A 405 Day 12 Problems

Niamh Chaparro

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1

The vapour pressure at V1 is $e = \frac{RH \times e_{sat}}{100} = .6 \times 2.337 \times 10^3 = 1402.2Pa$

e at V1 can be used to obtain the water vapour density at V1

$\rho_v^{'} = \frac{e}{R_v T} = \frac{1402.2}{461.51 \times 293.15} = .010364\ kg\ m^{-3}$

and the mass is obtained as follows: $m_w = .010364 \times 20 \times 10^{-3} = .00020728\ kg$.

Does the change in volume result in vapour pressure exceeding saturation?

$e_2 = \frac{V_1}{V_2} e_1 = \frac{20}{4} \times 1402.2 = 7011\ Pa > e_{sat}$

Yes, so the vapour pressure at V2 is e_{sat} and the vapour density at V2 is

$\rho_{v2}^{'} = \frac{e_{sat}}{R_v T} = \frac{2337}{461.51 \times 293.15} = .017273792\ kg\ m^{-3}$

The new vapour mass is $.017273793 \times 4 \times 10^{-3} = 6.9095 \times 10^{-5}\ kg$

so the mass of condensed water is $(2.0728 - .69095) \times 10^{-4} = 1.38185 \times 10^{-4}\ kg$.

2

a

The potential temperature is conserved: $\frac{\theta_1}{\theta_2} = 1 = \frac{T_1}{T_2} (\frac{P_0 P_2}{P_0 P_1})^{.286}$

$T_2 = T_1 (\frac{P_2}{P_1})^{.286} = 373.783K$

(Aside:

For the lower compartment $V_2 = (1-X)V_1$ so $(1-X) = \frac{373.783\times 1}{273\times 3}$ and the difference in volume $X = 1 - \frac{373.783}{273\times 3} = .544$)

b

For the lower compartment $\Delta q = \Delta u - \Delta w$. Since there is no thermal energy supplied or lost $\Delta q = 0$ and the change in internal energy is equal to the work done by the thermally induced pressure increase in the upper compartment via the energetically neutral membrane: $\Delta u = \Delta w = c_v \Delta T = 72261.276\ J\ kg^{-1}$

c

$\frac{T_1}{T_2} = \frac{P_1 V_1}{P_2 V_2} = \frac{1}{3\times(1+X)}$

$T_2 = 3 \times (1+X) \times T_1 = 1192\ K$

d

The total thermal energy supplied in the upper compartment is that which causes the temperature to increase and the pressure and volume to increase:
$\Delta q = \Delta u + \Delta w = c_v \times \Delta T + \Delta w = 717 \times (1192 - 273) + 72261.276 = 731184.276\ J\ kg^{-1}$