

Enthalpy

- heat energy (ΔH) measured in Joules (J) or kilojoules (kJ)
- $+\Delta H$ = endothermic
- $-\Delta H$ = exothermic

solid \leftrightarrow liquid heat of fusion (ΔH_{fus})

liquid \leftrightarrow gas heat of vaporization (ΔH_{vap})

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Endothermic vs. Exothermic

Endothermic or exothermic?



** not a chemical reaction, but it is a phase change which requires energy**

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Boiling and Condensing

Molar Enthalpy (heat) of Vaporization (ΔH_{vap})

- heat required to vaporize 1 mole of liquid

How much energy is required to boil 25.5g of water at 100°C?

$$H_2O(l) \rightarrow H_2O(g) \quad \Delta H_{vap} = +40.7 \text{ kJ/mol}$$

$$25.5 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18 \text{ g H}_2\text{O}} \times \frac{40.7 \text{ kJ}}{1 \text{ mol H}_2\text{O}} = 57.7 \text{ kJ}$$

$H = 2 \times 1 = 2$
 $O = 1 \times 16 = 16$
 $\frac{18 \text{ g/mol}}$

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Melting and Freezing

Molar Enthalpy (heat) of Fusion (ΔH_{fus})

- heat required to melt 1 mole of solid

How many grams of ice can be melted by providing 2250 kJ of heat at 0°C?

$$H_2O(s) \rightarrow H_2O(l) \quad \Delta H_{fus} = -6.01 \text{ kJ/mol}$$

$$2250 \text{ kJ} \times \frac{1 \text{ mol}}{6.01 \text{ kJ}} \times \frac{18 \text{ g H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = 6,739 \text{ g H}_2\text{O}$$

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Change in temp vs. Change in state

- If there is a phase change...

> Use ΔH

> look up values in textbook

Substance	Formula	ΔH_{fus} (kJ/mol)	ΔH_{vap} (kJ/mol)
Water	H ₂ O	6.01	40.7
Ethanol	C ₂ H ₅ OH	4.94	38.5
Methanol	CH ₃ OH	3.22	35.2
Acetic acid	CH ₃ COOH	11.7	23.3
Ammonia	NH ₃	5.66	23.3

- If there is a change in temperature...

> use $q = m\Delta T$

Substance	Specific Heat J/g°C @ 25°C
Water (l) (liquid)	4.184
Water (s) (ice)	2.03
Water (g) (steam)	2.01

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PRACTICE

How much heat is required to melt 25.3g of ice?

$$25.3 \text{ g H}_2\text{O} \times \frac{1 \text{ mol H}_2\text{O}}{18 \text{ g H}_2\text{O}} \times \frac{6.01 \text{ kJ}}{1 \text{ mol H}_2\text{O}} = 8.45 \text{ kJ}$$

Substance	Specific Heat J/g°C @ 25°C
Water (l) (liquid)	4.184
Water (s) (ice)	2.03
Water (g) (steam)	2.01

Substance	Formula	ΔH_{vap} (kJ/mol)	ΔH_{fus} (kJ/mol)
Water	H ₂ O	40.7	6.01
Ethanol	C ₂ H ₅ OH	38.5	4.94
Methanol	CH ₃ OH	35.2	3.22
Acetic acid	CH ₃ COOH	23.3	11.7
Ammonia	NH ₃	23.3	5.66

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PRACTICE

How much heat is released when 4.8g of steam condenses into water?

$$4.8g H_2O \times \frac{1 \text{ mol } H_2O}{18g H_2O} \times 40.7 \text{ kJ} = 10.9 \text{ kJ}$$

Substance	Specific Heat $J/g \cdot ^\circ C$ @ 25 $^\circ C$
Water (l) (liquid)	4.184
Water (s) (ice)	2.05
Water (g) (steam)	2.01

Table 4 Standard Enthalpies of Vaporization and Fusion

Substance	Formula	ΔH_{vap}° (kJ/mol)	ΔH_{fus}° (J/mol)
Water	H ₂ O	40.7	6.01
Ethanol	C ₂ H ₅ OH	38.6	9.4
Methanol	CH ₃ OH	35.2	3.23
Acetic acid	CH ₃ COOH	23.4	11.7
Ammonia	NH ₃	23.3	5.66

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