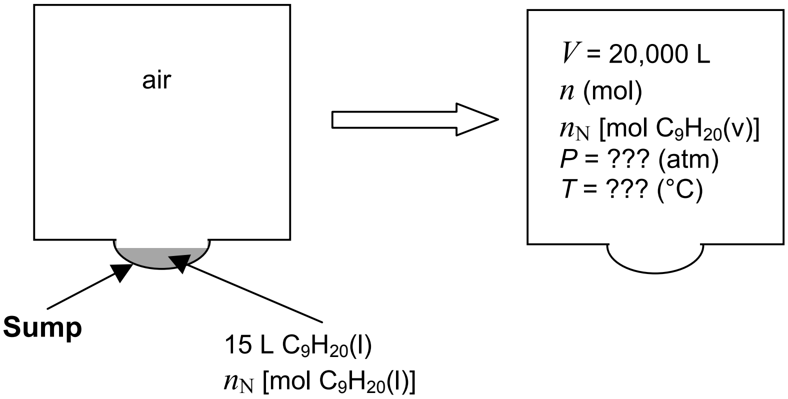
PROBLEM 6.24 (Modified)

A 20,000-liter storage tank was taken out of service to repair and reattach a feed line damaged in a collision with a tanker. The tank was drained and then opened several days later for a welder to enter and perform the required work. No one realized, however, that 15 liters of liquid nonane (C_9H_{20}) remained in a collection sump at the bottom of the tank after the draining had been completed.

(a) Nonane has a lower explosion limit of 0.80 mole% and an upper explosion limit of 2.9 mole% (i.e., nonane-air mixtures at 1 atm can explode when exposed to a spark or flame if the nonane mole percentage is between the two given values). Assume any liquid nonane that evaporates spreads uniformly throughout the tank. Is it possible for the average gas-phase composition in the tank to be within the explosion limits at any time? If the answer is yes, why might the actual percentage of nonane in the tank gas always be below the lower explosion limit? If the answer is no, why might explosion still be a possibility?

Strategy

The greatest possible mole fraction of nonane in the tank gas (assuming the nonane concentration is equal everywhere) would be attained if all the nonane in the sump evaporated and none escaped.



(6.24-1)

- Calculate n_N from the given liquid volume and ______________________ (from Table B.1).
- Estimate n from __________________________, assuming a reasonable value for T.
- Calculate the maximum mole% of nonane in the tank as $p_N = (n_N/n) \times 100\%$.
- If $p_N < 0.80\%$, then the average nonane composition in the tank cannot fall within the explosion limits. If $p_N \geq 0.80\%$, then the average nonane composition in the tank can fall within the explosion limits, either at steady state (if $p_N \leq 2.9\%$) or while the liquid nonane is evaporating (if $p_N > 2.9\%$). (We'll deal with the rest of the question later.)

Solution

Moles of nonane: We assume that after the tank is drained, the only nonane it contains is the liquid in the sump; that is, we neglect any nonane that may initially be in the vapor phase.

$$n_N = \begin{array}{c|c|c} 15\ \text{L}\ C_9H_{20}(l) & \overset{\text{Table B.1}}{\_\_\_\_ \times 1.00\ \text{kg}} & \\ \hline & \text{L}\ C_9H_{20} & \end{array} = 0.084\ \text{kmol}\ C_9H_{20} \qquad \textbf{(6.24-2)}$$