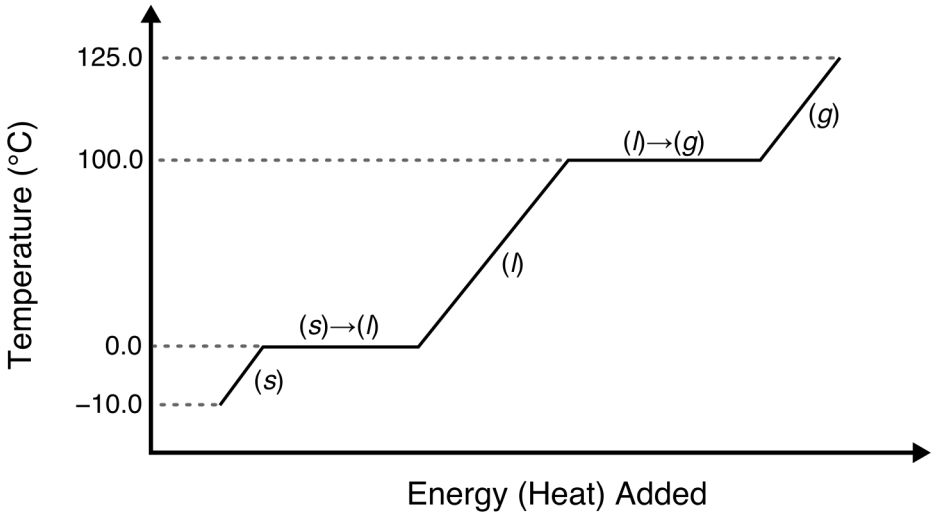

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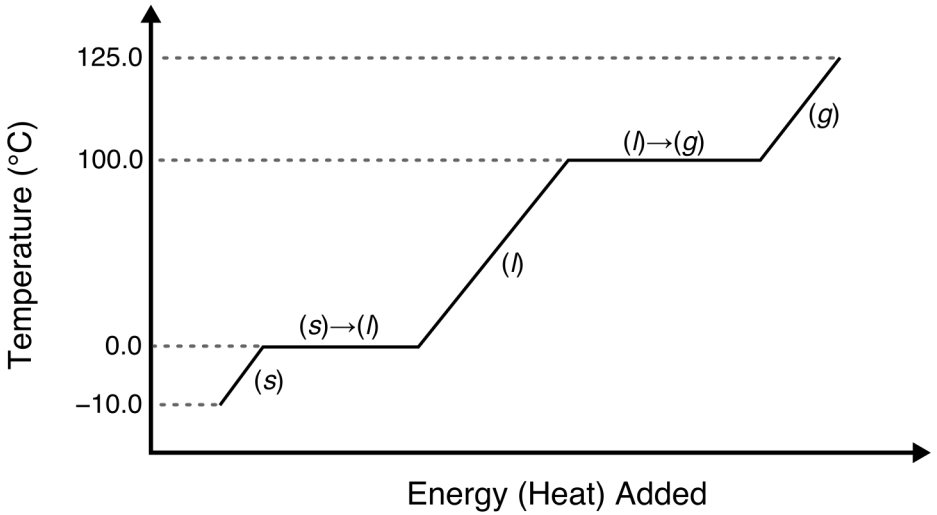

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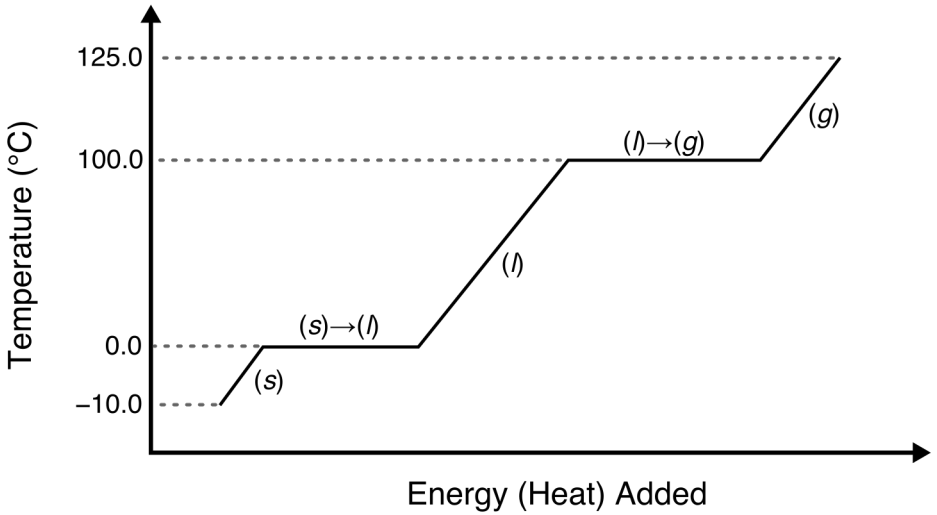

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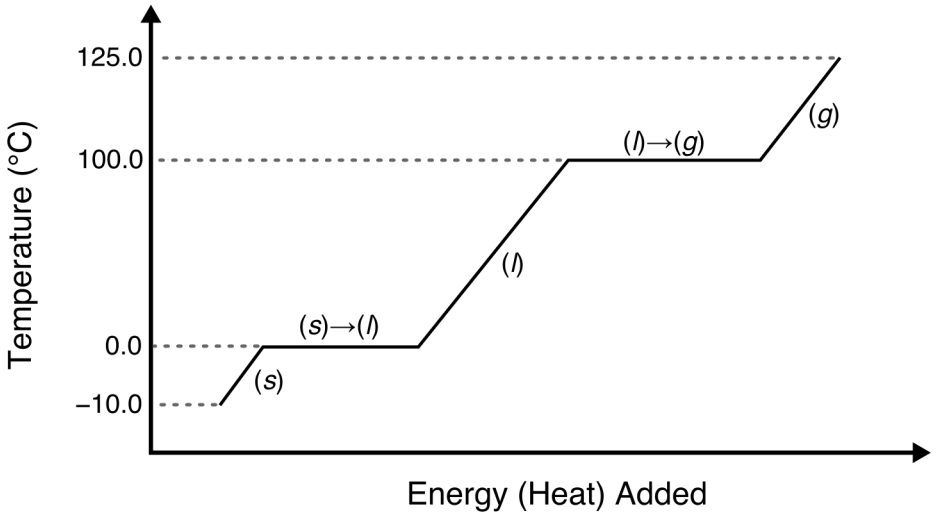

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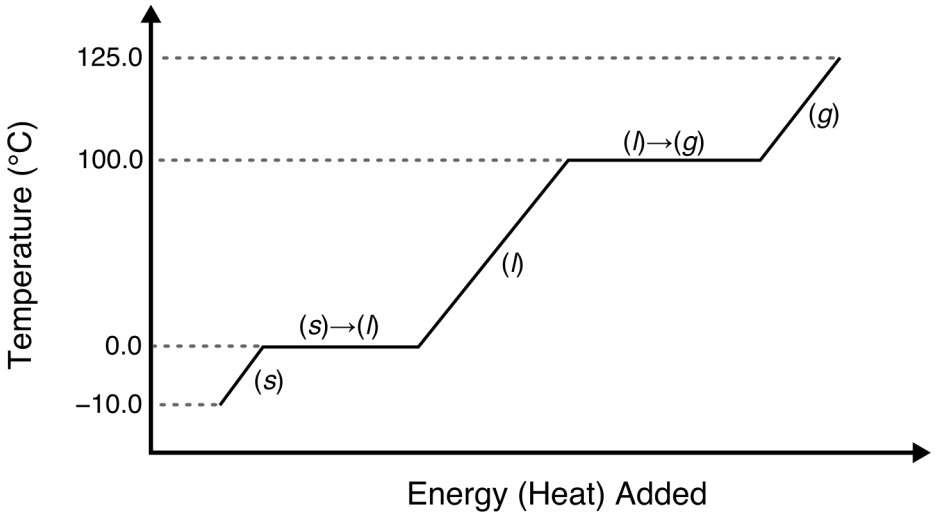

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Let's determine each of these q values one by one.

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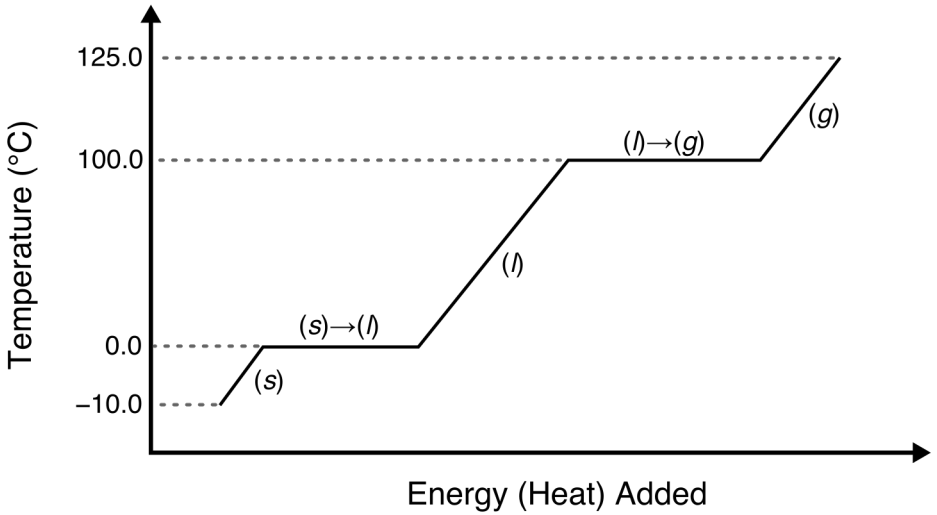

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There are five total heating regions:

- q_1 = heating ice from –10.0 °C to 0.0 °C

$$n_{H_2O} = 5.00\ \text{g}\ H_2O \times \frac{1\ \text{mol}\ H_2O}{18.02\ \text{g}\ H_2O} = 0.277_5\ \text{mol}\ H_2O$$

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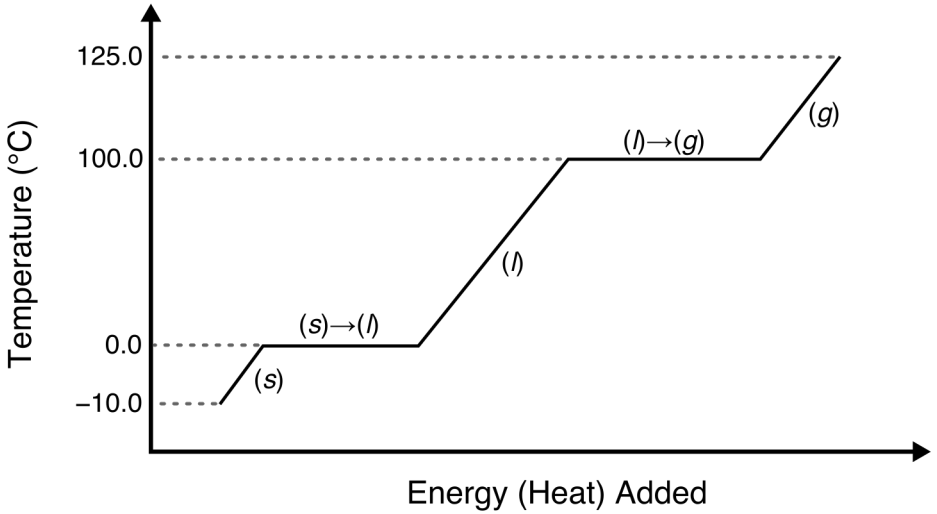

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- q_1 = heating ice from –10.0 °C to 0.0 °C

$$q_1 = nc_P\Delta T$$

$$= (0.277_5\ \text{mol})\left(37.1\ \frac{\text{J}}{\text{mol}\cdot\text{°C}}\right)(0.0\ \text{°C} - (-10.0\ \text{°C}))$$

$$q_1 = 102._9\ \text{J}$$

$$n_{H_2O} = 5.00\ \text{g}\ H_2O \times \frac{1\ \text{mol}\ H_2O}{18.02\ \text{g}\ H_2O} = 0.277_5\ \text{mol}\ H_2O$$

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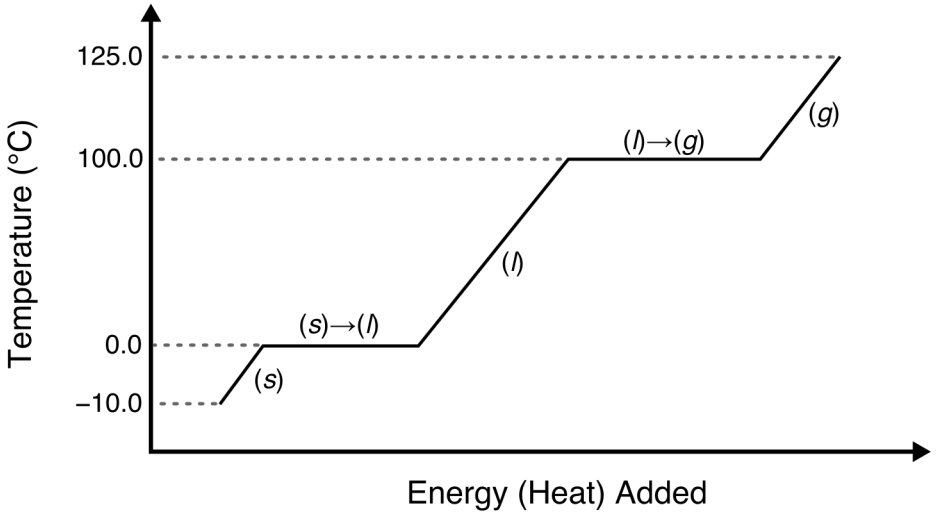

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There are five total heating regions:

- q_1 = heating ice from –10.0 °C to 0.0 °C = $102._9$ J
- q_2 = changing all ice to water at 0.0 °C

$$q_2 = n\Delta H_{fus}$$

$$= (0.277_5 \text{ mol})\left(6.01 \frac{\text{kJ}}{\text{mol}}\right)$$

$$q_2 = 1.66_8 \text{ kJ} = 166_8 \text{ J}$$

$$n_{H_2O} = 5.00 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} = 0.277_5 \text{ mol } H_2O$$

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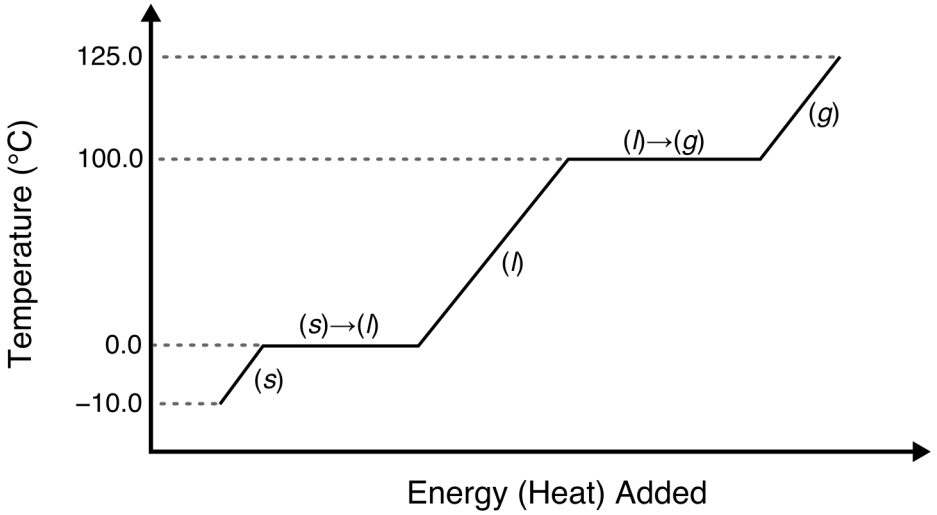

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There are five total heating regions:

- q_1 = heating ice from –10.0 °C to 0.0 °C = $102._9$ J
- q_2 = changing all ice to water at 0.0 °C = 166_8 J
- q_3 = heating water from 0.0 °C to 100.0 °C

$$q_3 = nc_P\Delta T$$

$$= (0.277_5 \text{ mol})\left(75.3\frac{\text{J}}{\text{mol}\cdot\text{°C}}\right)(100.0\text{ °C} - 0.0\text{°C})$$

$$q_3 = 208_9 \text{ J}$$

$$n_{H_2O} = 5.00\text{ g } H_2O \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O} = 0.277_5\text{ mol } H_2O$$

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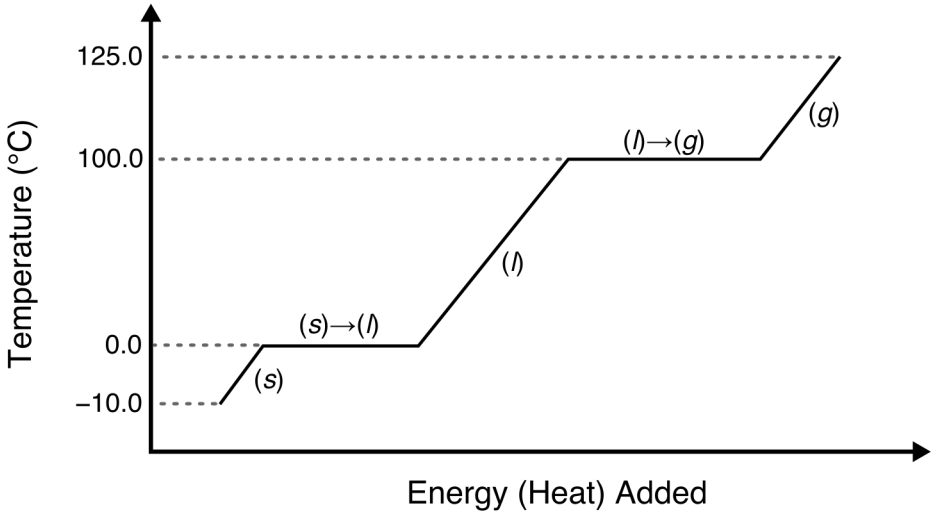

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- q_3 = heating water from 0.0 °C to 100.0 °C = 208_9 J
- q_4 = changing all water to vapor at 100.0 °C

$$q_4 = n\Delta H_{vap}$$

$$= (0.277_5 \text{ mol})\left(40.67 \frac{\text{kJ}}{\text{mol}}\right)$$

$$q_4 = 11.2_8 \text{ kJ} = 112_{84} \text{ J}$$

$$n_{H_2O} = 5.00 \text{ g } H_2O \times \frac{1 \text{ mol } H_2O}{18.02 \text{ g } H_2O} = 0.277_5 \text{ mol } H_2O$$

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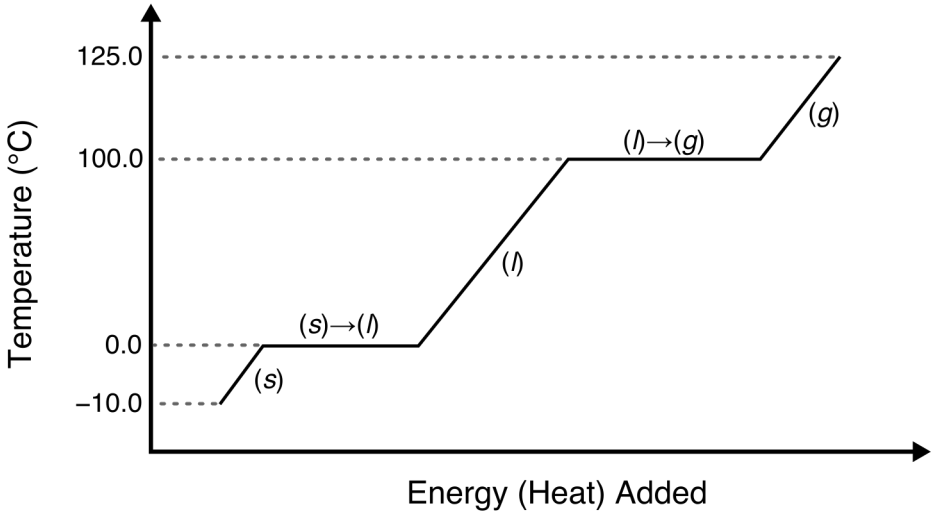

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- q_4 = changing all water to vapor at 100.0 °C = 112_{84} J
- q_5 = heating vapor from 100.0 °C to 125.0 °C

$$q_5 = nc_P\Delta T$$

$$= (0.277_5 \text{ mol})\left(33.6\frac{\text{J}}{\text{mol}\cdot\text{°C}}\right)(125.0\text{ °C} - 100.0\text{°C})$$

$$q_5 = 233._1 \text{ J}$$

$$n_{H_2O} = 5.00\text{ g } H_2O \times \frac{1\text{ mol } H_2O}{18.02\text{ g } H_2O} = 0.277_5\text{ mol } H_2O$$

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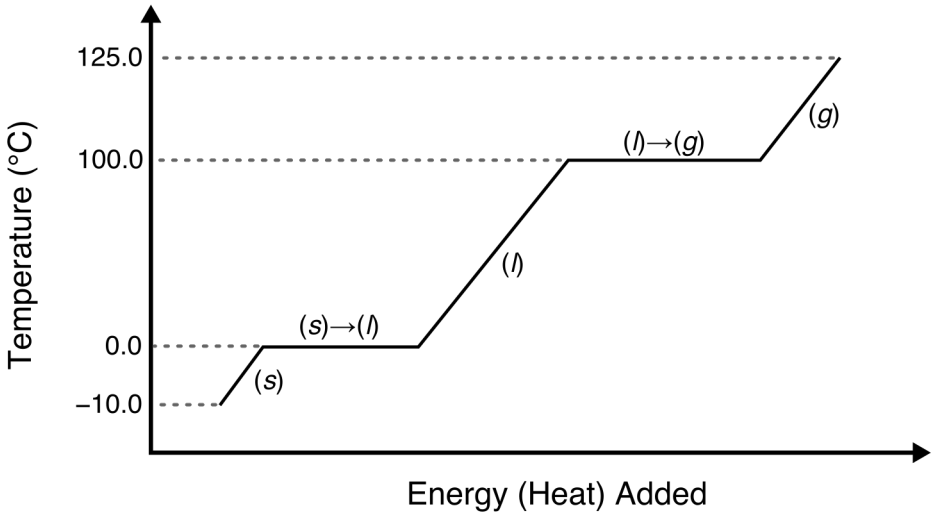

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$$n_{H_2O} = 5.00\ \text{g}\ H_2O \times \frac{1\ \text{mol}\ H_2O}{18.02\ \text{g}\ H_2O} = 0.277_5\ \text{mol}\ H_2O$$

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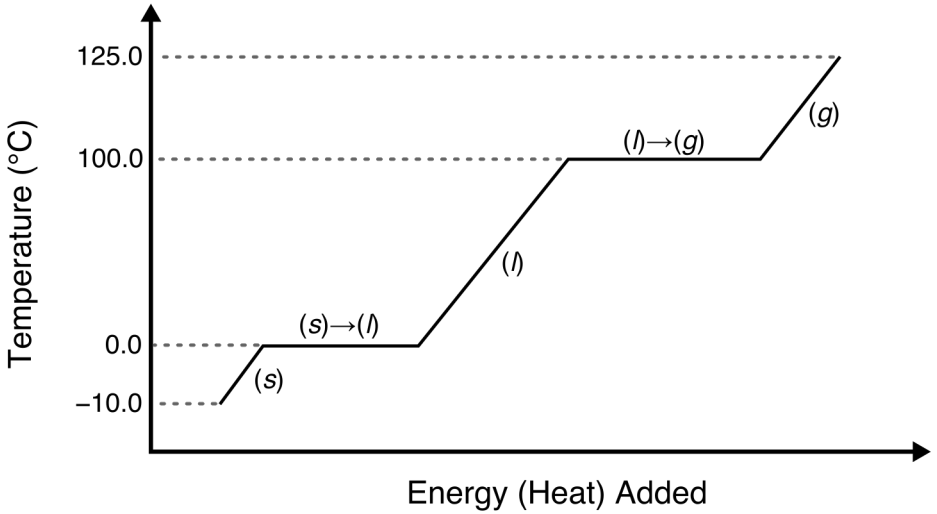

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$$q_{total} = q_1 + q_2 + q_3 + q_4 + q_5$$

$$q_{total} = 15400\ \text{J} = 15.4\ \text{kJ}$$

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