Warm Up

2.94 kJ of energy is added to a 375 g piece of aluminum at 15.6°C. Determine the new temperature.

$q = 2.94\ kJ$

$m = 375\ g$

$C = 0.900\ \frac{J}{g \cdot °C}$

$T_i = 15.6°C$

$T_f = ?$

$q = mC\Delta T$

$q = mC(T_f - T_i)$

$2940\ J = (375\ g)(0.900\ \frac{J}{g \cdot °C})(T_f - 15.6°C)$

$\frac{2940\ J}{(375\ g)(0.900\ \frac{J}{g \cdot °C})} = T_f - 15.6°C$

$8.71°C = T_f - 15.6°C$

$T_f = 8.71°C + 15.6°C$

$T_f = 24.3°C$

$$\frac{16}{2(4)} = \frac{2(4)(x-2)}{(2)(4)}$$

$$\frac{16}{8} = x-2$$

$$2 = x-2$$

$$16 = 8(x-2)$$

$$16 = 8x - 16$$

$$8x = 32$$

$$x = 4$$

Homework - Worksheet

(11) $C = 0.0012 \frac{kJ}{L \cdot °C}$

$\Delta T = -65.0°C$

$q = -3.32\ kJ$

$v = ?$

$q = vC\Delta T$

$-3.32\ kJ = v(0.0012 \frac{kJ}{L \cdot °C})(-65.0°C)$

$v = \frac{-3.32\ kJ}{(0.0012 \frac{kJ}{L \cdot °C})(-65.0°C)}$

$v = 42.6\ L$

1) 31 200 J

2) -31 700 J

3) 120 ^{o}C

4) 28 ^{o}C

5) 1100 J

6) 14 900 J

7) 0.0456 J/g ^{o}C

8) 424 g

9) 2.60 J/g ^{o}C

10) 6.21 J

11) 42.6 L

PHASE CHANGE AND ENTHALPY

ENTHALPY (H) - The total internal (potential) energy and kinetic energy of a system under constant pressure.
⇒Enthalpy is usually expressed in kJ.

ENTHALPY CHANGE (ΔH) - 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. $H_2O_{(l)} \longrightarrow H_2O_{(g)}$

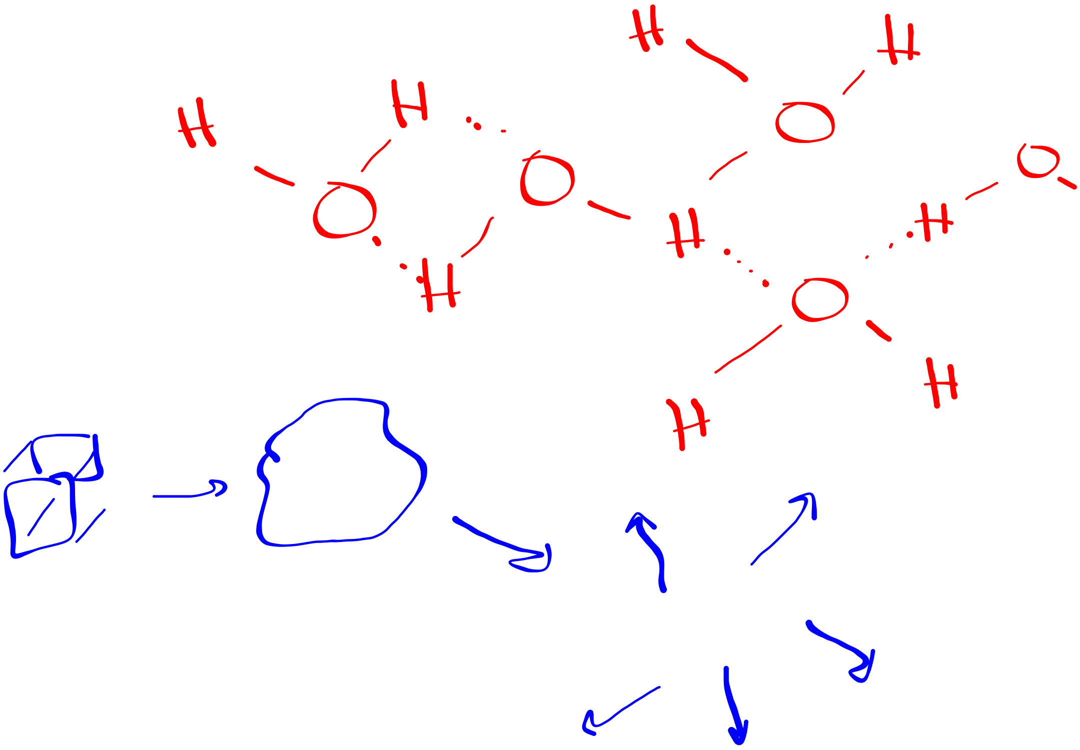
⇒**always involve a change in energy but never involve a change in temperature.**

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?

The energy is being used to break intermolecular bonds between molecules. This represents a change in phase.

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



MOLAR ENTHALPY

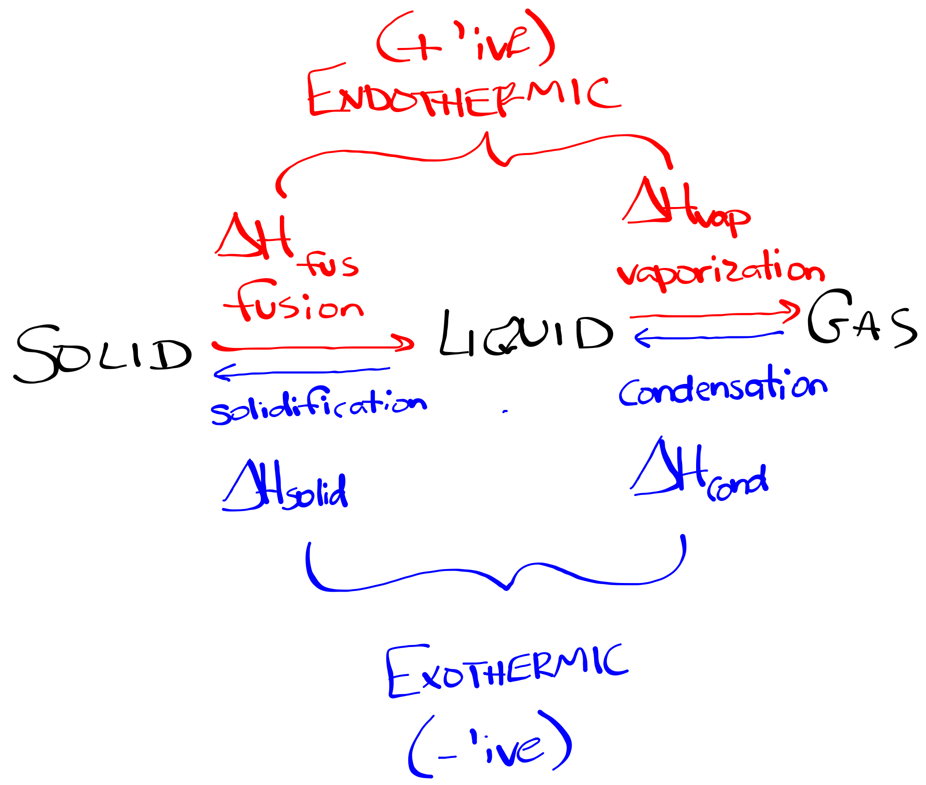
For any system:

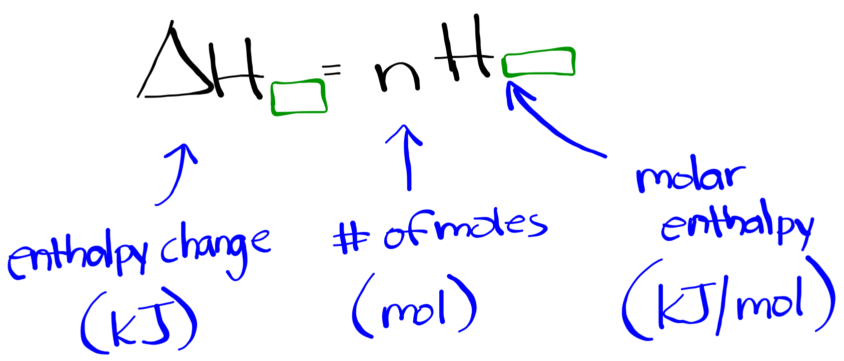
- an exothermic change involves a decrease in enthalpy
  ⇒ gives off energy to the surroundings
  ⇒ ΔH is negative.

- an endothermic change involves an increase in enthalpy.
  ⇒ takes in energy from the surroundings
  ⇒ ΔH is positive.

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.





Endothermic Phase Changes

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

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

fusion vaporization
--------> ---------->
SOLID LIQUID GAS
<------- <---------
solidification condensation

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

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

Exothermic Phase Changes

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

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              fusion            vaporization
              -------->          ---------->
   SOLID              LIQUID                 GAS
              <-------           <---------
         solidification      condensation
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$$\Delta H_{fus} = - \Delta H_{solid}$$

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

Example

If 500. g of $CCl_2F_{2(l)}$ is vaporized at SATP, find the enthalpy change of the system (H_{vap} = 34.99 kJ/mol).

$m = 500.\ g$

CCl_2F_2

$H_{vap} = 34.99\ kJ/mol$

$\Delta H_{vap} = ?$

$\Delta H_{vap} = nH_{vap}$

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

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

m / Mm n

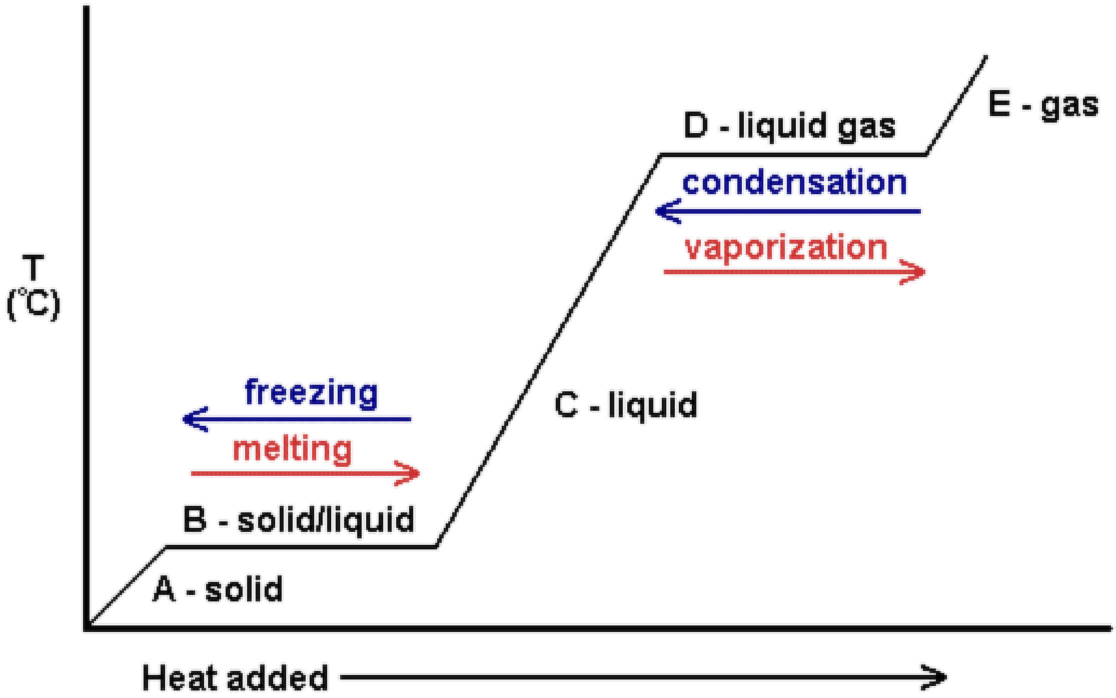
$CCl_2F_2 \rightarrow (1 \times 12.01) + (2 \times 35.45) + (2 \times 19.00)$

$= 120.91\ g/mol$

$$\left(\frac{\cancel{g}}{\cancel{g}/mol}\right)\left(\frac{kJ}{mol}\right)$$

$$\left(\cancel{mol}\right)\left(\frac{kJ}{\cancel{mol}}\right)$$

Worksheet


D - liquid gas
E - gas
condensation
vaporization
T
(°C)
freezing
melting
C - liquid
B - solid/liquid
A - solid
Heat added

Heat (q)

- change in kinetic energy
- measures transfer of energy when there are temperature changes (heating or cooling)

Enthalpy (H)

- measures potential energy
- change in energy transfer when system is at constant pressure and same initial and final temperatures

Heat of Solution

During the formation of a solution, heat is either released or absorbed.

$$NaOH_{(s)} \xrightarrow{H_2O_{(l)}} Na^+_{(aq)} + OH^-_{(aq)} \qquad \Delta H_{soln} = -445.1 \text{ kJ/mol}$$