Assignment 1

1. $PV = NkT$

$$N = \frac{PV}{kT}$$

$$= \frac{4 \times 10^5 \text{ Pas.} \times 5 \text{ m}^3}{1.38 \times 10^{-23} \text{ J/K} \times 298 \text{ K}}$$

$$= 6.08 \times 10^{26} \text{ air particles}$$

Air particle mass $= 0.8\,N_2 + 0.2\,O_2$

$$= (0.8 \times 28 + 0.2 \times 32) \times 1.67 \times 10^{-27} \text{ kg}$$

$$= 4.81 \times 10^{-26} \text{ kg.}$$

$$\therefore \text{air density} = \frac{N \cdot m_{air}}{5 \text{ m}^3}$$

$$= \frac{6 \times 10^{26} \times 4.81 \times 10^{-26} \text{ kg}}{5 \text{ m}^3}$$

$$= 5.85 \text{ kg/m}^3$$

2a. Isothermal Expansion: $PV = NkT = \text{constant}$

$$\therefore P_1 V_1 = P_2 V_2$$

$$P_2 = \frac{V_1}{V_2} P_1$$

$$= \frac{1\ell}{0.5\ell} \times 1 \text{ atm}$$

$$= 2 \text{ atm}$$

b) Isentropic Expansion: $PV^{\gamma} = \text{constant}$

$$\therefore P_1 V_1^{\gamma} = P_2 V_2^{\gamma}$$

$$P_2 = \left(\frac{V_1}{V_2}\right)^{\gamma} P_1 \quad \text{where } \gamma_{He} = \frac{5}{3}$$

$$= \left(\frac{1}{0.5}\right)^{5/3} 1 \text{ atm.}$$

$$= 3.16 \text{ atm.}$$

3. From notes, rise of fluid in capillary tube is:

$$h = \frac{2\sigma \cos\theta}{\rho R g}$$

$$\theta = 0^\circ \Rightarrow h = \frac{2\sigma}{\rho R g} < 1 \text{ mm}$$

$$\therefore 2R > \frac{4\sigma}{\rho g \times 1 \text{mm}}$$

$$> \frac{4 \times 0.0728 \text{ Nt/m}}{10^3 \frac{\text{kg}}{\text{m}^3} \times 9.8 \frac{\text{m}}{\text{sec}^2} \times 10^{-3} \text{ m}}$$

$$> 0.03 \text{ m}$$

$$\therefore 2R > 3 \text{ cm}$$

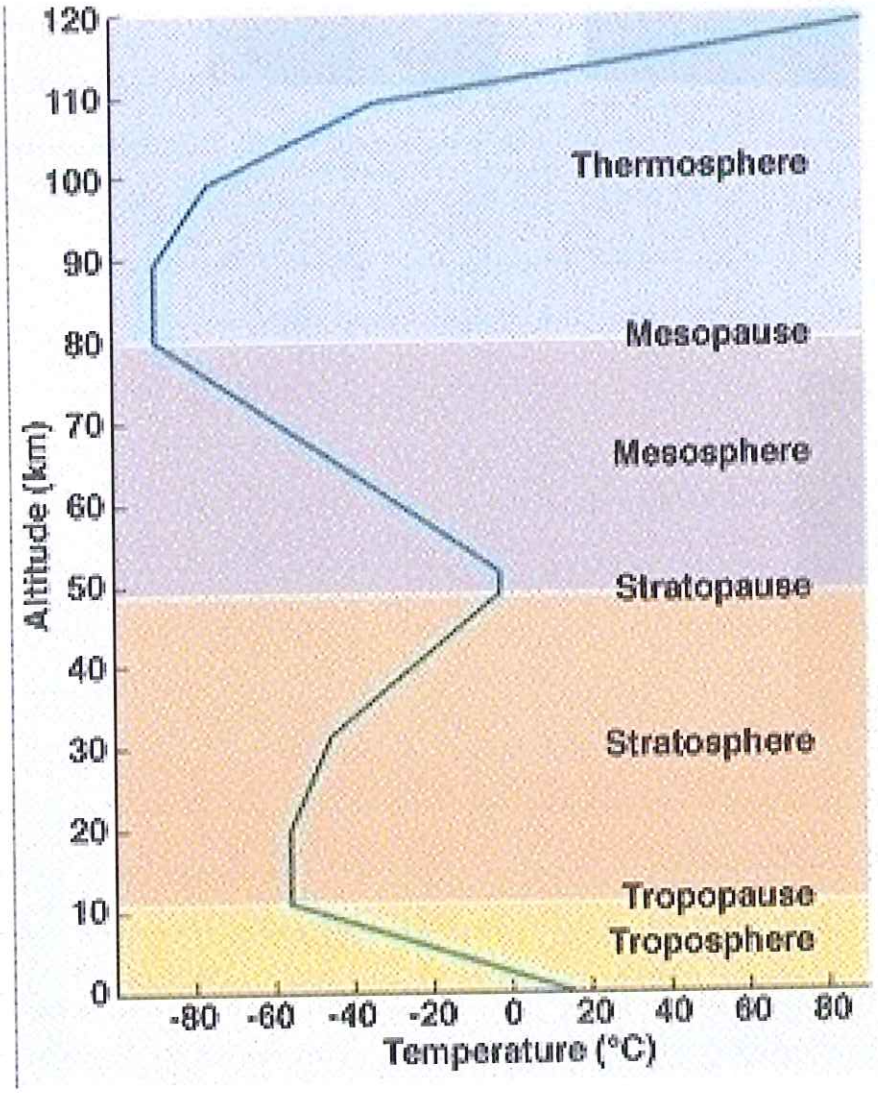
4. From notes: $\frac{P_2}{P_1} = \exp\left[\frac{-g M_w (z_2 - z_1)}{RT}\right]$

$$T = 25\,C \Rightarrow \frac{P_2}{P_1} = \exp\left[\frac{-9.8\,\frac{m}{s^2} \times 2.9\times10^{-2}\,\frac{kg}{mol} \times 550\,m}{8.314\,\frac{kg\,m^2}{mol\,K\,s^2} \times 298\,K}\right]$$

$$\frac{P_2}{P_1} = 0.939$$

$$T = -10\,C \Rightarrow \frac{P_2}{P_1} = 0.931$$

5.



← Increase in stratosphere due to O_3 absorption of UV.