Answer on Question #81410, Chemistry/ Organic Chemistry

Calculate the total amount of heat energy in kilocalories that must be released in order to condense 18.9 g of steam at 373.0 K, cool that liquid to 272.0 K, then freeze the liquid at 272.0 K.

Solution

latent heat of fusion of ice = 335 J/g,

latent heat of vaporisation of water = 2260 J/g,

specific heat capacity of ice = 2.14 J/(g °C),

specific heat capacity of water = 4.184 J/(g °C)

specific heat capacity of steam = 2.01 J/(g °C).

The energy released is determined in 4 stages:

$Q= Q_1 +Q_2 +Q_3+Q_4$

1. Find Q_1 –the heat of phase change(steam-water) at 373.0 K (or $T(^oC)=373-273=100\ ^0C$):
   $Q_1 = L_v \times m$, where $L_v = 2260$ J/g,
   $Q_1 = 2260$ J/g $\times 18.9$ g$= 2.23\cdot 10^6$ J $= 42714$ J.
   As Q is released then $Q_1 = -42714$ J
2. Find Q_2 – heat that is released when the temperature of water changes from 373 K to 273 K (or from 100^o C to 0^0C)
   $Q_2 = cm(T_2-T_1)$, where c (for water) = 4.184 J/g·°C
   $Q_3 = 4.184$ J/g·°C ·18.9 g ·(0-100)°C = -7907.8 J
3. Find Q_3 -the heat of phase change (water-ice):
   $Q_3=L_f \times m$, where L_f=335 J/g
   $Q_3 = 335$ J/g ·18.9g = 6331.5 J
   As Q is released then $Q_3 = -6331.5$ J
4. Find Q_4 – heat that is released when the temperature changes from 273K to 272 K (or from 0°C to -1°C.
   $Q_4 = cm(T_2-T_1)$, where c (for ice) = 2.14 J/g·°C
   $Q_4 = 2.14$ J/g·°C ·18.9 g ·(-1-0)°C =- 40.4 J

   $Q= Q_1 +Q_2 +Q_3+Q_4 = = -42714$ J -7907.8 J-6331.5 J-40.4 J = -56993.7 J

The sign "-" shows that the system loses 56993.7 J of energy releasing this amount of energy into surrounding. So, surrounding gets is 56993. 7 J of energy or 56993.7 J $\times$ 0.2388cal/J = 13610 cal = 13.6 kcal.

Answer: 13.6 kcal