a. From the Clausius-Clapeyron relation and the ideal gas law, the liquid-vapor saturation pressure as a function of temperature is well approximated by:

\[ P_s(T) = P_* e^{-\frac{L}{RT}}, \]

where \( L \) is the molar latent heat of vaporization, \( R = 8.315 \text{ J/K} \) is the molar gas constant, and \( T \) is the temperature. For the water-steam phase transition at \( T = 25 \text{ C (298 K)} \) one measures \( P_s = 0.0317 \text{ bar} \) with \( L = 4.27 \times 10^4 \text{ J/mol} \). From these values find \( P_* \).

**Solution:** From the above equation and the given data, one can solve for the constant:

\[ P_* = \left(0.0317\right)e^{\frac{4.27 \times 10^4}{8.315 \times (298)}} = 9.66 \times 10^5 \text{ bar}. \]

b. Suppose the temperature is 30 C (303 K) and the relative humidity is 80%. What is the actual water vapor pressure? (Recall that the relative humidity is the ratio of the actual water vapor pressure to the saturation pressure.)

**Solution:** Using the value of \( P_* \) found in part a, we have the saturation pressure at 30 C: \( P_s(303K) = 9.66 \times 10^5 e^{\frac{4.27 \times 10^4}{8.315 \times (303)}} = 0.0421 \text{ bar} \). Since the relative humidity is 80%, the actual water vapor pressure is \( P_w = 0.80 \times 0.0421 = 0.0337 \text{ bar} \).

c. For the situation described in part b, what is the dew point (temperature)?

**Solution:** To find the dew point temperature (\( T_{DP} \)) at which the vapor pressure from part b is the saturation pressure, one inverts the starting equation to find:

\[ T_{DP} = \frac{L}{R \ln \left(\frac{P_w}{P_*}\right)} = \frac{4.27 \times 10^4}{8.315 \ln \left(\frac{0.0337}{9.66 \times 10^5}\right)} = 299 \text{ K}. \]