KING SAUD UNIVERSITY
Department of Chemical Engineering
TEST-1: Part-1 (Closed Book) Mass Transfer (CHE 318) Time: 15 min

Roll No:	Gp: (i) 8:00– 10:00 (ii) 10:00 – 12:00

(1) Water evaporation is higher in Riyadh when compared with Jeddah at the same temperature since the humidity is lower in Riyadh. This is due to the fact that the humidity

(a) increases the diffusion coefficient of the water vapor	(b) increases the vapor pressure of the water
(c) increases driving force for the water evaporation	(d) None of these are valid reasons

(2) Water evaporation is higher in Riyadh when compared with Jeddah at the same temperature since the humidity is lower in Riyadh. What do you think about the evaporation of acetone? It will be

(a) higher in Riyadh and lower in Jeddah	(b) lower in Riyadh and higher in Jeddah
(c) nothing can be said with confidence about acetone	(d) identical (same) evaporation in both cities

(3) When you go to a busy gasoline station with many vehicles to fill up your car's gasoline tank. You often smell gasoline. You expect smell to be more strong

(a) in hot summer afternoon (high temperature)	(b) in cold winter morning (low temperature)
(c) same smell (no effect of weather temperature)	(d) in rainy season (high humidity)

(4) The Knudsen diffusion coefficient will be highest for

(a) hydrogen (MW = 2)	(b) nitrogen (MW = 28)
(c) oxygen (MW = 32)	(d) argon(MW = 40)

(5) The permeability of polyethylene is much higher than the nylon for the oxygen gas. For packaging pharmaceutical product (medicine), it required to keep the diffusion flux of atmospheric oxygen to the medicine as low as possible to avoid its oxidation to increase the shelf life (product expiry). Based on your mass transfer knowledge, which of the following options will you choose

(a) 0.2 mm film of polyethylene (PE)	(b) 0.2 mm film of nylon (NY)
(c) (i)0.1 mm film of PE and (ii) 0.1 mm film of NY	(d) (i)0.1 mm film of NY and (ii) 0.1 mm film of PE

(6) In laminar flow regime, the transport of mass occurs

(a) mainly by molecular diffusion	(b) mainly by turbulent diffusion (eddies)
(c) random motion of eddies	(d) all of these is correct

(7) In turbulent flow regime, the transport of mass occurs

(a) mainly by molecular diffusion	(b) mainly by turbulent diffusion (eddies)
(c) random motion of solute molecules	(d) none of these is correct

(8) In convective mass transport, the convective mass transfer coefficient depends upon _____

(a) molecular transport of solute only	(b) turbulent transport of solute only
(c) both molecular and turbulent solute transport	(d) none of these is correct

(9) The Reynolds number, $N_{Re} = \frac{Lv\rho}{\mu}$, is the ratio of _____

(a) convective to diffusive mass transport	(b) inertial forces to viscous forces
(c) momentum diffusivity to mass diffusivity	(d) none of these is correct

(10) The Schmidt number, $N_{Sc} = \frac{(\mu/\rho)}{D_{AB}}$, is the ratio of _____

(a) convective to diffusive mass transport	(b) inertial forces to viscous forces
(c) momentum diffusivity to mass diffusivity	(d) none of these is correct

(11) The Sherwood number, $N_{Sh} = k_c' \frac{L}{D_{AB}}$, is the ratio of _____

(a) convective to diffusive mass transport	(b) inertial forces to viscous forces
(c) momentum diffusivity to mass diffusivity	(d) none of these is correct

Answers

1	2	3	4	5	6	7	8	9	10	11

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Answers

1	2	3	4	5	6	7	8	9	10	11

KING SAUD UNIVERSITY

Department of Chemical Engineering

TEST-1: Part-2 (Open Book) Mass Transfer (CHE 318) Time: 75 min

Roll No:	Gp: (i) 8:00– 10:00 (ii) 10:00 – 12:00

Question 2a:

Water at 20°C is flowing in a covered irrigation ditch below ground. There is a vent line 30 mm inside diameter and 1.0 m long to the outside atmosphere at 20°C. The percent relative humidity in Riyadh under present weather conditions is about 10%. As a result, the partial pressure of the water vapor in the outside air can be taken as 234 Pa. Determine the molar flux of water vapor in $(kg\ mol/m^2 \cdot s)$

(Data: Use the diffusivity data from Table 6.2-1. You may need to change its value to the required temperature if needed. Vapor pressure of water vapor at 20°C = 2340 Pa)

Question 2b:

(Case I) A nylon film 0.15 mm thick is being considered for use in packaging a pharmaceutical product at 30°C. If the partial pressure of O_2 outside is 0.21 atm and inside the package it is 0.01 atm, calculate the diffusion flux of O_2 at steady state. Use permeability data from Table 6.5 -1. Assume that the resistances to diffusion outside the film and inside are negligible compared to the resistance of the film.

(Case II) A composite with two films in series is being considered for use in packaging a pharmaceutical product at 30°C. If the partial pressure of O_2 outside is 0.21 atm and inside the package it is 0.01 atm, calculate the diffusion flux of O_2 at steady state. Use permeability data from Table 6.5-1. Assume that the resistances to diffusion outside the film and inside are negligible compared to the resistance of the composite.

- Film 1: nylon film, thickness = 0.15 mm
- Film 2: polyethylene film, thickness = 0.15 mm

How much is the % reduction in the diffusion flux for Case II when compared with Case I.

Question 3:

A tube is coated on the inside with benzoic acid and has the inside diameter of 20 mm and length L = 5 m. Pure water at 26.1 °C flows through the tube at a velocity of 0.20 m/s. At 26.1 , the D_{AB} of benzoic acid is $1.254 \times 10^{-9}\ m^2/s$ and the solubility of benzoic acid in water is $2.948 \times 10^{-2}\ kg\ mol/m^3$. determine

- N_{Sh} and the mass transfer coefficient (write appropriate units)
- Concentration of benzoic acid concentration in the exiting gas stream in kgmol/m^3. (Since the **solution is dilute**, one can use arithmetic mean instead of log mean for simplicity of calculations)

(Data: At 26.1 °C for water, Density = $996.7\ kg/m^3$, Viscosity = $0.8718 \times 10^{-3} Pa.s$

Question 2a (15 = 5+ 10 Marks)

$T = 293\ K;\ P = 1.01325 \times 10^5\ Pa;\ D_{AB} = 2.6 \times 10^{-5}\ m^2/s$ @298 K;

$$\frac{D_{AB2}}{D_{AB1}} = \left(\frac{T_2}{T_1}\right)^{1.75};\ D_{AB2} = 2.6 \times 10^{-5}\left(\frac{293}{298}\right)^{1.75} = \mathbf{2.52 \times 10^{-5}\ m^2/s}$$

p_{A1} = 2340 Pa (Vapor pressure of water vapor at 20°C)
p_{A2} = 234 (10% Relative Humidity)
p_{B1} = P – p_{A1} = 101.325×10^3 – 2.34×10^3 = 98,985 Pa
p_{B2} = P – p_{A2} = 101325 – 234 = 101,091 Pa

$$p_{BM} = \frac{p_{B2} - p_{B1}}{ln\frac{p_{B2}}{p_{B1}}} = \frac{p_{A1} - p_{A2}}{ln\frac{p_{B2}}{p_{B1}}} = 100{,}034\ Pa$$

$$N_A = \frac{D_{AB}}{(z_2 - z_1)}\frac{P}{RT}\frac{p_{A1} - p_{A2}}{p_{BM}} = \frac{2.52 \times 10^{-5}}{1.0}\frac{1.01325 \times 10^5}{8314 \times 293}\frac{(2340 - 234)}{100{,}034} = \mathbf{2.21 \times 10^{-8}\ \frac{kg\ mol}{m^2 \cdot s}}$$

Question 2b (19 = 6 + 11+2 Marks)

$T = 303\ K;\ P_M = 2.9 \times 10^{-10}\ m^3(STP)/s \cdot m^2 \cdot atm$;

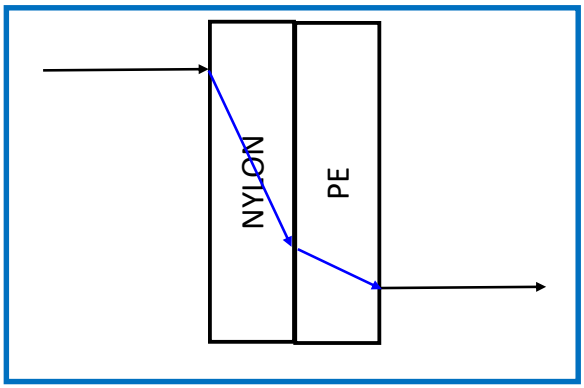
$$N_{A1} = \frac{P_M}{L}\frac{(p_{A1} - p_{A2})}{22.4} = \frac{2.9 \times 10^{-14}}{0.15/1000}\frac{(0.21 - 0.01)}{22.4} = 1.725 \times 10^{-10}\ \frac{kg\ mol}{m^2 \cdot s}$$

$T = 303\ K;\ P_M = 2.9 \times 10^{-10}\ m^3(STP)/s \cdot m^2 \cdot atm$;

For several solids of different thickness in series,

$$N_{A2} = \frac{(p_{A1} - p_{A2})}{22.4}\frac{1}{\left(\frac{L_1}{P_{M1}} + \frac{L_2}{P_{M2}} + \cdots\right)} = \frac{(0.21 - 0.01)}{22.4}\frac{1}{\left(\frac{0.00015}{2.9 \times 10^{-14}} + \frac{0.00015}{417 \times 10^{-14}}\right)} = 1.7132 \times 10^{-10}\ \frac{kg\ mol}{m^2 \cdot s}$$

$$\%\ \text{Reduction} = \frac{|N_{A1} - N_{A2}|}{N_{A1}} \times 100$$



Question 3 (32 Marks)

A tube is coated on the inside with benzoic acid and has the inside diameter of 20 mm and length L = 5 m. Pure water at 26.1 °C flows through the tube at a velocity of 0.20 m/s. At 26.1 , the D_{AB} of benzoic acid is $1.254 \times 10^{-9}\, m^2/s$ and the solubility of benzoic acid in water is $2.948 \times 10^{-2}\, kg\ mol/m^3$. determine

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MT Inside Tube Coated with Benzoic Acid	
Pressure	101300
T	**299.1**
Meu	8.72E-04
Rho	996.7
Dc	0.02
L	5
Ac	0.0003142
Tube Inside Area, A	3.142E-01
Uo	**0.2**
V=Uo*pi*(Dc^2)	6.283E-05
D_AB (given)	1.25E-09
N_Sc	702.56
N_Re	4,573
C_Ai	**2.948E-02**
C_A1	0
C_A2	1.94E-03
C_A_AM	2.851E-02
N_Sh	218.33
Kc'	**1.3591E-05**
A*Kc*C_A_AM	1.21734E-07
V*(C_A2-C_A1)	1.21731E-07
(n_Ax)-(n_Ay)	2.94041E-06