Pressure of the dry air in the mixture = 28.85 − 0.5676 = 28.282 in. Hg.
$pV = wR\,(t + 460)$ (R = 0.753 when partial pressure of air is expressed in in. Hg.).
$28.282 \times 1 = d_a \times 0.753 \times (80 + 460)$.

$$d_a = \frac{28.282}{0.753 \times 540} = 0.06955 \text{ lb} = \text{weight of dry air in 1 cu ft of the mixture.}$$

Likewise from Equation 4,

$$d_v = \frac{0.5676}{1.21 \times 540} = 0.000868 \text{ lb} = \text{weight of vapor per cubic foot at 55 per cent}$$

relative humidity.

Weight of 1 cu ft of the mixture = 0.06955 + 0.000868 = 0.070418 lb.

$$\text{Volume of 1 lb of the mixture} = \frac{1}{0.070418} = 14.2 \text{ cu ft.}$$

RELATION OF DEW-POINT TO RELATIVE HUMIDITY

A peculiar relationship exists between the dew-point and the relative humidity and this is found most useful in air conditioning work. This relationship is, that for a fixed relative humidity there is substantially a constant difference between the dew-point and the dry-bulb temperature over a considerable temperature range. Table 5, giving the dry-bulb and dew-point temperatures and the dew-point differentials for 50 per cent relative humidity, illustrates this relationship clearly.

TABLE 5. TEMPERATURES FOR 50 PER CENT RELATIVE HUMIDITY

Dry-bulb temperature	65.0	70.0	75.0	80.0	85.0	90.0
Dew-point temperature	45.8	50.5	55.25	59.75	64.25	68.75
Difference between dew-point and dry-bulb temperature	19.2	19.5	19.75	20.25	20.75	21.25

It will be seen from an inspection of this table that the difference between the dew-point temperature and the room temperature is approximately 20 deg throughout this range of dry-bulb temperatures or, to be more exact, the differential increases only 10 per cent for a range of practically 25 deg.

This principle holds true for other humidities and is due to the fact that the pressure of the water vapor practically doubles for every 20 deg through this range.

The approximate relative humidity for any difference between dew-point and dry-bulb temperature may be expressed in per cent as:

$$\frac{100}{2^{\frac{t-t_1}{20}}} \tag{8}$$

where

t = dry-bulb temperature, degrees Fahrenheit.
t_1 = dew-point temperature, degrees Fahrenheit.

This principle is very useful in determining the available cooling effect obtainable with saturated air when a desired relative humidity is to be maintained in a room, even though there may be a wide variation in room

temperature. This problem is one which applies to certain industrial conditions, such as those in cotton mills and tobacco factories, where relatively high humidities are carried and where one of the principal problems is to remove the heat generated by the machinery. It also permits the use of a differential thermostat, responsive to both the room temperature and the dew-point temperature, to control the relative humidity in the room.

Table 6 gives, for different temperatures, the density of saturated vapor, d_t, the weight of saturated vapor mixed with 1 lb of dry air, W_t, (at a relative humidity of 100 per cent and a barometric pressure, B, of 29.92 in. of mercury), the specific volume of dry air, and the volume of an air-vapor mixture containing 1 lb of dry air (at a relative humidity of 100 per cent and a pressure of 29.92 in. of mercury). The preceding equations or the data from Table 6 may be conveniently used in solving the following typical problems:

Example 3. Humidifying and Heating. Air is to be maintained at 70 F with a relative humidity of 40 per cent (Φ = 0.4) when the outside air is at 0 F and 70 per cent relative humidity (Φ = 0.7) and a barometric pressure, B, of 29.92 in. of mercury. Find the weight of water vapor added to each pound of dry air and the dew-point temperature of the humidified air.

Solution. From Equation 5 and Table 6,

$$W_1 = 0.622\left(\frac{0.7 \times 0.03773}{29.92 - 0.0264}\right) = 0.000548 \text{ lb per pound of dry air.}$$

$$W_2 = 0.622\left(\frac{0.4 \times 0.7386}{29.92 - 0.295}\right) = 0.00618 \text{ lb per pound of dry air.}$$

The water vapor added per pound of dry air must be $(W_2 - W_1)$ or 0.005632 lb. By inspection of Table 6, W_t = 0.00618 at 44.5 F, so this is the dew-point temperature of the humidified air.

An approximation of the same result from Table 6 is

$W_1 = 0.7 \times 0.0007852 = 0.00054964$ lb per pound of dry air.
$W_2 = 0.4 \times 0.01574 = 0.006296$ lb per pound of dry air.

The water vapor added per pound of dry air is approximately 0.00574636 lb and the dew-point temperature is approximately 45 F. The degree of approximation is evident.

Example 4. Dehumidifying and Cooling. Air with a dry-bulb temperature of 84 F, a wet-bulb of 70 F, or a relative humidity of 50 per cent (Φ = 0.5), and a barometric pressure, B, of 29.92 in. of mercury is to be cooled to 54 F. Find the dew-point temperature of the entering air and the weight of vapor condensed per pound of dry air.

Solution. From Equation 5 and Table 6,

$$W_1 = 0.622\left(\frac{0.5 \times 1.1752}{29.92 - 0.5876}\right) = 0.01248 \text{ lb per pound of dry air.}$$

$$W_2 = 0.622\left(\frac{0.42003}{29.92 - 0.42003}\right) = 0.00887 \text{ lb per pound of dry air.}$$

Since $W_1 = W_t$ when t = 63.4 F, this is the dew-point temperature of the entering air. The weight of vapor condensed is $(W_1 - W_2)$ or 0.00361 lb per pound of dry air.

An approximate result is

$W_1 = 0.5 \times 0.02543 = 0.012715$ lb per pound of dry air.
$W_2 = 1 \times 0.008856 = 0.008856$ lb per pound of dry air, since the exit air is saturated.

Since $W_1 = W_t$ at t = 64 F, this is the dew-point temperature of the entering air. The weight of vapor condensed is 0.003859 lb per pound of dry air. The degree of approximation is again evident.