Answer on Question #58707, Physics / Molecular Physics | Thermodynamics |

Calculate the change in internal energy of 2kg of water at 90°C when it is changed to 3.30m^3 of steam at 100°C. The whole process occurs at atmospheric pressure. The latent heat of vaporization of water is 2.26×10^{6}J/kg.

4.27 MJ

3.43 kJ

45.72 mJ

543.63 J

Solution:

The amount of heat received by water is equal to the sum of the change in internal energy of water and the work on the steam:

$$Q = \Delta U + W$$

where

$$Q = Q_{heat} + Q_{vapor}$$

$$Q_{heat} = Cm\Delta T$$
$$Q_{vapor} = rm$$

where r is the latent heat of vaporization of water.

The work is

$$W = p\Delta V = p\left(V_{steam} - \frac{m}{\rho}\right)$$

where ρ = 1000 kg/m^3 is the density of water.

The change of the internal energy is

$$\Delta U = Q - W = Cm\Delta T + rm - p\Delta V =$$

$$= 4200 \cdot 2 \cdot (100 - 90) + 2.26 \cdot 10^6 \cdot 2 - 1 \cdot 10^5 \left(3.30 - \frac{2}{1000}\right) = 4274200 \text{ J} = 4.27 \text{ MJ}$$

Answer: $\mathbf{4.27\ MJ.}$