Roll No:

(1) Liquid water slowly evaporates into surrounding air from a spherical drop maintained at constant pressure. If the temperature at the surface of the drop is increased, it will

(a) increase driving force for water evaporation	(b) decrease driving force for water evaporation
(c) not affect driving force for water evaporation	(d) no relationship with driving force

(2) Liquid water slowly evaporates into surrounding air from a spherical drop maintained at constant temperature and pressure. If the humidity of the surrounding air is decreased, it will

(a) increase the water evaporation rate	(b) decrease the water evaporation rate
(c) not change the water evaporation rate	(d) no relationship with water evaporation rate

(3) The molecular diffusivity of a solute is

(a) lower in gas as compared to liquid	(b) lower in liquid as compared to solids
(c) much lower in gas as compared to solids	(d) all of these are incorrect

(4) The molecular diffusivity of liquid in a very dilute solution **mainly** depends upon

(a) the temperature	(b) the pressure
(c) both temperature and pressure	(d) temperature, pressure and concentration

(5) Approximately 10% increase in the temperature of a binary gas mixture from 293 K to 313 K will increase the diffusion coefficient by

(a) less than 10%	(b) more than 10% and less than 100%
(c) 100%	(d) more than 100%

(6) A 100% increase in the pressure of a binary liquid mixture from 1 atm to 2 atm will decrease the diffusion coefficient by

(a) more than 10% and less than 100%	(b) 100%
(c) more than 100%	(d) no effect

(7) In order to decrease the flux of species A diffusing from Point 1 to Point 2 through a membrane of polyethylene, one should

(a) increase the pressure at both Points 1 and 2	(b) decrease the pressure at both Points 1 and 2
(c) decrease the pressure at Point 1 and increase pressure at Point 2	(d) increase the pressure at Point 1 and decrease pressure at Point 2

(8) The permeability of a species in a membrane of vulcanized rubber/nylon will depend upon its

(a) solubility only	(b) molecular diffusivity only
(c) both solubility and diffusivity	(d) no effect of either solubility or diffusivity

(9) For the diffusion of gases A and B, the flux of A is given by $N_A = -cD_{AB}\frac{d(x_A)}{dz} + \frac{c_A}{c}(N_A + N_B)$. For the diffusion of gas B through the stagnant non-diffusing gas C, the flux of B (N_B) is given by,

$(a) \quad -cD_{BC}\frac{d(x_B)}{dz} + \frac{c_B}{c}(N_B)$	$(b) \quad -cD_{BC}\frac{d(x_B)}{dz} + \frac{c_B}{c}(N_C)$
$(c) \quad -cD_{BC}\frac{d(x_C)}{dz} + \frac{c_B}{c}(N_C)$	$(d) \quad -cD_{BC}\frac{d(x_C)}{dz} + \frac{c_B}{c}(N_B)$

(10) At a given temperature and pressure, the complete evaporation of a droplet of liquid of 2 mm diameter takes about 300 s approximately. How much time will approximately be required for the complete evaporation of a droplet of water of diameter = 1 mm

(a) 75 s	(b) 150 s
(c) 600 s	(d) 1200 s

Roll No:

Answers

1	2	3	4	5	6	7	8	9	10										
a	**a**	**d**	**a**	**b**	**d**	**c**	**c**	**a**	**a**										

The molecular diffusivity can be predicted using,

$$D_{AB} = \frac{1.0 \times 10^{-7} T^{1.75}}{[(\sum v_A)^{1/3} + (\sum v_B)^{1/3}]^2 P} \left(\frac{1}{M_A} + \frac{1}{M_B}\right)^{1/2}$$

Here, A and B are two kinds of molecules present in the gaseous mixture, D_{AB} is the diffusivity (m^2/s), T is the absolute temperature (K), M is the molar mass (kg/ kg mol), P is the pressure (atm), and $\sum v_A$=sum of structural volume increments. Prediction accuracy of the above equation is about 8% up to about 1000 K. Using the given relationship, D_{AB1} is evaluated at temperature T_1 K and P_1 atm pressure.

For dilute solutes in liquids (Eq. 6.3-8 in C. J. Geankoplis):

$$D_{AB} = \frac{9.96 \times 10^{-16}}{V_A^{1/3}} (T) \left(\frac{1}{\mu}\right)$$

where, A is solute molecule present in low concentration in solvent B, D_{AB} is the diffusivity (m^2/s), T is the absolute temperature (K), μ is the viscosity (Pa·s or kg/(m·s)) and V_A is the solute molar volume at its normal boiling point ($m^3/kg\ mol$). This equation give good predictions for very large un-hydrated and spherical-like solute molecules of molecular weight more than 1000 or <u>where V_A> 0.5 $m^3/kg\ mol$ in aqueous solution</u>. For smaller solute molar volume, the Wike-Chang correlation can be used (Eq. 6.3-9 in C. J. Geankoplis):

$$D_{AB} = 1.173 \times 10^{-16} (\varphi M_B)^{1/2} \left(\frac{T}{\mu_B V_A^{0.6}}\right)$$

where, A is solute molecule present in low concentration in solvent B, D_{AB} is the diffusivity (m^2/s), T is the absolute temperature (K), μ is the viscosity (Pa·s or kg/(m·s)) and V_A (see Table 6.3-2) is the solute molar volume at its normal boiling point ($m^3/kg\ mol$). φ is an association parameter of the solvent.

$$N_A = \frac{D_{AB}}{(z_2 - z_1)} (c_{A1} - c_{A2}) = \frac{D_{AB}}{(z_2 - z_1)} \left(\frac{Sp_{A1}}{22.4} - \frac{Sp_{A2}}{22.4}\right) = \frac{D_{AB} S (p_{A1} - p_{A2})}{22.4 (z_2 - z_1)} = \frac{P_M (p_{A1} - p_{A2})}{22.4 (z_2 - z_1)}$$
$$= \frac{P_M}{L} \frac{(p_{A1} - p_{A2})}{22.4} = \frac{(p_{A1} - p_{A2})}{22.4 \left(\frac{L}{P_M}\right)}$$

<u>For a tube of constant cross-sectional area</u>, the total time of evaporation for the change in level from z_0 to z_F:

$$t_F = \frac{\rho_A}{M_A} \frac{(z_F^2 - z_0^2)}{2 D_{AB}} \left(\frac{P}{RT} \frac{p_{A1} - p_{A2}}{p_{BM}}\right)^{-1}$$

<u>For a sphere</u>, for the complete evaporation of initial radius r_1:

$$t_F = \frac{\rho_A}{M_A} \frac{(r_1^2)}{2 D_{AB}} \left(\frac{P}{RT} \frac{p_{A1} - p_{A2}}{p_{BM}}\right)^{-1}$$

Roll No:

(1) Liquid water slowly evaporates into surrounding air from a spherical drop maintained at constant pressure. If the temperature at the surface of the drop is decreased, it will

(a) increase driving force for water evaporation	(b) decrease driving force for water evaporation
(c) not affect driving force for water evaporation	(d) no relationship with driving force

(2) Liquid water slowly evaporates into surrounding air from a spherical drop maintained at constant temperature and pressure. If the humidity of the surrounding air is decreased, it will

(a) decrease the water evaporation rate	(b) increase the water evaporation rate
(c) not change the water evaporation rate	(d) no relationship with water evaporation rate

(3) The molecular diffusivity of a solute is

(a) lower in gas as compared to liquid	(b) lower in liquid as compared to solids
(c) much lower in gas as compared to solids	(d) all of these are incorrect

(4) At a given temperature and pressure, the complete evaporation of a droplet of liquid of 2 mm diameter takes about 300 s approximately. How much time will approximately be required for the complete evaporation of a droplet of water of diameter = 1 mm

(a) 75 s	(b) 150 s
(c) 600 s	(d) 1200 s

(5) The molecular diffusivity of liquid in a very dilute solution **mainly** depends upon

(a) the temperature	(b) the pressure
(c) both temperature and pressure	(d) temperature, pressure and concentration

(6) Approximately 10% increase in the temperature of a binary gas mixture from 293 K to 313 K will increase the diffusion coefficient by

(a) less than 10%	(b) more than 10% and less than 100%
(c) 100%	(d) more than 100%

(7) A 100% increase in the pressure of a binary liquid mixture from 1 atm to 2 atm will decrease the diffusion coefficient by

(a) more than 10% and less than 100%	(b) 100%
(c) more than 100%	(d) no effect

(8) In order to decrease the flux of species A diffusing from Point 1 to Point 2 through a membrane of polyethylene, one should

(a) increase the pressure at both Points 1 and 2	(b) decrease the pressure at both Points 1 and 2
(c) decrease the pressure at Point 1 and increase pressure at Point 2	(d) increase the pressure at Point 1 and decrease pressure at Point 2

(9) The permeability of a species in a membrane of vulcanized rubber/nylon will depend upon its

(a) solubility only	(b) molecular diffusivity only
(c) both solubility and diffusivity	(d) no effect of either solubility or diffusivity

(10) For the diffusion of gases A and B, the flux of A is given by $N_A = -cD_{AB}\frac{d(x_A)}{dz} + \frac{c_A}{c}(N_A + N_B)$. For the diffusion of gas B through the stagnant non-diffusing gas C, the flux of B (N_B) is given by,

$(a) \quad -cD_{BC}\frac{d(x_C)}{dz} + \frac{c_B}{c}(N_B)$	$(b) \quad -cD_{BC}\frac{d(x_B)}{dz} + \frac{c_B}{c}(N_C)$
$(c) \quad -cD_{BC}\frac{d(x_C)}{dz} + \frac{c_B}{c}(N_C)$	$(d) \quad -cD_{BC}\frac{d(x_B)}{dz} + \frac{c_B}{c}(N_B)$

Roll No:

Answers

1	2	3	4	5	6	7	8	9	10										
b	**b**	**d**	**a**	**a**	**b**	**d**	**c**	**c**	**d**										

The molecular diffusivity can be predicted using,

$$D_{AB} = \frac{1.0 \times 10^{-7} T^{1.75}}{[(\sum v_A)^{1/3} + (\sum v_B)^{1/3}]^2 P} \left(\frac{1}{M_A} + \frac{1}{M_B}\right)^{1/2}$$

Here, A and B are two kinds of molecules present in the gaseous mixture, D_{AB} is the diffusivity (m^2/s), T is the absolute temperature (K), M is the molar mass (kg/ kg mol), P is the pressure (atm), and $\sum v_A$=sum of structural volume increments. Prediction accuracy of the above equation is about 8% up to about 1000 K. Using the given relationship, D_{AB1} is evaluated at temperature T$_1$ K and P$_1$ atm pressure.

For dilute solutes in liquids (Eq. 6.3-8 in C. J. Geankoplis):

$$D_{AB} = \frac{9.96 \times 10^{-16}}{V_A^{1/3}} (T) \left(\frac{1}{\mu}\right)$$

where, A is solute molecule present in low concentration in solvent B, D_{AB} is the diffusivity (m^2/s), T is the absolute temperature (K), μ is the viscosity (Pa·s or kg/(m·s)) and V$_A$ is the solute molar volume at its normal boiling point $(m^3/kg\ mol)$. This equation give good predictions for very large un-hydrated and spherical-like solute molecules of molecular weight more than 1000 or where V$_A$> 0.5 $m^3/kg\ mol$ in aqueous solution. For smaller solute molar volume, the Wike-Chang correlation can be used (Eq. 6.3-9 in C. J. Geankoplis):

$$D_{AB} = 1.173 \times 10^{-16} (\varphi M_B)^{1/2} \left(\frac{T}{\mu_B V_A^{0.6}}\right)$$

where, A is solute molecule present in low concentration in solvent B, D_{AB} is the diffusivity (m^2/s), T is the absolute temperature (K), μ is the viscosity (Pa·s or kg/(m·s)) and V$_A$ (see Table 6.3-2) is the solute molar volume at its normal boiling point $(m^3/kg\ mol)$. φ is an association parameter of the solvent.

$$N_A = \frac{D_{AB}}{(z_2 - z_1)}(c_{A1} - c_{A2}) = \frac{D_{AB}}{(z_2 - z_1)}\left(\frac{Sp_{A1}}{22.4} - \frac{Sp_{A2}}{22.4}\right) = \frac{D_{AB} S (p_{A1} - p_{A2})}{22.4 (z_2 - z_1)} = \frac{P_M (p_{A1} - p_{A2})}{22.4 (z_2 - z_1)}$$
$$= \frac{P_M}{L} \frac{(p_{A1} - p_{A2})}{22.4} = \frac{(p_{A1} - p_{A2})}{22.4 \left(\frac{L}{P_M}\right)}$$

For a tube of constant cross-sectional area, the total time of evaporation for the change in level from z_0 to z_F:

$$t_F = \frac{\rho_A}{M_A} \frac{(z_F^2 - z_0^2)}{2D_{AB}} \left(\frac{P}{RT} \frac{p_{A1} - p_{A2}}{p_{BM}}\right)^{-1}$$

For a sphere, for the complete evaporation of initial radius r_1:

$$t_F = \frac{\rho_A}{M_A} \frac{(r_1^2)}{2D_{AB}} \left(\frac{P}{RT} \frac{p_{A1} - p_{A2}}{p_{BM}}\right)^{-1}$$