

## Exam 2 Practice Problems Solutions

1. (a) Determine the boiling point of methanol in a rotovap in which the pressure is 0.500 bar. Given: The standard boiling point of methanol (i.e.  $T_b$  at  $p = 1$  bar) is 337.2 K, and  $\Delta_{\text{vap}}H^\circ = 35.27 \text{ kJ mol}^{-1}$ . (You may treat  $\Delta_{\text{vap}}H^\circ = 35.27$  as constant.)

$$\ln \frac{p_f}{p_i} = \frac{\Delta_{\text{vap}}H^\circ}{R} \left( \frac{1}{T_i} - \frac{1}{T_f} \right)$$

$\begin{matrix} 0.5 \text{ bar} & 35.27 \text{ kJ/mol} \\ \swarrow & \swarrow \\ \ln \frac{p_f}{p_i} & = & \frac{\Delta_{\text{vap}}H^\circ}{R} & \left( \frac{1}{T_i} - \frac{1}{T_f} \right) \\ \swarrow & \swarrow & \swarrow & \swarrow \\ 1.0 \text{ bar} & 8.314 \text{ J K}^{-1} \text{ mol}^{-1} & 337.2 \text{ K} & T_f \end{matrix}$

$$\frac{1}{T_i} - \frac{1}{T_f} = -0.0001634 \text{ K}^{-1}$$

337.2 K

$$T_f = 319.6 \text{ K}$$

Makes sense, because lower  $T_b$  is expected for lower pressure.

- (b) What equation did you use to solve (a), and what approximations are inherent in the equation?

Equation is above: Clausius-Clapeyron

In deriving it, these approximations were used:

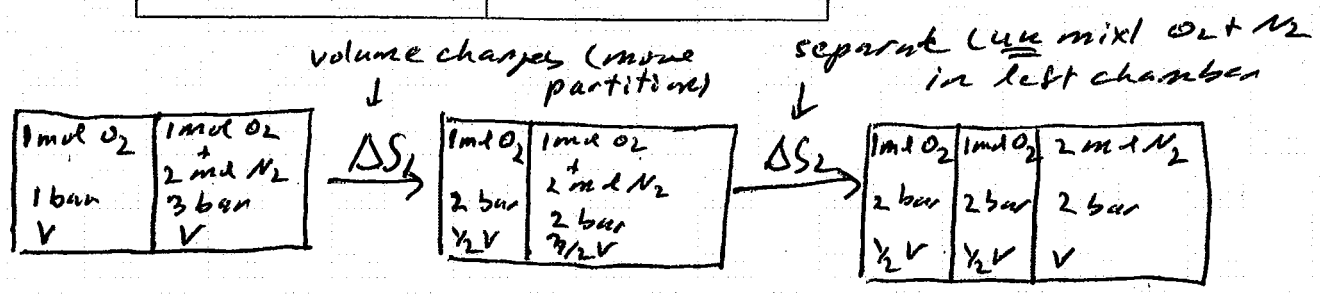
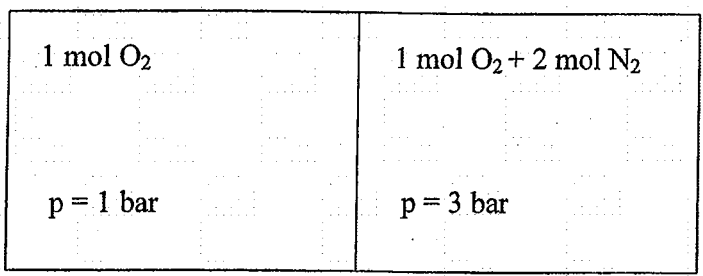
$V(\text{liq})$  neglected

Perfect gas equation

$\Delta_{\text{vap}}H^\circ$  treated as independent of  $T$

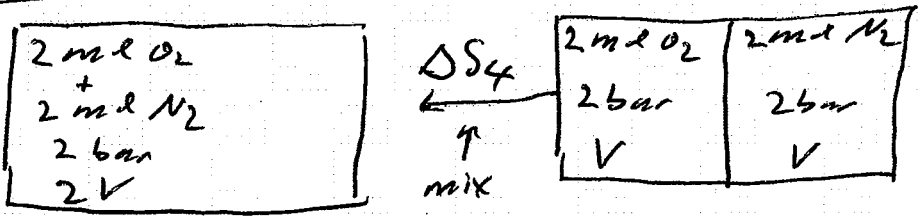


(b) Consider a rigid container as sketched below. It is divided into two sections of equal volume by a partition. Initially, there is 1 mol O<sub>2</sub> on one side at 1 bar pressure, and a mixture of 1 mol O<sub>2</sub> and 2 mol N<sub>2</sub> on the other side at 3 bar pressure. At a particular time, the partition is removed. Calculate ΔS, the change in entropy after the partition is removed. You may treat the gases as perfect. Hint: construct a cycle, that is, a series of fictitious steps.



or use  $nR \ln \frac{p_i}{p_f} = nR \ln \frac{1 \text{ bar}}{2 \text{ bar}}$  something

combine O<sub>2</sub> compartments → no change in S



$$\Delta S_1 = 1 \text{ mol} \cdot R \ln \frac{1/2 V}{V} + 3 \text{ mol} \cdot R \ln \frac{3/2 V}{V} = -5.76 + 10.11 = 4.35 \text{ J K}^{-1}$$

$$\Delta S_2 = 3 \text{ mol} \cdot R \left( \frac{1}{3} \ln \frac{1}{3} + \frac{2}{3} \ln \frac{2}{3} \right) = -15.88 \text{ J K}^{-1}$$

$$\Delta S_3 = 0$$

$$\Delta S_4 = 4 \text{ mol} \cdot R \left( \frac{1}{2} \ln \frac{1}{2} + \frac{1}{2} \ln \frac{1}{2} \right) = 23.05 \text{ J K}^{-1}$$

$$\Delta S = \sum_{i=1}^4 \Delta S_i = 11.53 \text{ J K}^{-1}$$

ΔS > 0 as expected (no heat flow ⇒ ΔS<sub>sur</sub> = 0, ΔS<sub>tot</sub> = ΔS)