

1) 31 200 J

7) 0.0456 J/g °C

2) -31 700 J

8) 424 g

3) 120°C

9) 2.60 J/g °C

4) 28°C

10) 6.21 J

5) 1100 J

11) 42.6 L

6) 14 900 J

## Homework - Worksheet

$$\textcircled{7} \quad m = 550 \text{ g}$$

$$T_i = 95.0^\circ\text{C}$$

$$T_f = 30.0^\circ\text{C}$$

$$q = -1.63 \times 10^3 \text{ J}$$

$$C = ?$$

$$q = mC\Delta T$$

$$-1.63 \times 10^3 \text{ J} = (550 \text{ g})C(-65.0^\circ\text{C})$$

$$C = \frac{-1.63 \times 10^3 \text{ J}}{(550 \text{ g})(65.0^\circ\text{C})}$$

$$C = 0.046 \frac{\text{J}}{\text{g}\cdot^\circ\text{C}}$$

# PHASE CHANGE AND ENTHALPY

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ENTHALPY (H) - The total internal (potential) energy and kinetic energy of a system under constant pressure.

⇒ Enthalpy is usually expressed in kJ.

ENTHALPY CHANGE ( $\Delta H$ ) - A change under constant pressure where the surroundings of a system absorb energy or release it to the system.

PHASE CHANGE - is a change in the state of matter without a change in the chemical composition of the system.

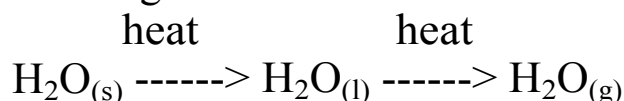
Ex.  $\text{H}_2\text{O}_{(l)} \longrightarrow \text{H}_2\text{O}_{(g)}$

⇒ **always involve a change in energy but never involve a change in temperature.**

## Question:

- (i) What is the temperature where water just starts boiling?
- (ii) What is the temperature when water is boiling violently?
- (iii) If energy is still going into the water and the temperature is not increasing, where is the energy going?

Consider melting ice to water and then boiling water to steam:



$$q = mc\Delta T$$

= 0

## MOLAR ENTHALPY

For any system:

- an exothermic change involves a decrease in enthalpy

⇒ gives off energy to the surroundings

⇒  $\Delta H$  is **negative**. *solidification, condensation*

- an endothermic change involves an increase in enthalpy.

⇒ takes in energy from the surroundings

⇒  $\Delta H$  is **positive**. *fusion, vaporization*

The enthalpies for substances undergoing phase changes have been measured experimentally. (TABLE 17.3 p. 522)

- enthalpies are reported as molar enthalpies and are expressed as kJ/mol.

$$H_{\text{fus}} = 6.01 \frac{\text{kJ}}{\text{mol}}$$

$$H_{\text{vap}} = 40.7 \frac{\text{kJ}}{\text{mol}}$$

$$H_{\text{solid}} = -6.01 \frac{\text{kJ}}{\text{mol}}$$

$$H_{\text{cond}} = -40.7 \frac{\text{kJ}}{\text{mol}}$$

	$H_{fus} \frac{\text{kJ}}{\text{mol}}$	$H_{vap} \frac{\text{kJ}}{\text{mol}}$
H <sub>2</sub> O	6.01	40.7
Cl <sub>2</sub>		

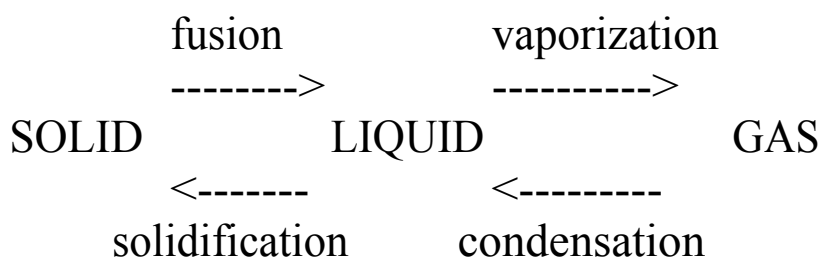
## Endothermic Phase Changes

- the molar enthalpy of fusion ( $H_{\text{fus}}$ ) represents the quantity of heat that the substance absorbs per mole as it changes state from **solid to liquid**.

- the molar enthalpy of vaporization ( $H_{\text{vap}}$ ) represents the quantity of heat that the substance absorbs per mole as it changes state from **liquid to gas**.

## Exothermic Phase Changes

- the molar enthalpy of condensation ( $H_{\text{cond}}$ ) represents the quantity of heat that the substance releases per mole as it changes state from **gas to liquid**
- the molar enthalpy of solidification ( $H_{\text{solid}}$ ) represents the quantity of heat that the substance releases per mole as it changes state from **liquid to solid**.



$$\Delta H_{\text{fus}} = - \Delta H_{\text{solid}}$$

$$\Delta H_{\text{vap}} = - \Delta H_{\text{cond}}$$



## Example

If 500. g of  $\text{CCl}_2\text{F}_2(l)$  is vaporized at SATP, find the enthalpy change of the system ( $H_{\text{vap}} = 34.99 \text{ kJ/mol}$ ).

$$m = 500. \text{ g}$$



$$H_{\text{vap}} = 34.99 \frac{\text{kJ}}{\text{mol}}$$

$$\Delta H_{\text{vap}} = ?$$

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

$$\Delta H_{\text{vap}} = \left( \frac{500. \text{ g}}{120.91 \text{ g/mol}} \right) \left( 34.99 \frac{\text{kJ}}{\text{mol}} \right)$$

$$\Delta H_{\text{vap}} = 145 \text{ kJ}$$



$$\rightarrow (1 \times 12.01) + (2 \times 35.45) + (2 \times 19.00)$$

Calculate the energy change required to condense 150.g of steam to water. ( $H_{\text{vap}} = 40.7 \text{ kJ/mol}$ )

$$m = 150 \text{ g}$$



$$\Delta H_{\text{cond}} = ?$$

$$H_{\text{cond}} = -40.7 \frac{\text{kJ}}{\text{mol}}$$

$$\Delta H_{\text{cond}} = n H_{\text{cond}}$$

$$\Delta H_{\text{cond}} = \left( \frac{150. \text{g}}{18.02 \text{g/mol}} \right) \left( -40.7 \frac{\text{kJ}}{\text{mol}} \right)$$

$$\Delta H_{\text{cond}} = -339 \text{ kJ}$$

# **Worksheet**