

45.23 What is the partial pressure of water in atmospheric air at 120°F and 70% RH?

- A. 0.3psi
- B. 0.8psi
- C. 1.2psi
- D. 1.7psi

There are 3 alternative approaches to this problem.

Approach #1: Search for **Properties of Saturated Water** by temperature and find 120°F in the steam table. The saturation pressure at 120°F is:

$$p_{ws@120^\circ F} = 1.7psia$$

Since the relative humidity is 70%, the partial pressure of water vapor in the air is only 70% of the saturation pressure. Recall that saturation pressure is the maximum possible pressure water vapor can have in air at a given temperature. Apply the definition of **relative humidity** to find the partial pressure of water.

$$\phi = \frac{p_w}{p_{ws}}$$

$$p_w = p_{sat}\phi = (1.7psia)(.7) = 1.19psia$$

Approach #2: This method involves looking up the dew point temperature on the **Psychrometric Chart** for **High Temperature** air. Recall that the dew point is the temperature at which the air would be saturated if it were sensibly cooled until reaching the saturation curve.

$$T_{dp} \approx 107^\circ F$$

Return to the steam table and look up the saturation pressure at the dew point temperature. By definition, the partial pressure of water vapor in moist air is the saturation pressure at the dew point temperature.

$$p_w = p_{ws@T_{dp}} = 1.17psia$$

Approach #3: This method involves looking up the humidity ratio on the **Psychrometric Chart** for **High Temperature** air.

$$\omega \approx .055 \frac{lb_{H_2O}}{lb_{da}}$$

Since the humidity ratio is a ratio of the mass of water vapor to the mass of dry air, it is possible to work out the mole fraction of water vapor in the air. There are 0.055lb_{H₂O} for every 1lb_{da}. Find the corresponding number of moles for water and dry air using the molecular weights. Refer to the **periodic table** as needed. Rounding is permissible.

$$MW_{H_2O} = (2)(1) + (16) = 18 \frac{lb}{mol}$$

$$MW_{da} = (2)(14)(.79) + (2)(16)(.21) \approx 29 \frac{lb}{mol}$$

Determining the number of moles of water vapor and dry air.

$$N_{H_2O} = \frac{0.055lb}{18 \frac{lb}{mol}} = 0.00305mol$$

$$N_{da} = \frac{1lb}{29 \frac{lb}{mol}} = 0.03448mol$$

Find the mole fraction of water vapor.

$$x_{H_2O} = \frac{N_{H_2O}}{N_{H_2O} + N_{da}} = \frac{0.00305mol}{0.00305mol + 0.03448mol} = .081$$

The ratio of the partial pressure of water vapor to the total pressure is the same as the ratio of the number of moles of water vapor to the total number of moles i.e. the mole fraction. (Note: This holds true for any mixture of gases. The contribution of any one gas in the mixture to the total pressure - its partial pressure - is equal to its mole fraction!)

$$\frac{p_w}{p_t} = x_{H_2O}$$

$$p_w = (x_{H_2O})(p_t) = (.081)(14.7psia) = 1.19psia$$

Answer C

45.24 A 2500ft² conference center with 14ft ceilings is maintained at 72°F and 50% relative humidity. What is the total mass of water vapor in the air?

- A. 15lb
- B. 22lb
- C. 140lb
- D. 290lb

Find the total volume of the room by multiplying the area and the height.

$$V = (2500ft^2)(14ft) = 35,000ft^3$$

Find the humidity ratio and specific volume for the room conditions using the [Psychrometric Chart](#).

$$T = 72^\circ F$$

$$\phi = 50\%$$