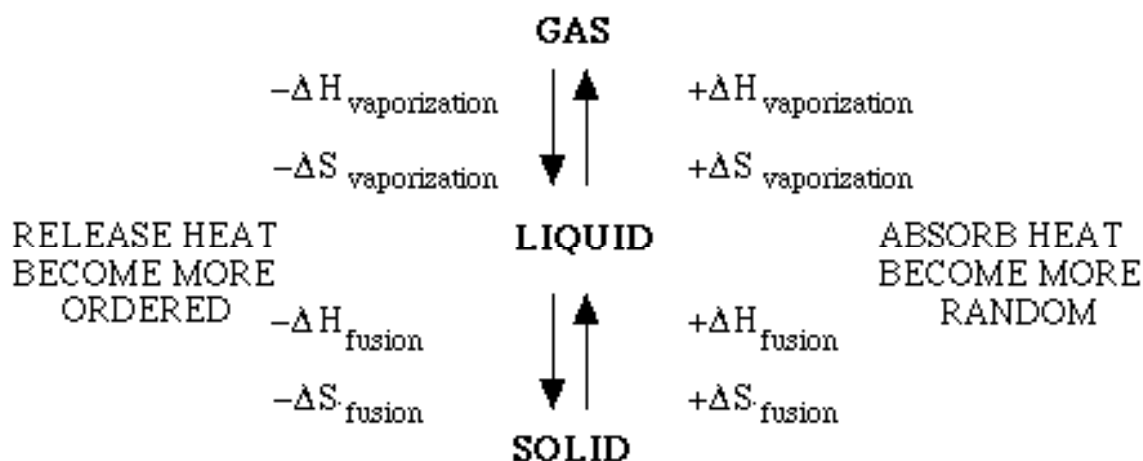


ENERGY RELATIONSHIPS IN PHASE CHANGES

Two factors of importance in phase changes is the enthalpy and entropy changes that occur.

ΔH (change in enthalpy) = amount of energy involved in the change of state

ΔS (change in entropy) = change in amount of disorder (randomness) that accompanies the change of state

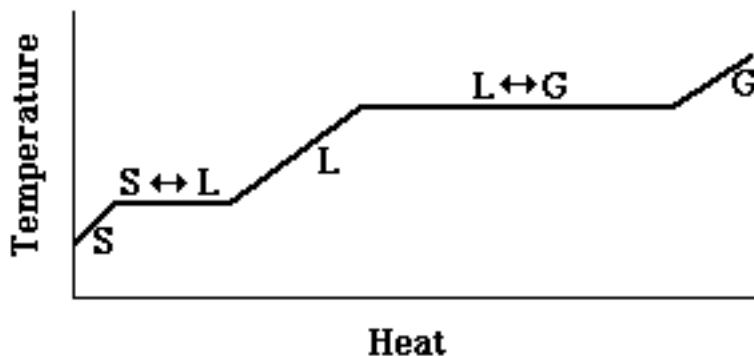


To determine the amount of heat involved as **temperature changes** in single phase, use the specific heat value for that state of matter (S, L and G regions).

$$\text{heat (q)} = \text{Specific heat (s)} \times \text{mass (m)} \times \text{temperature change } (\Delta T)$$

To determine the amount of heat involved during **phase change at constant temperature**, use the calorimetry formula involving ΔH (S \leftrightarrow L and L \leftrightarrow G regions).

$$\text{heat (q)} = \text{Change in enthalpy for phase change } (\Delta H) \times \text{moles (n)}$$



EXAMPLE PROBLEM

Determine the total heat involved in converting 15.0g of ethanol ($\text{CH}_3\text{CH}_2\text{OH}$, molar mass = 46.07 g/mole) in the gas state at 300.0°C and 1 atm pressure to liquid ethanol at 25.0°C and 1 atm pressure.

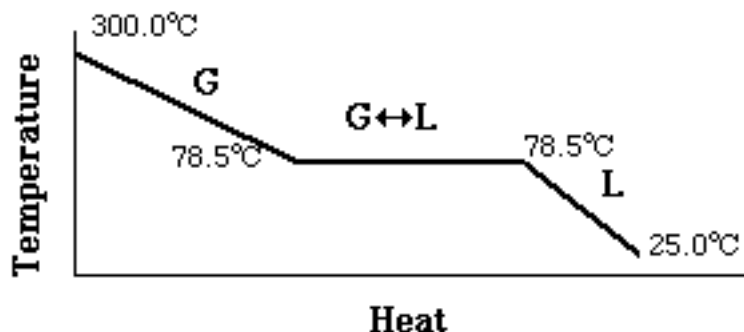
Data: Boiling Point at 1 atm = 78.5°C

$$C_{\text{gas}} = 1.43 \text{ J/g}^\circ\text{C}$$

$$C_{\text{liquid}} = 2.45 \text{ J/g}^\circ\text{C}$$

$$\Delta H_{\text{vap}} = 40.5 \text{ kJ/mole}$$

Draw diagram of process.



Notice that there are 3 distinct regions: gas, gas to liquid transition, and liquid. Thus 3 separate calculations must be performed and the results totaled.

REGION 1: Gas cooling from 300.0°C to 78.5°C . (Change in KE)

$$q_1 = s_{\text{gas}} m_{\text{gas}} \Delta T_{\text{gas}} = (1.43 \text{ J/g}^\circ\text{C})(15.0 \text{ g})(78.5^\circ\text{C} - 300.0^\circ\text{C}) = -4751 \text{ J}$$

REGION 2: Gas at 78.5°C condensing to liquid at 78.5°C . (Change in PE)

$$q_2 = \Delta H_{\text{vap}} n = \left(\frac{-40.5 \text{ kJ}}{\text{mole}}\right) \left(\frac{1000 \text{ J}}{\text{kJ}}\right) (15.0 \text{ g}) \left(\frac{1 \text{ mole}}{46.07 \text{ g}}\right) = -13186 \text{ J}$$

Why the negative sign in -40.5 kJ/mole ?

REGION 3: Liquid cooling from 78.5°C to 25.0°C . (Change in KE)

$$q_3 = s_{\text{liquid}} m_{\text{liquid}} \Delta T_{\text{liquid}} = (2.45 \text{ J/g}^\circ\text{C})(15.0 \text{ g})(25.0^\circ\text{C} - 78.5^\circ\text{C}) = -1966 \text{ J}$$

$$\begin{aligned} \text{TOTAL HEAT INVOLVED} &= q_1 + q_2 + q_3 = -4751 \text{ J} + -13186 \text{ J} + -1966 \text{ J} = -19903 \text{ J} \\ &= -1.99 \times 10^4 \text{ J} \quad (\text{rounded to 3 sig. figs}) \end{aligned}$$

The negative sign indicates that heat is released in the process.