<u>Step 1:</u> Determine the Partial Pressure of the Water Vapor (P_v)

The amount of moisture that air can hold is fundamentally capped by its dry-bulb temperature. Relative humidity (RH) represents the ratio of the actual partial pressure of the water vapor in the air (P_v) to the saturation pressure of water vapor (P_{sat}) at that exact same temperature. Mathematically, this relation is expressed as:

$$RH = \frac{P_v}{P_{sd}}$$

Substituting our known parameters (RH = 0.75 and P_{sat} = 5.324 kPa):

$$0.75 = \frac{P_v}{5.324\ kPa}$$

$$P_v = 3.993\ kPa$$

This means that out of the total 100 kPa of atmospheric pressure, $3.993\ kPa$ is exerted solely by colliding water vapor molecules.

<u>Step 2:</u> Calculate the Specific Humidity / Humidity Ratio (SH)

Specific humidity represents the actual mass of water vapor per kilogram of dry air. Using the ideal gas law applied to both components, the ratio of masses simplifies down to the ratio of their molecular weights (where the ratio of the molar mass of water to dry air is roughly 0.622) multiplied by their partial pressures. According to Dalton's Law of Partial Pressures, the pressure of the dry air component is simply the barometric pressure minus the vapor pressure ($P_B - P_v$).

$$SH = 0.622\left(\frac{P_v}{P_B - P_v}\right)$$

Substituting the calculated partial pressure and the given barometric pressure (100 kPa):

$$SH = 0.622\left(\frac{3.993\ kPa}{100\ kPa - 3.993\ kPa}\right) = 0.02587\ \frac{kg_{vapor}}{kg_{dry\ air}}$$

<u>Step 3:</u> Compute Total Enthalpy of the Mixture (h)

The total enthalpy of the psychrometric mixture is the sum of the sensible heat of the dry air and the total heat (sensible + latent) contained within the water vapor.

$$h = C_{pa}t_d + SH(h_g)$$

Where C_{pa} is the specific heat capacity of dry air (the provided solution uses 1.0062 kJ/kg-K), which is an excellent, highly accurate constant for standard conditions), t_d is the dry-bulb temperature in °C, and h_g is the enthalpy of saturated water vapor at that temperature.

$$h = \left(1.0062 \frac{kJ}{kg - {}^\circ C}\right)(34^\circ C) + \left(0.02587 \frac{kg_{vapor}}{kg_{dry\ air}}\right)\left(2563.5 \frac{kJ}{kg}\right) = 100.5285 \frac{kJ}{kg}$$

If this air is being utilized in an industrial drying room, knowing its baseline enthalpy tells an engineer how much thermal energy is already locked up in the environment. If the air is already holding $100.5285 \frac{kJ}{kg}$ of energy at 75% RH, its capacity to evaporate more moisture from wet goods is severely limited. This value dictates the heat-exchanger sizing required to modify the air state to maximize thermodynamic efficiency.