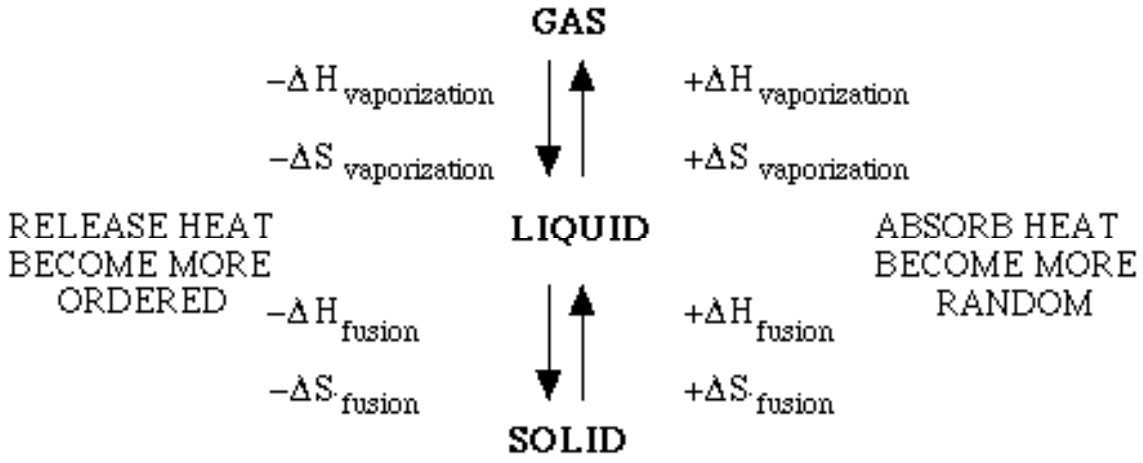
# ENERGY RELATIONSHIPS IN PHASE CHANGES

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

$\Delta H$ (change in enthalpy) = amount of energy involved in the change of state

$\Delta S$ (change in entropy) = change in amount of disorder (randomness) that accompanies the change of state

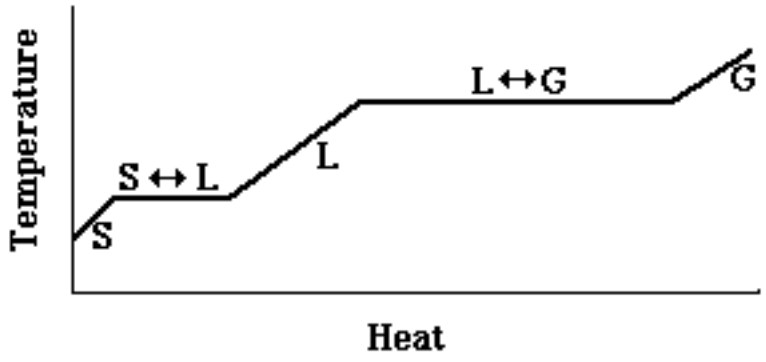



To determine the amount of heat involved as t**emperature changes** in single phase, use the specific heat value for that state of matter (S, L and G regions).

heat (q) = Specific heat (s) x mass (m) x temperature change ($\Delta T$)

To determine the amount of heat involved during **phase change at constant temperature**, use the calorimetry formula involving $\Delta H$ (S<->L and L<->G regions).

heat (q) = Change in enthalpy for phase change ($\Delta H$) x moles (n)



EXAMPLE PROBLEM

Determine the total heat involved in converting 15.0g of ethanol ($CH_3CH_2OH$, 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.

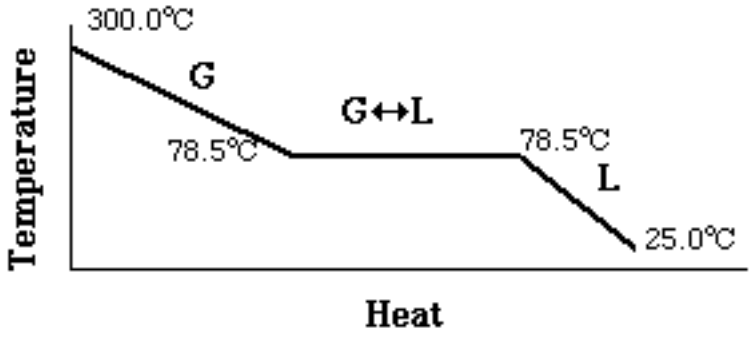
Data: Boiling Point at 1 atm = 78.5˚C

$C_{gas}$ = 1.43 J /g˚C

$C_{liquid}$ = 2.45 J /g˚C

$\Delta H_{vap}$ = 40.5 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)

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

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

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

Why the negative sign in –40.5kJ/mole?

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

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

TOTAL HEAT INVOLVED = $q_1 + q_2 + q_3$ = –4751J + –13186J + –1966J = –19903J

= $-1.99 \times 10^4$ J (rounded to 3 sig.figs)

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