Question 1: Winter 2016-2017 (Marks = 25)

Helium and nitrogen gas are contained in a conduit 6 mm in diameter and 0.1 m long at 298 K and a uniform constant total pressure of **2.0 atm** abs. The partial pressure of He at point one of the tube is 0.6 atm. and 0.2 atm at the other end (point two). At P = 1 atm and T = 298 K, the molecular diffusivity of Helium in Nitrogen is $0.687 \times 10^{-4}\ m^2/s$, calculate the following for steady-state equi-molar counter diffusion.

a.	Flux of He in kg mol/s. m^2.	(Marks = 10)
b.	Flux of N_2.	(Marks = 5)
c.	Rate of He in kg mol/s.	(Marks = 5)
d.	Partial pressure of He at a point 0.03 m from point one.	(Marks = 5)

$$\frac{D_{AB2}}{D_{AB1}} = \left(\frac{P_1}{P_2}\right) \qquad D_{AB2} = D_{AB1}\left(\frac{P_1}{P_2}\right) = 0.5 \times 0.687 \times 10^{-4} = 0.3435 \times 10^{-4} m^2/s$$

$$J^{\star}_{Az} = -\frac{D_{AB}(p_{A1} - p_{A2})}{RT(z_1 - z_2)} = \frac{0.3435 \times 10^{-4} \frac{m^2}{s} \times (0.6 - 0.2)atm}{0.08205 \frac{m^3 atm}{K \cdot kgmol} \times 298K \times 0.1m} = 5.68 \times 10^{-6} \frac{kgmol}{m^2 \cdot s}$$

$$J^{\star}_{Bz} = -J^{\star}_{Bz} = -5.68 \times 10^{-6} \frac{kgmol}{m^2 \cdot s}$$

$$N^{\star}_{Az} = J^{\star}_{Az} \times \pi R^2 = 5.68 \times 10^{-6} \frac{kgmol}{m^2 \cdot s} \times \pi \left(\frac{3}{1000}\right)^2 m^2 = 16.1 \times 10^{-11} \frac{kgmol}{s}$$

$$p_{A2} = p_{A1} - \frac{J^{\star}_{Az} \times RT(z_1 - z_2)}{D_{AB}} = 0.6 - \frac{5.68 \times 10^{-6} \times 0.08205 \times 298 \times (0.03)}{0.3435 \times 10^{-4}} = 0.60 - 0.16 = 0.48\ atm$$

Question 2: (Marks = 25)

Predict the diffusivity of acetic acid (CH_3COOH; MW=60) solute in solvent water using Wilke-Chang correlation at atmospheric conditions taking temperature 25 degree C. At 25 degree C, the viscosity of water at is 0.9×10^{-3} Pa.s. Compare your results with experimental value, compute the % error.

	Marks
$D_{AB} = 1.173 \times 10^{-16} (\varphi M_B)^{1/2} \left(\frac{T}{\mu_B V_A^{0.6}}\right)$	
$V_A = 2(0.0148) + 4(0.0037) + 2(0.0074) = 0.0592 \frac{m^3}{kg\ mol}$	5
$D_{AB} = 1.173 \times 10^{-16} \times (2.6 \times 18)^{1/2} \left(\frac{298}{0.9 \times 10^{-3} \times 0.0592^{0.6}}\right) = 1.44 \times 10^{-9} \frac{m^2}{s}$	10
$D_{AB}(Exptl) = 1.26 \times 10^{-9} \frac{m^2}{s}$	5
$\%\ Error = \frac{\lvert 1.44 \times 10^{-9} - 1.26 \times 10^{-9} \rvert}{1.26 \times 10^{-9}} \times 100 = 14.2$	5

	Marks
$D_{AB} = 1.173 \times 10^{-16}(\varphi M_B)^{1/2}\left(\frac{T}{\mu_B V_A^{0.6}}\right)$	
$V_A^{0.6} = 2(0.0148) + 4(0.0037) + 2(0.012) = 0.0684\,\frac{m^3}{kg\ mol}$	5
$D_{AB} = 1.173 \times 10^{-16} \times (2.6 \times 18)^{1/2}\left(\frac{298}{0.9 \times 10^{-3} \times 0.0684^{0.6}}\right) = 1.33 \times 10^{-9}\,\frac{m^2}{s}$	10
$D_{AB}(Exptl) = 1.26 \times 10^{-9}\,\frac{m^2}{s}$	5
$\%\ Error = \frac{\lvert 1.44 \times 10^{-9} - 1.33 \times 10^{-9}\rvert}{1.26 \times 10^{-9}} \times 100 = 5.4$	5

Question 1: Fall 2016-2017

A narrow tube contains Acetone ($(CH_3)_2CO$) at a constant temperature of 313 K. The total pressure of air (assumed dry) is 1.01325 x 10^5 Pa. Acetone evaporates and diffuses through the air in the tube. The initial height of the acetone was 0.1176 m when measured from the top. After sometime during the experiment, the liquid level decreased due to evaporation. The final height recorded was 0.1180 m from the top.

Assume that the system is isothermal. (Given: Acetone vapor pressure at 313 K = 55,864 Pa; Diffusion coefficient = 1.2 x 10^{-5} m^2/s; Density = 790 kg/m^3; MW = 58.08 kg per kg mol; R = 8314 (m^3.Pa)/(kg mol.K)). The diagram is similar to Fig. 6.2-2a.

- Determine the time taken in the experiment.
- Compute the diffusion coefficient of acetone-air system for the above case using Fuller et al. correlation and compare its value for the air-acetone system.

Question 1: Winter 2015-2016

i. Estimate the diffusivity of water vapor (solute, MW = 18) in Air (MW = 29) at 298 K and P =1 atm.
ii. Compare your results with the reported experimental data and compute the % error.
iii. What would be the diffusivity air (solute) in water vapor at 298 K and P = 2 atm?