

Introductory Chemical Engineering Thermodynamics | (2nd Edition)

Chapter 1, Problem 8HP

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Problem

Five grams of the specified pure solvent is placed in a variable volume piston. What is the volume of the pure system when 50% and 75% have been evaporated at: (i) 30°C, (ii) 50°C? Use the Antoine equation (Appendix E) to relate the saturation temperature and saturation pressure. Use the ideal gas law to model the vapor phase. Show that the volume of the system occupied by liquid is negligible compared to the volume occupied by vapor.

(a) Hexane ($\rho^L = 0.86 \text{ g/cm}^3$)

(b) Benzene ($\rho^L = 0.88 \text{ g/cm}^3$)

(c) Ethanol ($\rho^L = 0.79 \text{ g/cm}^3$)

(d) Water without using the steam tables ($\rho^L = 1 \text{ g/cm}^3$)

(e) Water using the steam tables

Step-by-step solution

Step 1 of 69

Mass density of a substance is expressed as,

$$\rho = \frac{m}{V}$$

Here ρ is density, m is mass and V is the volume of the substance.

Ideal gas law is expressed as,

$$PV = mRT$$
$$= nR_u T$$

Here P is absolute pressure, T is absolute temperature, n is number of moles of the gas, m is the mass of the gas, R_u is the universal gas constant, R is the gas constant.

Number of moles (n) of a substance is calculated as,

$$n = \frac{m}{M}$$

Here m is mass and M is molecular weight.

Antoine equation is expressed as,

$$\log_{10} P^{sat} = A - \frac{B}{T + C}$$

Here P^{sat} is the saturation pressure in mmHg, T is in Celsius and A, B, C are constants.

$$T_c = T_c + 273.15$$

Comment

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(a)

For Hexane as a pure solvent,

The density of the Hexane in liquid phase is given as,

$$\rho^L = 0.66 - \frac{8}{\text{cm}^3}$$

Calculate number of moles of hexane as,

Take molecular weight of Hexane as $(86.178) \frac{\text{g}}{\text{mol}}$.

Substitute $(86.178) \frac{\text{g}}{\text{mol}}$ for M and 5 g for m and solve for number of moles,

$$n = \frac{5 \text{ g}}{86.178 \frac{\text{g}}{\text{mol}}} = 0.058 \text{ moles}$$

Now to solve for volume (V_L) of the liquid available per mole, substitute $0.66 \frac{\text{g}}{\text{cm}^3}$ for ρ and $(86.178) \frac{\text{g}}{\text{mol}}$ for m in the expression of mass density and solve as,

$$(0.66) \frac{\text{g}}{\text{cm}^3} = \frac{(86.178) \frac{\text{g}}{\text{mol}}}{V}$$
$$V_L = \left(\frac{(86.178) \frac{\text{g}}{\text{mol}}}{0.66 \frac{\text{g}}{\text{cm}^3}} \right)$$
$$= 130.573 \frac{\text{cm}^3}{\text{mol}}$$

Hence the volume of the liquid available per mole is $130.573 \frac{\text{cm}^3}{\text{mol}}$.

Comment

Step 3 of 69

At 30°C,

From Antoine equation calculate pressure as,

Substitute 6.91058 for constant A , 1189.64 for constant B , 226.28 for constant C , 30°C for T and solve for P^{sat} as,

$$\log_{10} P^{sat} = 6.91058 - \frac{1189.64}{30^\circ\text{C} + 226.28}$$
$$P^{sat} = 185.62 \text{ mmHg}$$
$$= \left(\frac{101325 \text{ Pa}}{760 \text{ mmHg}} \right) (185.62 \text{ mmHg})$$
$$= 24747.362 \text{ Pa}$$

Further solve,

$$P^{sat} = (24747.362 \text{ Pa}) \left(\frac{1 \text{ MPa}}{10^6 \text{ Pa}} \right)$$
$$= 0.025 \text{ MPa}$$

Hence at 30°C hexane evaporates at pressure of 0.025 MPa .

Now calculate the volume of the vapor as,

Substitute 0.025 MPa for P , $(30 + 273.15) \text{ K}$ for T , $8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$ for R_u and solve for volume (V_v) of vapor per mole, that have been evaporated as,

$$(0.025 \text{ MPa})(V_v) = \left(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) ((30 + 273.15) \text{ K})$$
$$V_v = \frac{2520.39 \frac{\text{J}}{\text{mol}}}{(0.025 \times 10^6) \text{ Pa}}$$
$$= 100815.56 \frac{\text{cm}^3}{\text{mol}}$$

Now since 50% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

$$V_{f,50\%} = V_L + V_v$$
$$= n^L V_L + n^V V_v$$
$$= \left(\frac{1}{2} (0.058 \text{ mol}) \right) \left(130.573 \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{1}{2} (0.058 \text{ mol}) \right) \left(100815.56 \frac{\text{cm}^3}{\text{mol}} \right)$$
$$= 3.788 \text{ cm}^3 + 2923.65 \text{ cm}^3$$

Further solve,

$$V_{f,50\%} = 2927.44 \text{ cm}^3$$

Hence final volume of hexane in pure system for 50% evaporation is $[2927.44 \text{ cm}^3]$.

Comment

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Now since for second case 75% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

$$V_{f,75\%} = V_L + V_v$$
$$= n^L V_L + n^V V_v$$
$$= \left(\frac{1}{4} (0.058 \text{ mol}) \right) \left(130.573 \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{3}{4} (0.058 \text{ mol}) \right) \left(100815.56 \frac{\text{cm}^3}{\text{mol}} \right)$$
$$= 1.893 \text{ cm}^3 + 4385.477 \text{ cm}^3$$
$$= 4387.37 \text{ cm}^3$$

Hence final volume of hexane in pure system for 75% evaporation is $[4387.37 \text{ cm}^3]$.

Comment

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At 50°C,

Comment

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From Antoine equation calculate pressure as,

Comment

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Substitute 6.91058 for constant A , 1189.64 for constant B , 226.28 for constant C , 50°C for T and solve for P^{sat} as,

$$\log_{10} P^{sat} = 6.91058 - \frac{1189.64}{50^\circ\text{C} + 226.28}$$
$$P^{sat} = 402.4 \text{ mmHg}$$
$$= \left(\frac{101325 \text{ Pa}}{760 \text{ mmHg}} \right) (402.4 \text{ mmHg})$$
$$= 53648.983 \text{ Pa}$$
$$= (53648.983 \text{ Pa}) \left(\frac{1 \text{ MPa}}{10^6 \text{ Pa}} \right)$$
$$= 0.054 \text{ MPa}$$

Hence at 50°C hexane evaporates at pressure of 0.054 MPa .

Now calculate the volume of the vapor as,

Substitute 0.054 MPa for P , $(50 + 273.15) \text{ K}$ for T , $8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$ for R_u and solve for volume (V_v) of liquid per mole, that have been evaporated as,

$$(0.054 \text{ MPa})(V_v) = \left(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) ((50 + 273.15) \text{ K})$$
$$V_v = \frac{2686.67 \frac{\text{J}}{\text{mol}}}{(0.054 \times 10^6) \text{ Pa}}$$
$$= 49753.13 \frac{\text{cm}^3}{\text{mol}}$$

Comment

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Now since 50% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

Comment

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$$V_{f,50\%} = V_L + V_v$$
$$= n^L V_L + n^V V_v$$
$$= \left(\frac{1}{2} (0.058 \text{ mol}) \right) \left(130.573 \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{1}{2} (0.058 \text{ mol}) \right) \left(49753.13 \frac{\text{cm}^3}{\text{mol}} \right)$$
$$= 3.788 \text{ cm}^3 + 1442.84 \text{ cm}^3$$
$$= 1446.63 \text{ cm}^3$$

Comment

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Hence final volume of hexane in pure system for 50% evaporation is $[1446.63 \text{ cm}^3]$.

Comment

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Now since for second case 75% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

Comment

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$$V_{f,75\%} = V_L + V_v$$
$$= n^L V_L + n^V V_v$$
$$= \left(\frac{1}{4} (0.058 \text{ mol}) \right) \left(130.573 \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{3}{4} (0.058 \text{ mol}) \right) \left(49753.13 \frac{\text{cm}^3}{\text{mol}} \right)$$
$$= 1.893 \text{ cm}^3 + 2164.26 \text{ cm}^3$$
$$= 2166.16 \text{ cm}^3$$

Hence final volume of hexane in pure system for 75% evaporation is $[2166.16 \text{ cm}^3]$.

Comment

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Hence, at both given temperatures the volume occupied by the liquid in the system is less than 1%. Also, the volumes are lower at the higher temperature, due to rapid increase in pressure than expansion, due to temperature.

(b)

For Benzene as a pure solvent,

The density of the Benzene in liquid phase is given as,

$$\rho^L = 0.88 - \frac{8}{\text{cm}^3}$$

Calculate number of moles of benzene as,

Take molecular weight of Benzene as $(78.12) \frac{\text{g}}{\text{mol}}$.

Substitute $(78.12) \frac{\text{g}}{\text{mol}}$ for M and 5 g for m and solve for number of moles,

$$n = \frac{5 \text{ g}}{(78.12) \frac{\text{g}}{\text{mol}}} = 0.064 \text{ moles}$$

Now to solve for volume (V_L) of the liquid available per mole, substitute $0.88 \frac{\text{g}}{\text{cm}^3}$ for ρ and $(78.12) \frac{\text{g}}{\text{mol}}$ for m in the expression of mass density and solve as,

$$0.88 \frac{\text{g}}{\text{cm}^3} = \frac{(78.12) \frac{\text{g}}{\text{mol}}}{V}$$
$$V_L = \left(\frac{(78.12) \frac{\text{g}}{\text{mol}}}{0.88 \frac{\text{g}}{\text{cm}^3}} \right)$$
$$= 88.773 \frac{\text{cm}^3}{\text{mol}}$$

Hence the volume of the liquid available per mole is $88.773 \frac{\text{cm}^3}{\text{mol}}$.

Comment

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At 30°C,

From Antoine equation calculate pressure as,

Substitute 6.87987 for constant A , 1196.76 for constant B , 219.161 for constant C , 30°C for T and solve for P^{sat} as,

$$\log_{10} P^{sat} = 6.87987 - \frac{1196.76}{30^\circ\text{C} + 219.161}$$
$$P^{sat} = 119.32 \text{ mmHg}$$
$$= \left(\frac{101325 \text{ Pa}}{760 \text{ mmHg}} \right) (119.32 \text{ mmHg})$$
$$= 15907.93 \text{ Pa}$$
$$= (15907.93 \text{ Pa}) \left(\frac{1 \text{ MPa}}{10^6 \text{ Pa}} \right)$$
$$= 0.0159 \text{ MPa}$$

Hence at 30°C benzene evaporates at pressure of 0.0159 MPa .

Now calculate the volume of the vapor as,

Substitute 0.0159 MPa for P , $(30 + 273.15) \text{ K}$ for T , $8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$ for R_u and solve for volume (V_v) of vapor per mole, that have been evaporated as,

$$(0.0159 \text{ MPa})(V_v) = \left(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) ((30 + 273.15) \text{ K})$$
$$V_v = \frac{2520.39 \frac{\text{J}}{\text{mol}}}{(0.0159 \times 10^6) \text{ Pa}}$$
$$= 158515.04 \frac{\text{cm}^3}{\text{mol}}$$

Comment

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Now since 50% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

Comment

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$$V_{f,50\%} = V_L + V_v$$
$$= n^L V_L + n^V V_v$$
$$= \left(\frac{1}{2} (0.064 \text{ mol}) \right) \left(88.773 \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{1}{2} (0.064 \text{ mol}) \right) \left(158515.04 \frac{\text{cm}^3}{\text{mol}} \right)$$
$$= 2.84 \text{ cm}^3 + 5072.48 \text{ cm}^3$$
$$= 5075.322 \text{ cm}^3$$

Comment

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Hence final volume of benzene in pure system for 50% evaporation is $[5075.322 \text{ cm}^3]$.

Comment

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Now since for second case 75% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

Comment

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$$V_{f,75\%} = V_L + V_v$$
$$= n^L V_L + n^V V_v$$
$$= \left(\frac{1}{4} (0.064 \text{ mol}) \right) \left(88.773 \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{3}{4} (0.064 \text{ mol}) \right) \left(158515.04 \frac{\text{cm}^3}{\text{mol}} \right)$$
$$= 1.42 \text{ cm}^3 + 7608.722 \text{ cm}^3$$
$$= 7610.14 \text{ cm}^3$$

Hence final volume of benzene in pure system for 75% evaporation is $[4387.37 \text{ cm}^3]$.

Comment

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At 50°C,

From Antoine equation calculate pressure as,

Substitute 6.87987 for constant A , 1196.76 for constant B , 219.161 for constant C , 50°C for T and solve for P^{sat} as,

$$\log_{10} P^{sat} = 6.87987 - \frac{1196.76}{50^\circ\text{C} + 219.161}$$
$$P^{sat} = 271.4 \text{ mmHg}$$
$$= \left(\frac{101325 \text{ Pa}}{760 \text{ mmHg}} \right) (271.4 \text{ mmHg})$$
$$= 36183.64 \text{ Pa}$$
$$= (36183.64 \text{ Pa}) \left(\frac{1 \text{ MPa}}{10^6 \text{ Pa}} \right)$$
$$= 0.0362 \text{ MPa}$$

Hence at 50°C benzene evaporates at pressure of 0.0362 MPa .

Now calculate the volume of the vapor as,

Substitute 0.0362 MPa for P , $(50 + 273.15) \text{ K}$ for T , $8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}}$ for R_u and solve for volume (V_v) of vapor per mole, that have been evaporated as,

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$$\begin{aligned} &= \left(\frac{1}{4} (0.2775 \text{ mol}) \left((18.02) \frac{\text{cm}^3}{\text{mol}} \right) \right) + \left(\frac{3}{4} (0.2775 \text{ mol}) \left(595601.135 \frac{\text{cm}^3}{\text{mol}} \right) \right) \\ &= 1.25 \text{ cm}^3 + 123959.49 \text{ cm}^3 \\ &= 123960.74 \text{ cm}^3 \end{aligned}$$

Hence final volume of water in pure system for 75% evaporation is $\boxed{123960.74 \text{ cm}^3}$.

[Comment](#)

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At 50°C,
From Antoine equation calculate pressure as,
Substitute 8.07131 for constant A , 1730.63 for constant B , 233.426 for constant C , 50°C for T and solve for P^{sat} as,
$$\log_{10} P^{\text{sat}} = 8.07131 - \frac{1730.63}{50^\circ\text{C} + 233.426}$$
$$P^{\text{sat}} = 92.3 \text{ mmHg}$$
$$= \left(\frac{101325 \text{ Pa}}{760 \text{ mmHg}} \right) (92.3 \text{ mmHg})$$
$$= 12305.64 \text{ Pa}$$
$$= (12305.64 \text{ Pa}) \left(\frac{1 \text{ MPa}}{10^6 \text{ Pa}} \right)$$
$$= 0.0123 \text{ MPa}$$

Hence at 50°C water evaporates at pressure of 0.0123 MPa.
Now calculate the volume of the vapor as,
Substitute 0.0123 MPa for P , (50+273.15) K for T , 8.314 $\frac{\text{J}}{\text{mol} \cdot \text{K}}$ for R , and solve for volume (V_g) of vapor per mole, that have been evaporated as,

$$(0.0123 \text{ MPa})(V_g) = \left(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) ((50 + 273.15) \text{ K})$$
$$V_g = \frac{2686.67 \frac{\text{J}}{\text{mol}}}{(0.0123 \times 10^6) \text{ Pa}}$$
$$= 218328.35 \frac{\text{cm}^3}{\text{mol}}$$

[Comment](#)

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Now since 50% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

[Comment](#)

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$$\begin{aligned} V_{f,50\%} &= V_L + V_V \\ &= n^L V_L + n^V V_V \\ &= \left(\frac{1}{2} (0.2775 \text{ mol}) \right) \left((18.02) \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{1}{2} (0.2775 \text{ mol}) \right) \left(218328.35 \frac{\text{cm}^3}{\text{mol}} \right) \\ &= 2.5 \text{ cm}^3 + 30293.06 \text{ cm}^3 \\ &= 30295.56 \text{ cm}^3 \end{aligned}$$

[Comment](#)

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Hence final volume of water in pure system for 50% evaporation is $\boxed{30295.56 \text{ cm}^3}$.

[Comment](#)

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Now since for second case 75% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

[Comment](#)

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$$\begin{aligned} V_{f,75\%} &= V_L + V_V \\ &= n^L V_L + n^V V_V \\ &= \left(\frac{1}{4} (0.2775 \text{ mol}) \right) \left((18.02) \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{3}{4} (0.2775 \text{ mol}) \right) \left(218328.35 \frac{\text{cm}^3}{\text{mol}} \right) \\ &= 1.25 \text{ cm}^3 + 45439.59 \text{ cm}^3 \\ &= 45440.84 \text{ cm}^3 \end{aligned}$$

Hence final volume of water in pure system for 75% evaporation is $\boxed{45440.84 \text{ cm}^3}$.

[Comment](#)

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Hence, at both given temperatures the volume occupied by the liquid in the system is less than 1%. Also, the volumes are lower at the higher temperature, due to rapid increase in pressure than expansion, due to temperature.

[Comment](#)

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(e)
For water as a pure solvent, and using data from steam tables
The density of the water in liquid phase is given as,
$$\rho^L = 1 \frac{\text{g}}{\text{cm}^3}$$

Calculate number of moles of water as,
Take molecular weight of water as $(18.02) \frac{\text{g}}{\text{mol}}$.
Substitute $(18.02) \frac{\text{g}}{\text{mol}}$ for M and 5 g for m and solve for number of moles,
$$n = \frac{5 \text{ g}}{(18.02) \frac{\text{g}}{\text{mol}}}$$
$$= 0.2775 \text{ moles}$$

Now to solve for volume (V_L) of the liquid available per mole, substitute 1 $\frac{\text{g}}{\text{cm}^3}$ for ρ and
 $(18.02) \frac{\text{g}}{\text{mol}}$ for m in the expression of mass density and solve as,

$$1 \frac{\text{g}}{\text{cm}^3} = \frac{(18.02) \frac{\text{g}}{\text{mol}}}{V}$$
$$V_L = \left(\frac{(18.02) \frac{\text{g}}{\text{mol}}}{1 \frac{\text{g}}{\text{cm}^3}} \right)$$
$$= (18.02) \frac{\text{cm}^3}{\text{mol}}$$

[Comment](#)

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Hence the volume of the liquid available per mole is $(18.02) \frac{\text{cm}^3}{\text{mol}}$.

[Comment](#)

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At 30°C,
From steam tables,
 $P^{\text{sat}} = 0.004247 \text{ MPa}$

Hence at 30°C water evaporates at pressure of 0.004247 MPa.
Now calculate the volume of the vapor as,
Substitute 0.004247 MPa for P , (30+273.15) K for T , 8.314 $\frac{\text{J}}{\text{mol} \cdot \text{K}}$ for R , and solve for volume (V_g) of vapor per mole, that have been evaporated as,

$$(0.004247 \text{ MPa})(V_g) = \left(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) ((30 + 273.15) \text{ K})$$
$$V_g = \frac{2520.39 \frac{\text{J}}{\text{mol}}}{(0.004247 \times 10^6) \text{ Pa}}$$
$$= 593451.85 \frac{\text{cm}^3}{\text{mol}}$$

[Comment](#)

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Now since 50% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

[Comment](#)

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$$\begin{aligned} V_{f,50\%} &= V_L + V_V \\ &= n^L V_L + n^V V_V \\ &= \left(\frac{1}{2} (0.2775 \text{ mol}) \right) \left((18.02) \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{1}{2} (0.2775 \text{ mol}) \right) \left(593451.85 \frac{\text{cm}^3}{\text{mol}} \right) \\ &= 2.5 \text{ cm}^3 + 82341.444 \text{ cm}^3 \\ &= 82343.944 \text{ cm}^3 \end{aligned}$$

[Comment](#)

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Hence final volume of water in pure system for 50% evaporation is $\boxed{82343.944 \text{ cm}^3}$.

[Comment](#)

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Now since for second case 75% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

[Comment](#)

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$$\begin{aligned} V_{f,75\%} &= V_L + V_V \\ &= n^L V_L + n^V V_V \\ &= \left(\frac{1}{4} (0.2775 \text{ mol}) \right) \left((18.02) \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{3}{4} (0.2775 \text{ mol}) \right) \left(593451.85 \frac{\text{cm}^3}{\text{mol}} \right) \\ &= 1.25 \text{ cm}^3 + 123512.16 \text{ cm}^3 \\ &= 123513.42 \text{ cm}^3 \end{aligned}$$

Hence final volume of water in pure system for 75% evaporation is $\boxed{123513.42 \text{ cm}^3}$.

[Comment](#)

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At 50°C,
From steam tables,
 $P^{\text{sat}} = 0.0124 \text{ MPa}$

Hence at 50°C water evaporates at pressure of 0.0124 MPa.
Now calculate the volume of the vapor as,
Substitute 0.0124 MPa for P , (50+273.15) K for T , 8.314 $\frac{\text{J}}{\text{mol} \cdot \text{K}}$ for R , and solve for volume (V_g) of vapor per mole, that have been evaporated as,

$$(0.0124 \text{ MPa})(V_g) = \left(8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \right) ((50 + 273.15) \text{ K})$$
$$V_g = \frac{2686.67 \frac{\text{J}}{\text{mol}}}{(0.0124 \times 10^6) \text{ Pa}}$$
$$= 216666.935 \frac{\text{cm}^3}{\text{mol}}$$

[Comment](#)

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Now since 50% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

[Comment](#)

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$$\begin{aligned} V_{f,50\%} &= V_L + V_V \\ &= n^L V_L + n^V V_V \\ &= \left(\frac{1}{2} (0.2775 \text{ mol}) \right) \left((18.02) \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{1}{2} (0.2775 \text{ mol}) \right) \left(216666.935 \frac{\text{cm}^3}{\text{mol}} \right) \\ &= 2.5 \text{ cm}^3 + 30062.54 \text{ cm}^3 \\ &= 30065.04 \text{ cm}^3 \end{aligned}$$

[Comment](#)

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Hence final volume of water in pure system for 50% evaporation is $\boxed{30065.04 \text{ cm}^3}$.

[Comment](#)

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Now since for second case 75% of the available volume evaporates, therefore the final volume (V_f) of the pure system is,

[Comment](#)

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$$\begin{aligned} V_{f,75\%} &= V_L + V_V \\ &= n^L V_L + n^V V_V \\ &= \left(\frac{1}{4} (0.2775 \text{ mol}) \right) \left((18.02) \frac{\text{cm}^3}{\text{mol}} \right) + \left(\frac{3}{4} (0.2775 \text{ mol}) \right) \left(216666.935 \frac{\text{cm}^3}{\text{mol}} \right) \\ &= 1.25 \text{ cm}^3 + 45093.806 \text{ cm}^3 \\ &= 45095.056 \text{ cm}^3 \end{aligned}$$

Hence final volume of water in pure system for 75% evaporation is $\boxed{45095.056 \text{ cm}^3}$.

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Hence, at both given temperatures the volume occupied by the liquid in the system is less than 1%. Also, the volumes are lower at the higher temperature, due to rapid increase in pressure than expansion, due to temperature.

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Was this solution helpful? ☐ No ☐ Yes

