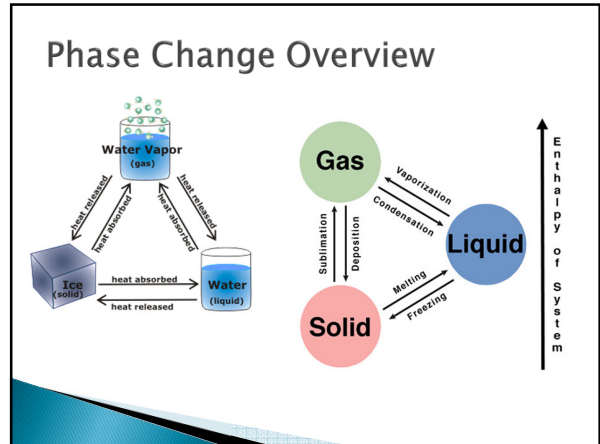
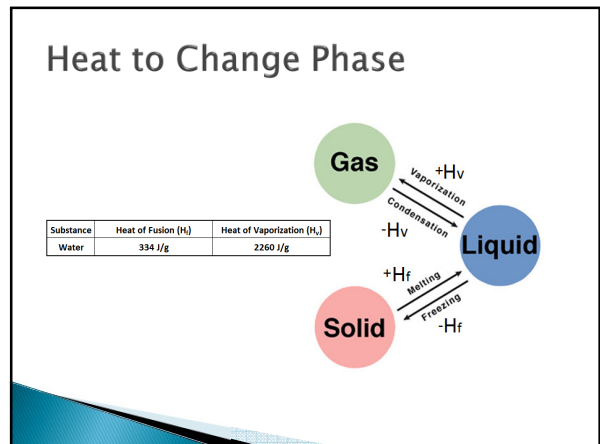
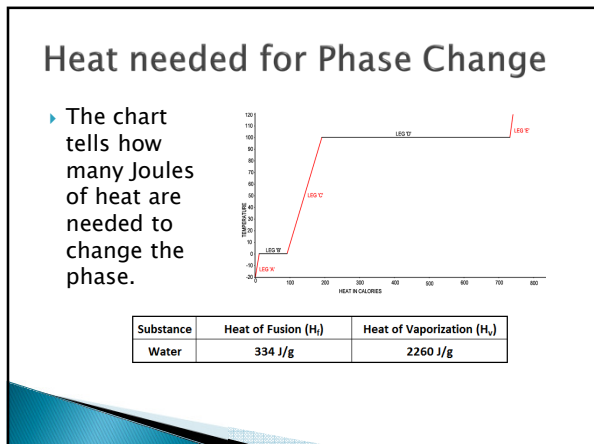
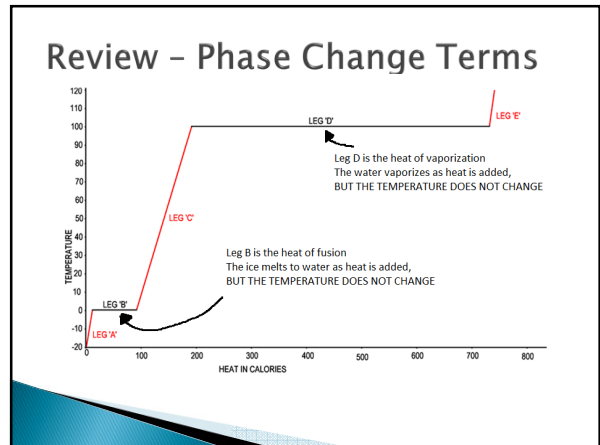


Phase Change Calculations

Mr. Sudbury



- ## Phase Change Terms
- ▶ **Heat of Fusion - H_f**
 - The extra heat required to change phases between solids and liquids. (The temp doesn't change)
 - ▶ **Heat of Vaporization - H_v**
 - The extra heat required to change phases between liquids and gases. (The temp doesn't change)



Heat to Change Phase

$$Q = mH_f \quad Q = mH_v$$

- ▶ Q = "heat"
- ▶ m = mass in grams
- ▶ H_f = Heat of Fusion (334 J/g)
- ▶ H_v = Heat of Vaporization (2,260 J/g)

Practice Problems

- ▶ How much heat is needed to melt 55 grams of 0°C ice to 0°C water?
- ▶ How much heat should be removed to freeze 180 grams of 0°C water to 0°C ice?

$$Q = m \cdot H_f$$

$$Q = m \cdot -H_f$$

$$Q = 55g \cdot 334 \text{ J/g}$$

$$Q = 180g \cdot -334 \text{ J/g}$$

$$Q = 18,370 \text{ J}$$

$$Q = -60,120 \text{ J}$$

Practice Problems II

- ▶ How much heat is needed to vaporize 120 grams of 100°C water to 100°C steam?
- ▶ How much heat should be removed to condense 20 grams of 100°C steam to 100°C liquid?

$$Q = m \cdot H_v$$

$$Q = m \cdot -H_v$$

$$Q = 120g \cdot 2,260 \text{ J/g}$$

$$Q = 20g \cdot -2,260 \text{ J/g}$$

$$Q = 271,200 \text{ J}$$

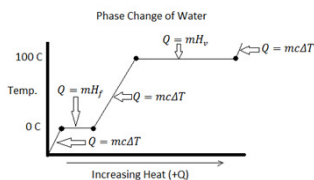
$$Q = -45,200 \text{ J}$$

Phase Change Formulas

- ▶ Solid to Solid: $Q = m \cdot c \cdot \Delta T$
- ▶ Liquid to Liquid: $Q = m \cdot c \cdot \Delta T$
- ▶ Gas to Gas: $Q = m \cdot c \cdot \Delta T$
- ▶ Freezing and melting: $Q = m \cdot H_f$
- ▶ Boiling and condensing: $Q = m \cdot H_v$

Overview

Substance	Specific Heat
$\text{H}_2\text{O}_{(s)}$	2.108 J/g°C
$\text{H}_2\text{O}_{(l)}$	4.186 J/g°C
$\text{H}_2\text{O}_{(g)}$	1.996 J/g°C



Substance	Heat of Fusion (H_f)	Heat of Vaporization (H_v)
Water	334 J/g	2260 J/g

Practice

- ▶ What heat must be used to increase the temperature of 59 g of ice from -29°C to -3°C?
- ▶ What heat must be used to heat 145 g of a liquid from a temperature of 9°C to 100°C?

$$Q = m \cdot c \cdot \Delta T$$

$$Q = m \cdot c \cdot \Delta T$$

$$Q = (59g) \cdot (2.108 \text{ J/g} \cdot \text{°C}) \cdot (26\text{°C}) \quad Q = (145g) \cdot (4.186 \text{ J/g} \cdot \text{°C}) \cdot (91\text{°C})$$

$$Q = 3,233.7 \text{ J}$$

$$Q = 55,234.3 \text{ J}$$

Practice

- What heat must be used to increase the temperature of 80 g of steam from 103 °C to 111 °C?

$$Q = m \cdot c \cdot \Delta T$$

$$Q = (80 \text{ g}) \cdot (1.996 \text{ J/g} \cdot \text{°C}) \cdot (8\text{°C})$$

$$Q = 1,277.4 \text{ J}$$

- What heat must be used to heat 88 g of a liquid from a temperature of 79 °C to 112 °C?

$$Q = m \cdot c \cdot \Delta T$$

$$Q = (88 \text{ g}) \cdot (4.186 \text{ J/g} \cdot \text{°C}) \cdot (21\text{°C})$$

$$Q = 7,735.7 \text{ J}$$

$$Q = m \cdot H_v$$

$$Q = 88 \text{ g} \cdot 2,260 \text{ J/g}$$

$$Q = 198,880 \text{ J}$$

$$Q = m \cdot c \cdot \Delta T$$

$$Q = (88 \text{ g}) \cdot (1.996 \text{ J/g} \cdot \text{°C}) \cdot (12\text{°C})$$

$$Q = 2,107.7 \text{ J}$$

$$Q_{total} = 208,723.4 \text{ J}$$

Practice Problems

- How much heat is released when 25 g grams of 30 °C warm water is frozen to form ice at -5 °C.

$$Q = m \cdot H_f$$

$$Q = 25 \text{ g} \cdot -334 \text{ J/g}$$

$$Q = -8,350 \text{ J}$$

$$Q = m \cdot c \cdot \Delta T$$

$$Q = (25 \text{ g}) \cdot (4.186 \text{ J/g} \cdot \text{°C}) \cdot (-30\text{°C})$$

$$Q = -3,139.5 \text{ J}$$

$$Q = m \cdot c \cdot \Delta T$$

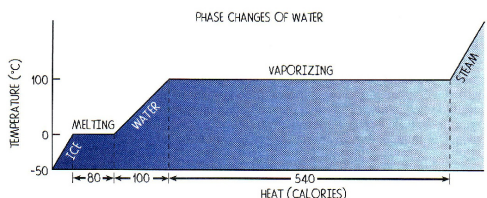
$$Q = (25 \text{ g}) \cdot (2.108 \text{ J/g} \cdot \text{°C}) \cdot (-5\text{°C})$$

$$Q = -263.5 \text{ J}$$

$$Q_{total} = -11,753 \text{ J}$$

Practice Problems

- What heat is necessary to heat 100 grams of ice at -14 °C and turn it into steam and 110 °C?



$$Q = (100 \text{ g}) \cdot (4.186 \text{ J/g} \cdot \text{°C}) \cdot (100\text{°C})$$

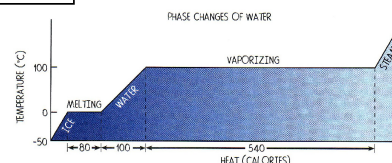
$$Q = 41,860 \text{ J}$$

$$Q_{total} = 306,207.2 \text{ J}$$

Phase Change Summary

Substance	Specific Heat
H ₂ O(s)	2.108 J/g°C
H ₂ O(l)	4.186 J/g°C
H ₂ O(g)	1.996 J/g°C

▶ The End



Substance	Heat of Fusion (H _f)	Heat of Vaporization (H _v)
Water	334 J/g	2260 J/g