Problem: 11-9

Given: Stoichiometric reaction of n-butane with air @ 18 psia
n-butane ⇒ C_4H_{10}

Find: Dew point of products
Dew point of products if 100% excess air is used

Reaction:

$$C_4H_{10} + a(O_2 + 3.76N_2) \rightarrow bCO_2 + cH_2O + dN_2$$

Conservation of mass:

$$\begin{aligned} C &: 4 = b \\ H &: 10 = 2c \Rightarrow c = 5 \\ O &: 2a = 2b + c = 13 \Rightarrow a = 6.5 \\ N &: 3.75a = d \Rightarrow d = 24.44 \end{aligned}$$

$$\sum N_{products} = 4 + 5 + 24.44 = 34.44 \ moles$$

$$\begin{aligned} X_{H_2O} &= 5/33.44 = 0.1495 \\ P_{H_2O} &= X_{H_2O}P_{TOT} = (0.1495)(18 \ psia) = 2.691 \ psia \end{aligned}$$

Remember the dew point is the temperature at which the H_2O vapour reaches saturation at the given pressure:

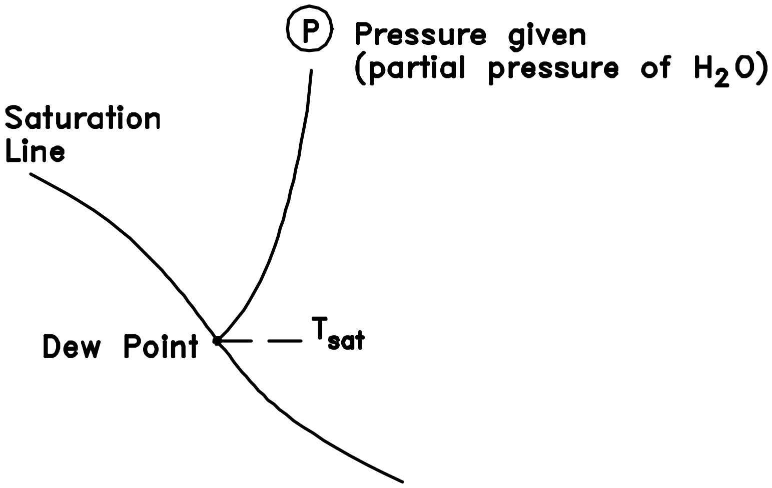
From Table B.1a,

$$T_{sat}@2.691 \ psia \approx \boxed{136.98°F}$$

With 100% excess air the major products in the reaction are assumed to be CO_2, H_2O, N_2, O_2
The reaction becomes

$$C_4H_{10} + 13(O_2 + 3.76N_2) \rightarrow 4CO_2 + 5H_2O + 48.88N_2 + 6.50O_2$$

$$\sum N_{products} = 4 + 5 + 48.88 + 6.50 = 64.38$$



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\begin{aligned}
X_{H_2O} &= 5/64.38 = 0.0777 \\
P_{H_2O} &= X_{H_2O} P_{TOT} = (0.0777)(18\ psia) = 1.398\ psia
\end{aligned}
$$

From Table B.1a

$$T_{sat}@1.398\ psia \approx \boxed{115.8\ ^\circ F}$$