General Aptitude

Q.1 to Q.5 Carry one mark each

Q.1 Rajiv Gandhi Khel Ratna Award was conferred___Mary Kom, a six-time world champion in boxing, recently in a ceremony _____ the Rashtrapati Bhawan (the President's official residence) in New Delhi.

(A) to, at (B) on, at (C) On, in (D) With, at

Ans. **A**

Q.2 Despite a string of poor performances, the chances of K.L. Rahul's selection in the team are___.

(A) slim (B) bright (C) uncertain (D) obvious

Ans. **(B)**

Sol. Despite is used as a preposition when a something happens even though it might have been prevented (i.e. in contrast).

$\therefore$ Opposite of poor performance is bright.

Hence, the correct option is (B).

Q.3 Select the word that fits the analogy:

Cover : Uncover : : Associate : ____

(A) Unassociate (B) Dissociate (C) Inassociate (D) Misassociate

Ans. **(B)**

Sol. Uncover is the antonym of cover. So, antonym of associate is dissociate.

Hence, the correct option is (B).

Q.4 Hit by floods, the Kharif (summer sown) crops in various parts of the country have been affected. Officials believe that the loss in production of the kharif crops can be recovered in the output of the rabi (winter sown) crops so that the country can achieve its food-grain production target of 291 million tons in the crop year 2019-20 (July-June). They are hopeful that good rains in July-August will help the soil retain moisture for a longer period, helping winter sown crops such as wheat and pulses during the November-February period.

Which of the following statements can be inferred from the given passage?

(A) Officials want the food-grain production target to be met by the November-February period.

(B) Officials feel that the food-grain production target cannot be met due to floods.

(C) Officials declared that the food-grain production target will be met due to good rains.

(D) Officials hope that the food-grain production target will be met due to good rabi produce.

Ans. **(D)**

Sol. Officials are hopeful that good rains in July-August will help to recover loss in longer period. Therefore, it can be inferred from the passage that the officials hope that the food grain production target will be met due to great rabi produce.

Hence, the correct options is (D).

Q.5 The difference between the sum of the first 2n natural numbers and the sum of the first n odd numbers is

(A) $2^n - n$ (B) $n^2 - n$ (C) $2^n + n$ (D) $n^n + n$

Ans. **(D)**

Sol. The difference between the sum of first '2n' natural numbers and the sum of the first 'n' odd positive integers are as follows

First '2n' natural numbers are as follows :

$$1, 2, 3, \ldots\ldots\ldots 2n$$

$$\text{Sum} = \frac{\text{Number of terms}}{2} \times [\text{First term} \times 2 + (\text{Number of terms} - 1) \times \text{Common difference}]$$

$$= \frac{2n}{2}[2\times1 + (2n-1)\times1]$$

$$= n(2+2n-1) = n(2n+1) = 2n^2 + n$$

First 'n' odd positive integers are : $1, 3, 5, \ldots\ldots.n$

$$\text{Sum } = \frac{n}{2}[2\times1 + (n-1)\times2]$$

$$= \frac{n}{2}[2+2n-2] = n^2$$

Difference $= 2n^2 + n - n^2 = n^2 + n$

Hence, the correct option is (D).

Q.6 to Q.10 Carry two marks each

Q.6 Repo rate is the rate at which Reserve Bank of India (RBI) lends commercial banks, and reverse repo rate is the rate at which RBI borrows money from commercial banks.

Which of the following statements can be inferred from the above passage?

(A) Decrease in repo rate will decrease cost of borrowing and increase lending by commercial banks.

(B) Decrease in repo rate will increase cost of borrowing and decrease lending by commercial banks.

(C) Increase in repo rate will decrease cost of borrowing and decrease lending by commercial banks.

(D) Increase in repo rate will increase cost of borrowing and Increase lending by commercial banks.

Ans. **(A)**

Sol. Repo rate is the rate at which RBI lends commercial banks. The decrease in repo rate increases the flow of money in the economy, hence, increase leading by commercial banks and decrease cost of borrowing.

Hence, the correct option is (A).

Q.7 P,Q,R,S,T,U,V, and W are seated around a circular table.

(i) S is seated opposite to W.

(ii) U is seated at the second place to the right of R.

(iii) T is seated at the third place to the left of R.

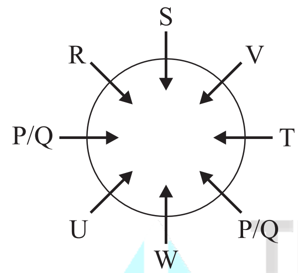
(iv) V is a neighbor of S.

Which of the following must be true?

(A) P is not seated opposite to Q
(B) R is the left neighbor of S
(C) Q is a neighbor of R
(D) P is a neighbor of R

Ans. **(A)**

Sol. The seating arrangement of P, Q, R ,S ,T, U, V and W around a circular table can be as follows



So, the statement which must be true is *P* is not seated opposite to *Q*.

Hence, the correct option is (A).

Q.8 The distance between Delhi and Agra is 233 km. A car P started travelling from Delhi to Agra and another car Q started from Agra to Delhi along the same road 1 hour after the car P started. The two cars crossed each other 75 minutes after the car Q started. Both cars were travelling at constant speed. The speed of car P was 10km/hr more than the speed of car Q. How many kilometers the car Q had travelled when the cars crossed each other?

(A) 116.5
(B) 88.2
(C) 66.6
(D) 75.2

Ans. **(D)**

Sol. **Given :** The distance between Delhi and Agra is 233 km.

$$\text{Delhi} \xrightarrow{233\text{km}} \text{Agra}$$

$$\text{Car P} \rightarrow \qquad \leftarrow \text{Car Q}$$

Car P and Q crossed each other 75 minutes after the car Q started.

Let x km be the distance covered by Car Q in 75 minutes.

$$\therefore \text{ Speed at Car } Q = \frac{x}{\frac{75}{60}} \text{km/hr} = \frac{4x}{5} \text{km/hr}$$

$$\therefore \text{ Speed at Car } P = \frac{4x}{5} + 10 \text{ km/hr}$$

This distance has been covered by car $P = 1\text{hr}$ and 75 min $= \frac{9}{4}\text{hr}$

$\therefore$ The distance covered by car P till the point of crossing $= (233 - x)$

The distance travelled by car Q is given by

$$(233 - x) = \frac{9}{4}\left(\frac{4x}{5} + 10\right)$$

$$x = 75.2 \text{ km}$$

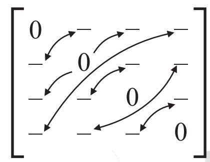
Hence, the correct option is (D).

Q.9 For a matrix $M = [m_{ij}]$; $i, j = 1, 2, 3, 4$ the diagonal elements are all zero and $m_{ij} = -m_{ji}$. The minimum number of elements required to fully specify the matrix is_______.

(A) 12 (B) 16 (C) 6 (D) 0

Ans. **(C)**

Sol. Given matrix $M = [m_{uij}]$, $i, j = 1, 2, 3, 4$ and the diagonal elements are all zero and $m_{ij} = -m_{ji}$. So we can represent the matrix as follows :

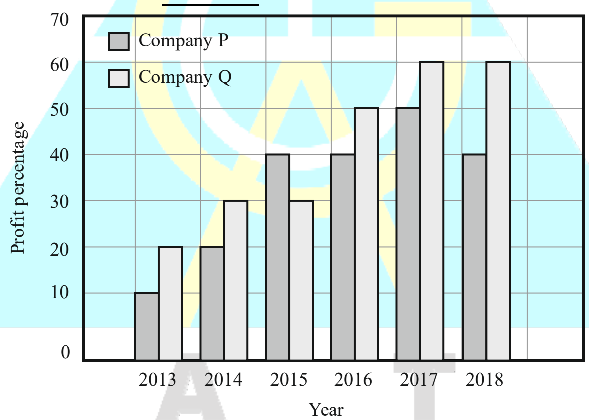


The numbers which are connected by arrows will be the same in magnitude and opposite in sign.

So the minimum number of elements required to fully specify the matrix is just 6 and other will be known accordingly.

Hence, the correct option is (C).

Q.10 The profit shares of two companies P and Q are shown in the figure. If the two companies have invested a fixed and equal amount every year, then the ratio of the total revenue of company P to the total revenue of company Q, during 2013 – 2018 is _______.



(A) 15 : 17 (B) 16 : 17 (C) 17 : 15 (D) 17 : 16

Ans. **(B)**

Sol. **Basic concept :** Revenue = Profit + Investment

According to the question, a basic amount is invested by the two companies, let it be 100 and the profit of both the companies is given in the graph.

So according to the graph,

$$\frac{\text{Total revenue of company } P}{\text{Total revenue of company } Q} = ?$$

$$= \frac{(100+10)+(100+20)+(100+40) + (100+40)+(100+50)+(100+40)}{(100+20)+(100+30)+(100+30) + (100+50)+(100+60)+(100+60)} = 16:17$$

Hence, the correct option is (B)

Technical Section

Q.1 to Q.25 Carry one mark each

Q.1 Which one of the following methods requires specifying an initial interval containing the root (i.e., bracketing) to obtain the solution of $f(x)=0$, where $f(x)$ is a continuous non-linear algebraic function?

(A) Regula falsi method
(B) Newton- Rephson method
(C) Secant method
(D) Fixed point iteration method

Ans. **(A)**

Q.2 Consider the hyperbolic function in Group 1 and their definitions in Group 2.

Group 1		Group 2	
P.	tanh x	(i)	$\frac{e^x+e^{-x}}{e^x-e^{-x}}$
Q.	coth x	(ii)	$\frac{2}{e^x+e^{-x}}$
R.	sech x	(iii)	$\frac{2}{e^x-e^{-x}}$
S.	cosech$x$	(iv)	$\frac{e^x-e^{-x}}{e^x+e^{-x}}$

The correct combination is

(A) P – IV, Q – I, R – III, S – II
(B) P – II, Q – III, R – I, S – IV
(C) P – IV, Q – I, R – II, S – III
(D) P – I, Q – II, R – IV, S – III

Ans. **(C)**

Q.3 Consider the following continuously differentiable function

$$v(x,y,z)=3x^2y\,i+8y^2z\,j+5xyz\,k$$

Where i, j and k represent the respective unit vectors along the x, y and z directions in the Cartesian coordinate system. The curl of this function is

(A) $y(11x+16z)$
(B) $-3x^2\,i-8y^2\,j+5z(x+y)k$
(C) $6xy\,i-16yz\,j+5xy\,k$
(D) $(5xz-8y^2)i-5yz\,j-3x^2k$

Ans. **(D)**

Sol. **Given :** $V(x,y,z)=3x^2y\hat{i}+8y^2z\hat{j}+5xyz\hat{k}$

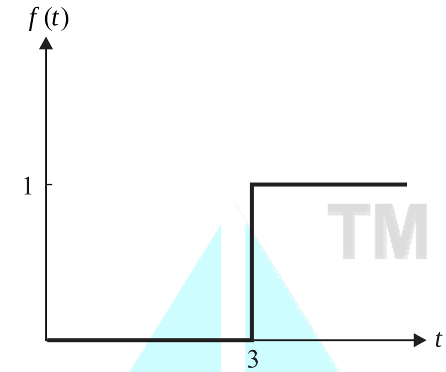
$$\nabla\times V=\begin{vmatrix}\hat{i} & \hat{j} & \hat{k}\\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z}\\ 3x^2y & 8y^2z & 5xyz\end{vmatrix}$$

$$\nabla \times V = \hat{i}[5xz - 8y^2] - \hat{j}[5yz] + \hat{k}[-3x^2]$$

$$\nabla \times V = [5xz - 8y^2]\hat{i} - [5yz]\hat{j} + [-3x^2]\hat{k}$$

Hence, the correct option is (D)

Q.4 Consider the following unit step function.



The Laplace transform of this function is

(A) $\dfrac{e^{-3s}}{s}$ (B) $\dfrac{e^{-3s}}{s^2}$ (C) $\dfrac{e^{-3s}}{3s}$ (D) $\dfrac{e^{-6s}}{s}$

Ans. **(A)**

Sol. **Given :** From figure the function

$$f(t) = \begin{cases} 0; & 0 < t < 3 \\ 1; & 3 < t < \infty \end{cases}$$

Now taking Laplace transform,

$$L[f(t)] = \int_0^\infty e^{-st} \cdot f(t)dt$$

$$L[f(t)] = \int_0^3 f(t)e^{-st}dt + \int_3^\infty f(t)e^{-st}dt$$

$$L[f(t)] = \int_0^3 0e^{-st}dt + \int_3^\infty 1.e^{-st}dt$$

$$L[f(t)] = 0 + \left[\frac{e^{-st}}{-s}\right]_3^\infty$$

$$L[f(t)] = \frac{e^{-\infty}}{-s} - \frac{e^{-s\times 3}}{-s}$$

$$L[f(t)] = 0 + \frac{e^{-3s}}{s}$$

$$L[f(t)] = \frac{e^{-3s}}{s}$$

Hence, the correct option is (A).

Q.5 In a constant-pressure cake filtration with an incompressible cake layer, volume of the filtrate (V) is measured as a function of time t. The plot of t/V versus V results in a straight line with an intercept of 10^4 s m^{-3}. Area of the filter is 0.05 m^2, viscosity of the filtrate is 10^{-3} Pa s, and the overall pressure drop across the filter is 200 kPa. The value of the filter-medium resistance (in m^{-1}) is

(A) 1×10^9 (B) 1×10^{11} (C) 1×10^{12} (D) 1×10^{10}

Ans. **(B)**

Sol.
$$\frac{R_m \times \mu}{A\Delta p} = 10^4$$

$$10^4 = \frac{R_m \times 10^{-3}}{0.05\times 2,00\times 1000}$$

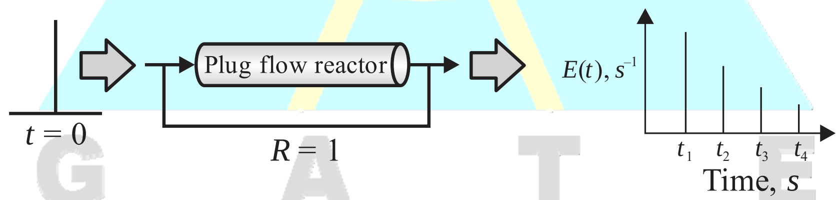
$$10^8 = R_m \times 10^{-3}$$

$$\Rightarrow \quad R_m = \frac{10^8}{10^{-3}}$$

$$R_m = 10^{11} m^{-1}$$

Hence, the correct option is (B).

Q.6 In a laboratory experiment, a unit pulse input of tracer is given to an ideal plug flow reactor operating at steady state with a recycle ration, $R = 1$. The exit age distribution $E(t)$, of the tracer at the outlet of the reactor is measured. The first four pulses observed at t_1, t_2, t_3, and t_4 are shown below.



In addition, use the following data and assumptions

- R is defined as ratio of the volume of fluid returned to the entrance of the reactor to the volume leaving the system
- No reaction occurs in the reactor
- Ignore any dead volume in the recycle loop

If the space time of the plug flow reactor is τ seconds, which one of the following is correct?

(A) $t_1 = \tau, t_2 = 2\tau, t_3 = 3\tau, t_4 = 4\tau$

(B) $t_1 = \frac{\tau}{2}, t_2 = \tau, t_3 = \frac{3\tau}{2}, t_4 = 2\tau$

(C) $t_1 = \frac{\tau}{3}, t_2 = \frac{2\tau}{3}, t_3 = \tau, t_4 = \frac{4\tau}{3}$

(D) $t_1 = \frac{\tau}{2}, t_2 = \frac{\tau}{4}, t_3 = \frac{\tau}{8}, t_4 = \frac{\tau}{16}$

Ans. **(B)**

Sol. We know that, an ideal PFR delays the traces profile by the time τ_p, where τ_p is the space time defined as

Space time, $\tau_p = \dfrac{\text{Vol. of reactor}}{\text{Vol flow rate at entrance}}$

So, here in case of PFR with recycle stream,

$$\tau_p' = \frac{V}{(R+1)V_0} = \frac{V}{2V_0} = \frac{\tau_p}{2}$$

So, first pulse will leave at, $t_1 = \tau_p' = \dfrac{\tau_p}{2}$

Second pulse will leave at, $t_2 = \tau_p' + \tau_p' = \tau_p$

Third pulse will leave at,

$$t_3 = \tau_p' + \tau_p' + \tau_p = \frac{3}{2}\tau_p$$

$$t_4 = t_3 + \frac{\tau_p}{2} = 2\tau_p$$

Q.7 The square of Thiele modulus, M_T, is given by $M_T^2 = \dfrac{L^2 k}{D_{eff}}$, where L is the characteristic length of the catalyst pellet, k is the rate constant of a first order reaction, and D_{eff} is the effective diffusivity of the species in the pores. M_T^2 is a measure of

(A) $\dfrac{\text{rate of reaction}}{\text{rate of external mass transfer}}$

(B) $\dfrac{\text{rate of pore diffusion}}{\text{rate of reaction}}$

(C) $\dfrac{\text{time scale of reaction}}{\text{time scale of pore diffusion}}$

(D) $\dfrac{\text{time scale of pore diffusion}}{\text{time scale of reaction}}$

Ans. **(C)**

Sol.

$$(M_T)^2 = L^2 k / D_{eff}$$

$$(M_T) = \sqrt{K / Deff}\,.L$$

$$= \sqrt{\frac{rx^n \text{rate}}{\text{Diffusion rate}}}$$

$$= \text{characteristic Length}$$

Thiele modulus $\alpha \sqrt{\dfrac{\text{intrinsic rx}^n \text{ rate}}{\text{Diffusion rate}}}$

Thiele modulus = reaction rate / diffusion rate

rate α 1/time

So,

$$\text{Thiele modulus} = \frac{\begin{array}{c}\text{Time scale of the limiting}\\ \text{transport mechanism}\\ \text{(not necesary diffusion)}\end{array}}{\begin{array}{c}\text{Time scale of intrinsic}\\ \text{reaction kinetics}\end{array}}$$

Finally $(M_T)^2$ is measure of $\frac{\text{time scale of pore diffusion}}{\text{Time scale of reaction}}$

Q.8 Hot-wire anemometer is used for the measurement of

(A) composition (B) flow (C) pressure (D) temperature

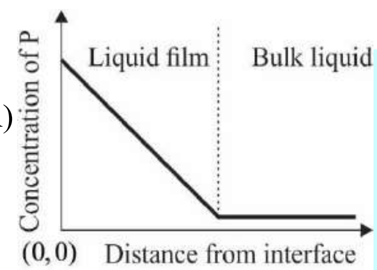
Ans. **(B)**

Sol. Hot wire anemometer $\rightarrow$ flow [velocity]

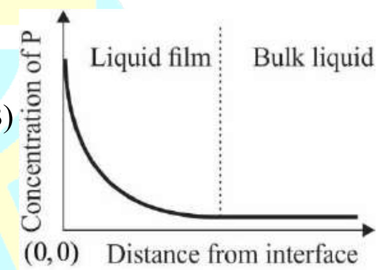
Hence, the correct option is (B).

Q.9 Pure gas P is being absorbed into a liquid. The dissolved P undergoes an irreversible reaction in the liquid film. The reaction is first order with respect to P. Which one of the following represents the concentration profile of P in the liquid film at steady state?

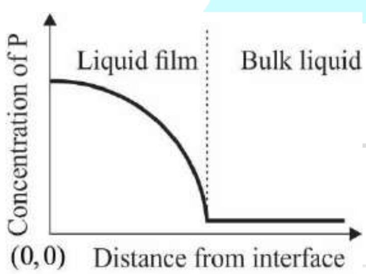
(A)



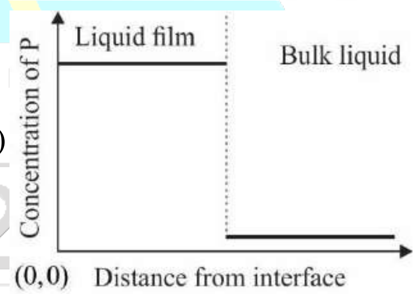
(B)



(C)



(D)



Ans. **(B)**

Sol. As P absorbed into liquid, conc, continuously decreases with distance from interface for I^{st} order reaction conc. Decreases exponentially.

Hence, the correct option is (B).

Q.10 Consider a batch distillation process for an equimolar mixture of benzene and toluene at atmospheric pressure. The mole fraction of benzene in the distillate collected after 10 minutes is 0.6. The process in further continued for additional 10 minutes. The mole fraction of benzene in the total distillate collected after 20 minutes of operation is

(A) Less than 0.6 (B) Exactly equal to 0.7 (C) Greater than 0.7 (D) Exactly equal to 0.6

Ans. **(A)**

Sol. As Distillation progresses, more volatile vaporizes but less volatile also comes into action and vaporizes, making the mole fraction of more volatile in the vapor low. That's why if Distillation progresses for additional 10 minutes then more volatile fraction decreases in the top product.

Hence, the correct option is (A).

Q.11 Which one of the following is **NOT CORRECT?**

(A) NYLON-6,6 is produced by condensation polymerization.

(B) Phenol-formaldehyde resin is a thermosetting polymer

(C) High density polyethylene (HDPE) is produced by condensation polymerization

(D) Poly (ethylene terephthalate) (PET) is a polyester

Ans. **(C)**

Sol. High Density Polyethylene (HDPE) is produced by Low pressure polymerization in fluidized bed reactor at 25kg/cm^2 and 100° C using Ziegler-Natta catalyst by addition type kinetics.

Hence, the correct option is (C).

Q.12 The operating temperature range for the Haber process is 350-500°C. It is used for the production of ammonia at

(A) 20 MPa using Fe catalyst in an exothermic reaction

(B) 0.1 MPa using Fe catalyst in an exothermic reaction

(C) 20 MPa using Fe catalyst in an endothermic reaction

(D) 20 MPa using zeolite catalyst in an endothermic

Ans. **(A)**

Sol. The iron catalyst is used with added promoters for ammonia synthesis e.g. aluminum oxides, zirconium or silicone. These prevent sintering, and the catalyst becomes more porous. Iron catalysts quickly lose their activity, when heated above 520 ° C. Depending on the conversion required the pressure is around 100-1000 atm.

Hence, the correct option is (A).

Q.13 Consider the refinery processes in Group-I and the catalysts in Group-II

	Group-I		Group-II
P	Hydrodesulphurization	**I**	Zeolites
Q	Fluid catalytic cracking (FCC)	**II**	Pt/Al_2O_3
R	Naphtha reforming	**III**	$Co\text{-}Mo/\ Al_2O_3$

The correct combination is

(A) P-II, Q-I, R-III (B) P-III, Q-II, R-I (C) P-III, Q-I, R-II (D) P-I, Q-III, R-II

Ans. **(C)**

Sol. *Hydrodesulfurization* (HDS) or Hydrotreating is a catalytic chemical process that is widely used to remove sulfur compounds from refined petroleum products such as petrol or gasoline. In fact, most HDS systems in petroleum refineries use cobalt-modified molybdenum disulfide (MoS_2)-based catalysts along with smaller quantities of other metals. Nickel and tungsten are also used aside from the MoS_2 catalysts, depending on the nature of the feed.

Fluid catalytic cracking is now major secondary conversion process in Petroleum refinery using Zeolite catalyst.

Platinum supported on porous alumina is used as a catalyst in Catalytic reforming unit.

Hence, the correct option is (C).

Q.14 Consider the processes in Croup - 1 and the reactions in Group - 2

	Group – 1		Group 2
P	Solvay process	**I**	$RCOOH + NaOH \rightarrow RCOONa + H_2O$
Q	Oxo process	**II**	$CH_2{=}CH_2 + CO + H_2 \rightarrow CH_3CH_2CHO$
R	Saponification	**III**	$CaCO_3 + 2NaCl \rightarrow Na_2CO_3 + CaCl_2$

The correct combination is

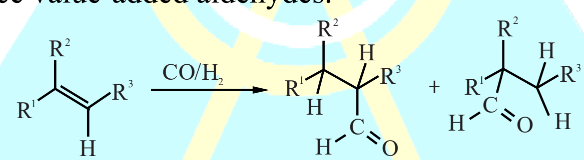
(A) P-II, Q-I, R-III (B) P -III, Q- II, R-I (C) P -III, Q- I, R-II (D) P -I, Q-III, R-II

Ans. **(B)**

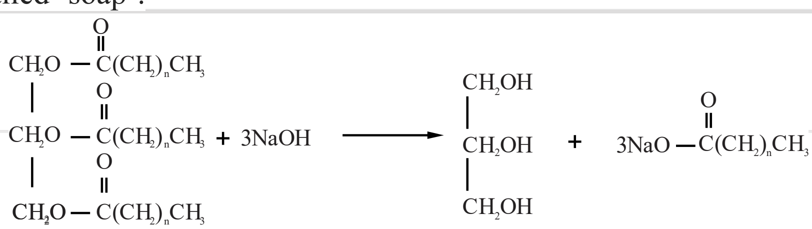
Sol. *Sodium carbonate (Soda Ash)* is manufactured by following process. 1. Leblanc process. 2. Solvay's ammonia soda process. 3. Dual process (modified Solvay's process) 4. Electrolytic process. In Solvay process Common Salt (NaCl) and limestone ($CaCO_3$) are used as a raw material.

$$CaCO_3 + 2NaCl \rightarrow Na_2CO_3 + CaCl_2$$

Hydroformylation, commonly referred to as the "oxo" process, is a Co or Rh catalyzed reaction of olefins with CO and H_2 to produce value-added aldehydes.



Saponification is simply the process of making soaps. Soaps are just potassium or sodium salts of long-chain fatty acids. During saponification, ester reacts with an inorganic base to produce alcohol and soap. it occurs when triglycerides are reacted with potassium or sodium hydroxide (lye) to produce glycerol and fatty acid salt, called 'soap'.



A Triglceride Caustic Soda Glycerine Metal Soap

Hence, the correct option is (B).

Q.15 Annual capacity of a plant producing phenol is 100 metric tons. Phenol sells at INR 200per kg , and its production cost is 200per kg . The sum of annual fixed charges, overhead costs and general expenses is INR 30, 00, 000. Taxes are payable at 18 % on gross profit. Assuming the plant runs at full capacity ad that all the phenol produced is sold, the annual net profit of the plant (in INR) is

(A) 98, 40, 000 (B) 1, 50, 00, 000 (C) 1, 20, 00, 000 (D) 1, 39, 40, 000

Ans. **(A)**

Sol. Annual Production capacity= 100 metric ton

$$= 100\times10^3 \text{ kg} = 1\times10^5 \text{ kg}$$

Phenol selling price = 200 Rs/kg

Production cost = 50 Rs/kg

Annual total expenses $= 30,00,000 = 3\times10^6$ Rs/year

Taxes = 18 % of gross profit

Annual return = Annual production $\times$ selling price

$$= 1\times10^5 \text{ kg/year} \times 200 \text{ Rs/kg}$$

$$= 2\times10^7 \text{ Rs/year}$$

Annual expenses = Annual production $\times$ production cost + other total expenses

$$= 1\times10^5 \text{ kg/year} \times 50 \text{ Rs/kg} + 3\times10^6 \text{ Rs/year}$$

$$= 5\times10^6 \text{ Rs/year} + 3\times10^6 \text{ Rs/year} = 8\times10^6 \text{ Rs/year}$$

Annual net profit of the plant = Gross profit after tax

$$= 12\times10^6 - \left(12\times10^6\right)\times18\%$$

$$= \left(12\times10^6\right)[1-.18]$$

$$= 9.84\times10^6 = 98,40,000$$

Hence, the correct option is (A)

Q.16 A rigid spherical particle undergoes free settling in a liquid of density $750\,\text{kg}\,\text{m}^{-3}$ and viscosity 9.81×10^{-3} Pa s. Density of the particle is $3000\,\text{kg}\,\text{m}^{-3}$ and the particle diameter is $2\times10^{-4}\,\text{m}$. Acceleration due to gravity is $9.81\,\text{m}\,\text{s}^{-2}$. Assuming stokes' law to be valid, the terminal settling velocity (in $\text{m}\,\text{s}^{-1}$) of the particle is

(A) 4×10^{-3} (B) 3×10^{-3} (C) 2×10^{-3} (D) 5×10^{-3}

Ans. **(D)**

Sol.

$$V_t = \frac{g\times D_p^2\times(\rho_p - p)}{18\times\mu}$$

$$V_t = \frac{9.81\times(2\times10^{-4})^2\times(3000-750)}{18\times9.81\times10^{-3}}$$

$$V_t = 5\times10^{-3}$$

Hence, the correct option is (D).

Q.17 Consider an incompressible flow of a constant property fluid over a smooth, thin and wide flat plate. The free stream flows parallel to the surface of the plate along its length and its velocity is constant. Value of the Reynolds number at a distance of 2.0 m from the leading edge of the plate is 8000. The flow within the boundary layer at a distance of 1.0 m from the leading edge of the plate is

(A) Laminar
(B) Turbulent
(C) Transitioning from laminar to turbulent
(D) Inviscid

Ans. **(A)**

Sol. Reynolds number is low over a flat plate so flow is laminar.

Hence, the correct option is (A).

Q.18 Ratio of momentum diffusivity to thermal diffusivity is

(A) Peclet number
(B) Nusselt number
(C) Reynolds number
(D) Prandtl number

Ans. **(D)**

Sol. Prandtl number is the ratio of momentum diffusivity to thermal diffusivity.

Hence, the correct option is (D).

Q.19 Mole fraction and activity coefficient of component 1 in a binary liquid mixture are x_1 and γ_1, respectively. G^E is excess molar Gibbs energy of the mixture, R is universal gas constant and T is absolute temperature of the mixture. Which one of the following is always true?

(A) $\lim_{x_1 \to 1} \gamma_1 = 0.5$
(B) $\lim_{x_1 \to 1} \frac{G^E}{RT} = 0$
(C) $\lim_{x_1 \to 1} \frac{G^E}{RT} = 0.5$
(D) $\lim_{x_1 \to 1} \gamma_1 = 0$

Ans. **(B)**

Sol.

$$\frac{G^E}{RT} = AX_1X_2$$

$$\lim_{X_1 \to 1} \frac{G^E}{RT} = 0 \quad (\text{At } X_2 = 0)$$

Hence, the correct option is (B).

Q.20 Leiden frost phenomena is true for

(A) Condensation of vapor on a cold surface
(B) The melting of frost
(C) The exchange of heat between two solids
(D) Film boiling evaporation of liquid droplets falling on a very hot surface

Ans. **(D)**

Sol. Film boiling evaporation of liquid droplets falling on a very hot surface

Hence, the correct option is (D)

Q.21 An irreversible gas phase reaction $2P \rightarrow 4Q + R$ is conducted in an isothermal and isobaric batch reactor. Assume ideal gas behavior. The feed is an equimolar mixture of the reactant P and inert gas. After complete conversion of P, the fraction change in volume is ________(round off to 2 decimal places).

Ans. **0.75**

Sol.

$$\xi_A = y_A \delta_A$$

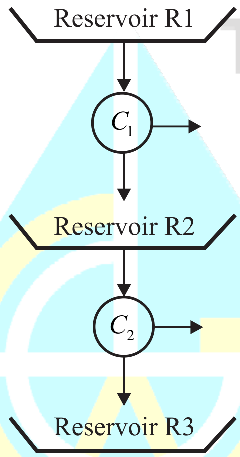
$$\delta_A = \frac{5-2}{2} = \frac{3}{2}$$

$$\xi_A = \frac{3}{2} \times 0.5$$

$$\xi_A = 0.75$$

Hence, the correct answer is 0.75

Q.22 Consider two carnot engines C_1 and C_2 as shown in the figure.



The efficiencies of the engines C_1 and C_2 are 0.40 and 0.35, respectively. If the temperature of Reservoir R_1 is 800 K, then the temperature (in K) of Reservoir R_3 is _____(round off to nearest integer)

Ans. **312**

Sol.

$$T_3 = ?$$

$$n_1 = 1 - \frac{T_2}{T_1}$$

$$0.4 = 1 - \frac{T_2}{800}$$

$$\frac{T_2}{800} = 0.6 \Rightarrow T_2 = 480 \text{ K}$$

$\Rightarrow$ $$n_2 = 1 - \frac{T_3}{T_2}$$

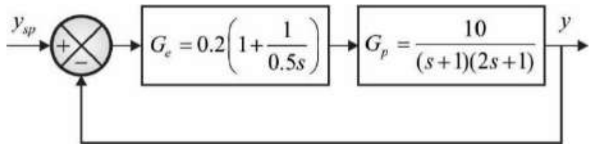
$$0.35 = 1 - \frac{T_3}{400}$$

$\Rightarrow$ $$0.65 = \frac{T_3}{480}$$

$\Rightarrow$ $$T_3 = 312 \text{ K}$$

Hence, the correct answer is 312.

Q.23 Consider the following closed loop system with G_p and G_c as the transfer function of the process and the controller, respectively.



For a unit step change in the set point (y_{sp}), the change in the value of the response (y) at steady state is ___(round off to 1 decimal place).

Ans. **1**

Sol.

$$\frac{Y}{Y_{sp}} = \left(\frac{0.2(0.05s+1)}{0.5s}\right)\left(\frac{10}{(s+1)(2s+1)}\right)$$

$$\frac{Y}{Y_{sp}} = \frac{\left(\frac{0.1s+0.2}{0.5s}\right)\left(\frac{10}{(s+1)(2s+1)}\right)}{1+\left(\frac{0.1s+0.2}{0.5s}\right)\left(\frac{10}{(s+1)(2s+1)}\right)}$$

$$= \frac{(.1s+.2)10}{(0.5s)(s+1)(2s+1)+(0.1s+0.2)1}$$

$$Y = \frac{1}{s}\frac{(0.1s+0.2)10}{0.5s(s+1)(2s+1)+(0.1s+0.2)10}$$

$$\lim_{s\to 0} s\left(\frac{1}{s}\frac{(0.1s+0.2)10}{0.5s(s+1)(2s+1)+(0.1s+0.2)10}\right) = \frac{0.2\times 10}{0.2\times 10}$$

$$\bar{Y} = 1$$

Hence, the correct answer is 1.

Q.24 The decomposition of acetaldehyde (x) to methane and carbon monoxide follow four step free radical mechanism. The overall rate of decomposition of X is, $-r_A = K_2\left(\frac{k_1}{2K_3}\right)^{\frac{1}{2}} C_X^{\frac{3}{2}} = K_{overall} Cx^{\frac{3}{2}}$. Where K_1, K_2, K_3 denotes the rate constant of the elementary steps with corresponding activation energy (in KJ/mol) of 320,40 and 0 respectively. The temperature dependency of the rate constant is described by Arrhenius equation. C_x denotes the concentration of a acetaldehyde. The rate constant for the overall reaction is $K_{overall}$. The activation energy for the overall reaction (in KJ/mol) is ____

Ans. **200**

Sol.

$$E_1 = 320$$

$$E_2 = 40$$

$$E_3 = 0$$

$$-r_A = k_2\left(\frac{K_1}{2K_3}\right)^{\frac{1}{2}}.Cx^{\frac{3}{2}} \qquad \left[K = K_0 e^{-\frac{E}{RT}}\right]$$

$$-r_A = \left(K_{0_2} e^{-\frac{E_2}{RT}}\right)\left(\frac{K_{0_1} e^{-\frac{E_1}{RT}}}{2K_{0_3} e^{-\frac{E_3}{RT}}}\right)^{\frac{1}{2}}.Cx^{\frac{3}{2}}$$

$$-r_A = K_{0_2} e^{-\frac{40}{RT}}\left\{\frac{\left(K_{0_1}\right)^{\frac{1}{2}}.e^{-\frac{320}{RT}}}{\left(2K_{0_3}\right)^{\frac{1}{2}}.e^{-\frac{0}{2RT}}}\right\}.Cx^{\frac{3}{2}}$$

$$-r_A = \left[\left\{\frac{K_{0_2}.K_{0_1}^{\frac{1}{2}}}{\left(2k_{0_3}\right)^{\frac{1}{2}}}\right\}.\frac{e^{\frac{\left[40-\frac{320}{2}\right]}{RT}}}{e^{-0}}\right]Cx^{\frac{3}{2}}$$

$$-r_A = \left\{K_{0_{overall}}.e^{-\frac{200}{RT}}\right\}.Cx^{\frac{3}{2}} = K_{0_{overall}}.Cx^{\frac{3}{2}}$$

$\Rightarrow \qquad E = 200$

Hence, the correct answer is 200.

Q.25 Sum of the Eigen values of the matrix $\begin{bmatrix} 2 & 4 & 6 \\ 3 & 5 & 9 \\ 12 & 1 & 7 \end{bmatrix}$ is ______. (round off to nearest integer)

Ans. **14**

Sol. Sum of Eigen value

= Trace of matrix $= 2+5+7 = 14$

Q.26 to Q.55 Carry two marks each

Q.26 In a box, there are 5 green balls and 10 blue balls. A person picks 6 balls randomly. The probability that the person has picked 4 green balls and 2 blue balls is

(A) $\frac{240}{1001}$ (B) $\frac{420}{1001}$ (C) $\frac{42}{1001}$ (D) $\frac{45}{1001}$

Ans. **(D)**

Sol. **Given :** In the box,

Number of Green balls = 5

Number of Blue balls = 10

Balls chosen at random = 6

Probability of getting 4 Green Ball 2 Blue Ball

$$= \frac{^5C_4 \times ^{10}C_2}{^{15}C_6} = \frac{45}{1001}$$

Hence, the correct option is (D)

Q.27 The maximum value of the function

$$f(x) = -\frac{5}{3}x^3 + 10x^2 - 15x + 16$$

in the interval (0.5, 3.5) is

(A) 16 (B) 48 (C) 0 (D) 8

Ans. **(A)**

Sol. **Given :** $f(x) = \frac{-5}{3}x^3 + 10x^2 - 15x + 16$

differentiating w.r.t. x

$$f'(x) = -5x^2 + 20x - 15$$

Putting, $f'(x) = 0$ to find critical points.

$$-5x^2 + 20x - 15 = 0$$

$$x^2 - 4x + 3 = 0$$

$$x^2 - 3x - x + 3 = 0$$

$$(x-3)(x-1) = 0$$

$\therefore \quad x = 3$ and $x = 1$

$$f''(x) = -10x + 20$$

$$f''(3) = -10 \text{ and } f''(1) = 10$$

$\therefore$ maxima lies at 3 as $f''(3) < 0$

Now checking the value of $f(x)$ at 3 and boundary value,

$$f(0.5) = \frac{-5}{3}(0.5)^3 + 10(0.5)^2 - 15(0.5) + 16$$

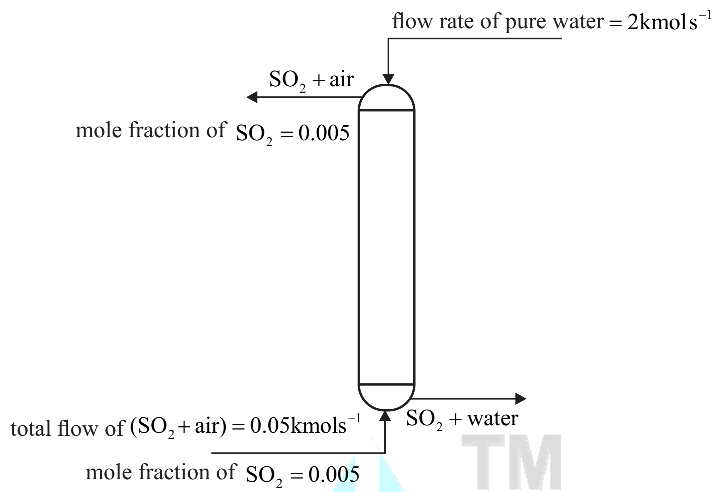
$$f(0.5) = 10.792$$

Similarly, $f(3) = 16$

$$f(3.5) = 14.542$$

Hence, the correct option is (A).

Q.28 SO_2 from air is absorbed by pure water in a counter current packed column operating at constant pressure. The compositions and the flow rates of the streams are shown in the figure.



In addition, use the following data and assumptions

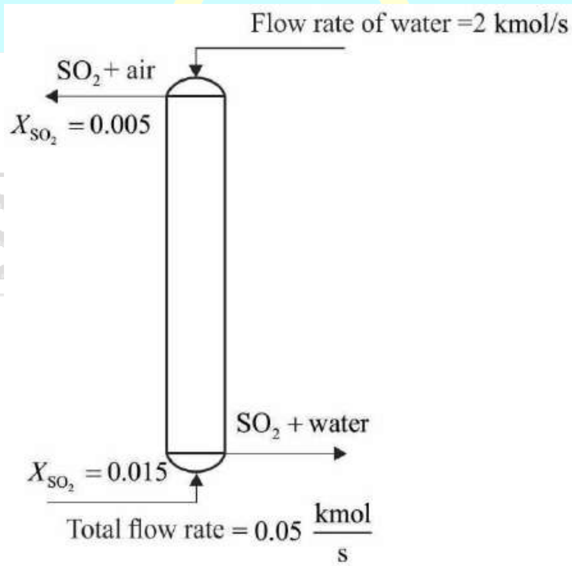
- Column operates under isothermal conditions
- At the operating temperature of the column, $y^* = 40x$ where y^* is the mole fraction of SO_2 at a mole fraction of x
- Solution is dilute and the operating line is linear
- Negligible amount of water evaporates

The number of transfer units (NTU) for this column is

(A) 0.5 (B) 1.0 (C) 1.5 (D) 2.0

Ans. **(D)**

Sol.



Assume operating line are linear

Relation is given as

$$Y^* = 40\text{ x}$$

Solution is dilute and no water evaporation

$$A_2 = \frac{L}{MG}$$

$$A = \frac{2}{40 \times .05}$$

$$A = 1$$

$$\text{NTOG} = \frac{Y_1 - Y_2}{Y_2 - MX_2} = \frac{.015 - .005}{.005 - 0} = 2$$

Hence, the correct options is (D).

Q.29 Two film theory applies for absorption of a solute from a gas mixture into a liquid solvent. The interfacial mass transfer coefficient (in mol $\text{m}^{-2}\text{s}^{-1}$) for the gas side is 0.1 and for the liquid side is 3. The equilibrium relationship is $y^* = 2x$, where x and y^* are mole fractions of the solute in the liquid and gas phases, respectively. The ratio of the mass transfer resistance in the liquid film to the overall resistance is

(A) 0.0161 (B) 0.0322 (C) 0.0625 (D) 0.0645

Ans. **(C)**

Sol.

$$k_x = 3$$

$$k_y = 2$$

$$y = 0.1x$$

$$\frac{1}{K_{ox}} = \frac{1}{k_x} + \frac{1}{mk_y} = \frac{1}{3} + \frac{1}{0.1 \times 2}$$

$$\Rightarrow \quad \frac{1}{3} + \frac{1}{0.1 \times 2}$$

$$\Rightarrow \quad \frac{1}{3} + \frac{1}{0.2}$$

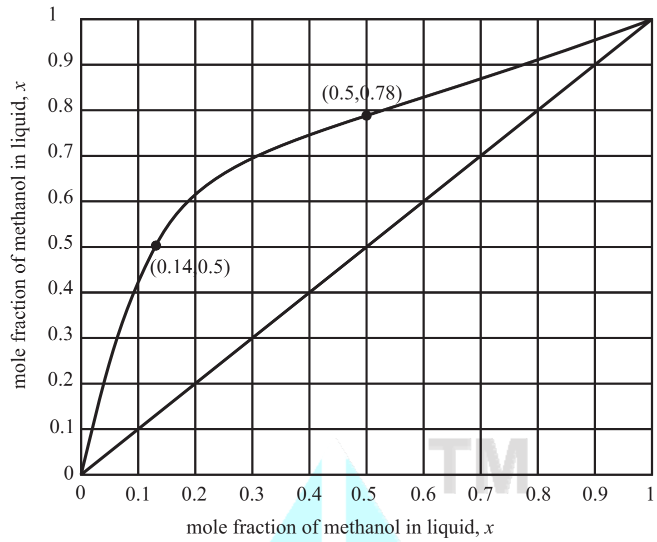
$$\Rightarrow \quad 0.34 + 5$$

$$\frac{1}{k_x} = 5.34$$

$$\frac{\frac{1}{k_x}}{\frac{1}{K_{ox}}} = \frac{\frac{1}{3}}{5.34} = \frac{1}{3 \times 5.34} = 0.06242$$

Hence, the correct options is (C).

Q.30 Consider the equilibrium data for methanol-water system at 1 bar given in the figure below.

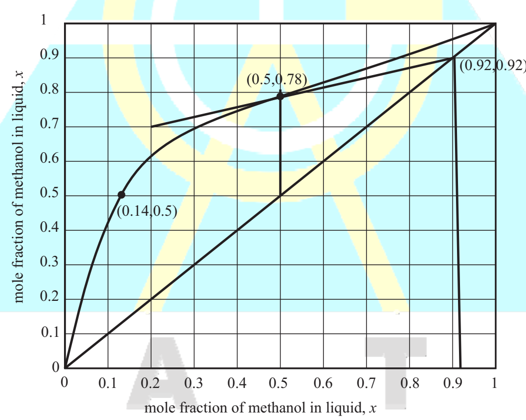


A distillation column operating at 1.0 bar is required to produce 92 mol % methanol. The feed is a saturated liquid. It is an equimolar mixture of methanol and water. The minimum reflux ratio is

(A) 0.33 (B) 0.50 (C) 0.54 (D) 1.17

Ans. **(B)**

Sol. Saturate liquid $q = 1$



$$\frac{R_m}{R_{m+1}} = \left[\frac{0.92 - 0.78}{0.92 - 0.5}\right]$$

$$R_m = 0.5$$

Hence, the correct options is (B).

Q.31 Consider the gas phase reaction $N_2O_4 \rightleftarrows 2NO_2$ occurring in an isothermal and isobaric reactor maintained at 298 K and 1.0 bar. The standard Gibbs energy change of the reaction at 298 K is $\Delta G^0_{298} = 5253 \text{ J mol}^{-1}$. The standard states are those of pure ideal gases at 1.0 bar. The equilibrium mixture in the reactor behaves as in the ideal gas. The value of the universal gas constant is $8.314 \text{ J mol}^{-1}\text{K}^{-1}$. If one mole of pure N_2O_4 is initially charged to the reactor, the fraction of N_2O_4 that decomposes into NO_2 at equilibrium is

(A) 0 (B) 0.17 (C) 0.38 (D) 1

Ans. **(B)**

Sol. $$N_2O_4 \rightleftharpoons 2NO_2$$

As you know that

$$\Delta G^0 = -RT \ln k$$

$$5253 = -8.314 \times 298 \ln k$$

$$k = 0.12$$

$$k = k_y P^{\Sigma \gamma_i}$$

$$k_y = \frac{y_{NO_2}}{y_{N_2O_4}}$$

$$y_{NO_2} = \left[\frac{2\varepsilon}{(1+\varepsilon)}\right]$$

$$y_{N_2O_4} = \frac{1-\varepsilon}{1+\varepsilon}$$

$$k = \frac{\left(\frac{2\varepsilon}{1+\varepsilon}\right)^2}{\left(\frac{(1-\varepsilon)}{1+\varepsilon}\right)}$$

$$0.12 = \frac{(2\varepsilon)^2}{(1-\varepsilon^2)}$$

$$\varepsilon = 0.17$$

Hence, the correct option is (B).

Q.32 A tank initially contains a gas mixture with 21 mol % oxygen and 79 mol % nitrogen. Pure nitrogen enters the tank, and a gas mixture of nitrogen and oxygen exits the tank. The molar flow rate of both the inlet and exit streams is 8 mol s^{-1}.

In addition, use the following data and assumptions

- Assume the tank contents to be well mixed
- Assume ideal gas behavior
- The temperature and pressure inside the tank are held constant
- Molar density of the gas mixture in the tank is constant at 40 mol m^{-3}

If the volume of the tank is 20 m^3, then the time (in seconds) required for oxygen content in the tank to decrease to 1 mol % is

(A) 100.45 (B) 30.45 (C) 3.445 (D) 10

Ans. **(B)**

Sol. $O_2 \rightarrow$ from general mole balance equation

Molar rate = molar rate – molar rate

of O_2 accumulation of O_2 in of O_2 out

$$\frac{d(\rho.Vx)}{dt} = f_1 \times x_1 - f_2 \times x_2$$

$$\rho = 40 \text{ mol/m}^3, \; V = 20 \text{ m}^3$$

Where $f_1 =$ inlet flow rate

$f_2 =$ Outlet flow rate

$x =$ Mole fraction of O_2

$$\rho V.\frac{dx}{dt} = f_1 \times O - f_2 x$$

$$40 \text{ mol/m}^3 \times 20 \text{ m}^3 \frac{dx}{dt} = -8 \text{ mol/ sec}\, x$$

$$\Rightarrow \quad \frac{dx}{dt} = \frac{x}{100}$$

$$\Rightarrow \quad \int_{x_0}^{x} \frac{dx}{x} = \int_0^t \frac{dt}{100}$$

$$\ln\left(\frac{x}{x_0}\right) = \frac{-t}{100}$$

$$\Rightarrow \quad \ln\left(\frac{0.01}{0.21}\right) = \frac{-t}{100}$$

$$\Rightarrow \quad t = 30.45 \text{ sec}$$

Hence, the correct option is (B).

Q.33 Consider steady, laminar, fully developed flow of an incompressible Newtonian fluid through two horizontal straight pipes, I and II, of circular cross section. The volumetric flow rates in both the pipes are the same. The diameter of pipe II is twice the diameter of pipe I, i.e., $d_{II} = 2d_1$. The ratio of the shear stress at the wall of pipe I to the shear stress at the wall of pipe II is

(A) 0.5 (B) 2 (C) 4 (D) 8

Ans. **(D)**

Sol. We know that

$$\tau = \left(-\frac{\partial p}{\partial x}\right).\frac{R}{2} = \left(-\frac{\partial p}{\partial x}\right).\frac{D}{4}$$

Laminar flow

$$\partial p = \frac{32\mu u L}{D^2} = \text{For const Q}$$

$$\partial p = \frac{32\mu QL}{A.DL} = \frac{32\mu QL}{\frac{\pi}{4}\times D^4}$$

$$\partial p \propto \frac{1}{D^4}$$

So, $\tau \propto D_4 \times D$

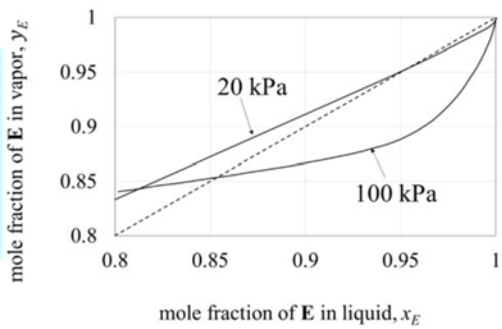
$$\tau \propto \frac{1}{D^3}$$

$$\frac{\tau_1}{\tau_2} = \left(\frac{D_2}{D_1}\right)^3 = (2)^3 = 8$$

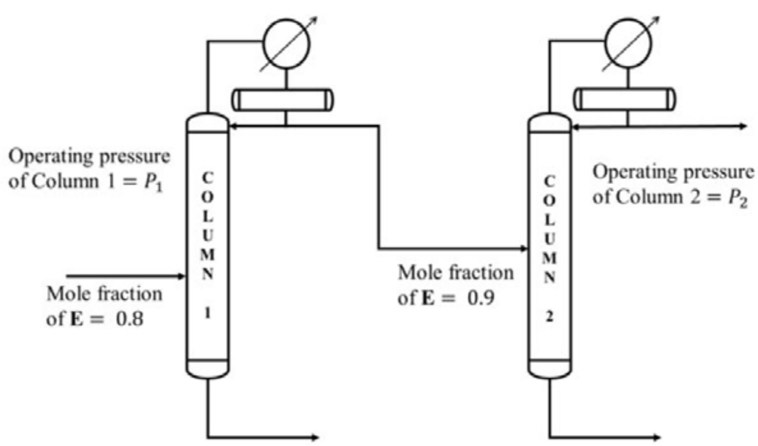
$$\frac{\tau_1}{\tau_2} = 8$$

Hence, the correct option is (D).

Q.34 Equilibrium data for a binary mixture of **E** and **F** at two different pressures is shown in the figure.



It is desired to process a feed containing 80 mol % **E** and 20 mol % **F,** and obtain a product with a purity of 99.5 mol % **E**. A sequence of two distillation columns, one operating at pressure P_1 and another at P_2, is employed for this operation, as shown below.



Mole fraction of **E** in the distillate obtained from column 1 is 0.9. If the column pressures P_1 and P_2 are in kPa, which one of the following is correct?

(A) $P_1 = 100$, $P_2 = 20$, and high purity **E** is recovered from the top of column 2

(B) $P_1 = 100$, $P_2 = 20$, and high purity **E** is recovered from the bottom of column 2

(C) $P_1 = 20$, $P_2 = 100$, and high purity **E** is recovered from the top of column 2

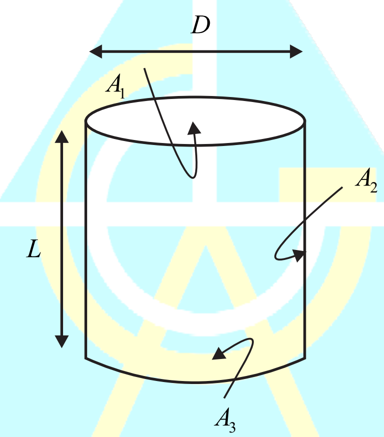
(D) $P_1 = 20$, $P_2 = 100$, and high purity **E** is recovered from the bottom of column 2

Ans. **(D)**

Sol. From the figure we can observe that relative volatility is less than 1 so more volatile component will come out from the bottom of the column...

Hence D option will be correct

Q.35 A hollow cylinder of equal length and inner diameter (i.e., $L = D$) is sealed at both ends with flat plate, as shown in the figure. Its inner surfaces $A_1 A_2$ and A_3 radiate energy.

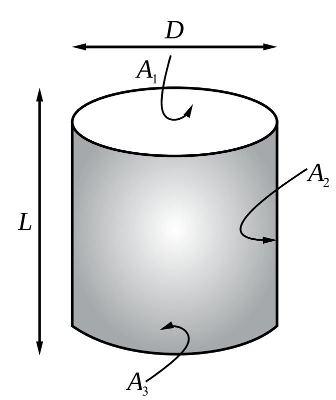


F_{ij} denotes the fraction of radiation energy leaving the surface A_i which reaches the surface A_j. It is also known that $F_{13} = 3 - 2\sqrt{2}$. Which one of the following is correct?

(A) $F_{21} = \sqrt{2} - 1$ (B) $F_{21} = \frac{\sqrt{2}-1}{2}$ (C) $F_{21} = \frac{\sqrt{2}-1}{4}$ (D) $F_{21} = \frac{\sqrt{2}-1}{8}$

Ans. **(B)**

Sol.



Given, $F_{13} = 3 - 2\sqrt{2}$ & $L = D$

$$F_{11} + F_{12} + F_{13} = 1$$

$$0 + F_{12} + 3 - 2\sqrt{2} = 1$$

$$F_{12} = 2\sqrt{2} - 2$$

From Reciprocity theorem

$$A_1 F_{12} = A_2 F_{21} \Rightarrow F_{21} = \frac{A_1}{A_2} \times F_{12}$$

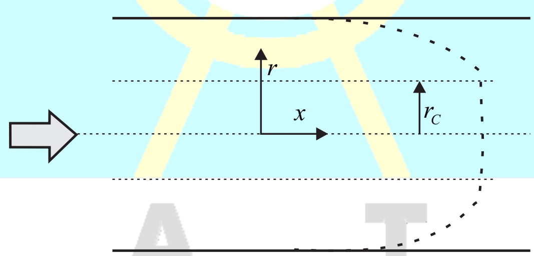
$$F_{21} = \frac{\pi R^2}{2\pi RL} \times \left(2\sqrt{2} - 2\right)$$

$$F_{21} = \frac{\pi R^2}{2\pi R(2R)} \times (2\sqrt{2} - 2)$$

$$F_{21} = \frac{\sqrt{2} - 1}{2}$$

Hence, the correct option is (B).

Q.36 A student performs a flow experiment with Bingham plastic under fully developed laminar flow conditions in a tube of radius 0.01 m with a pressure drop (ΔP) of 10 kPa over tube length (L) of 1.0 m. The velocity profile is flat for $r < r_c$ and parabolic for $r \geq r_c$, as shown in the figure.



Consider r and x as the radial and axial directions, and the shear stress is finite as r approaches zero. A force balance results in the following equation

$$\frac{d(r\tau_{rx})}{dr} = r\frac{(-\Delta P)}{L}$$

Where τ_{rx} is the shear stress. If r_c is 0.001 m, then the magnitude of yield stress for this Bingham Plastic (in Pa) is

(A) 1 (B) 5 (C) 8 (D) 12

Ans. (B)

Sol.

$$\frac{d}{dr}(r\tau_{rx}) = \int r\frac{(-\Delta p)}{L}$$

$$r\tau_{rx} = \left(-\frac{\partial p}{L}\right)\frac{r^2}{2} + C$$

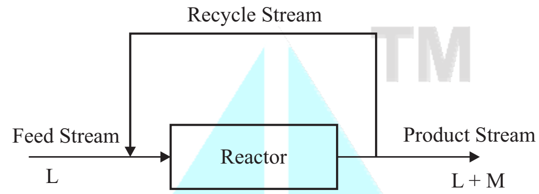
$$\tau_{rx} = \left(-\frac{\partial P}{L}\right)\frac{r}{2} + \frac{C}{r}$$

$$r = 0,\ \tau_{rx} = 0,\ C = 0$$

$$\tau_{rx}\Big|_{\text{yield stress}} = \left(-\frac{\partial p}{\partial l}\right).\frac{r}{2} = 10\times 10^3 \times \frac{0.001}{2} = 5$$

Hence, the correct option is (B).

Q.37 A feed stream containing pure species L flows into a reactor, where L is partly converted to M as shown in the figure.

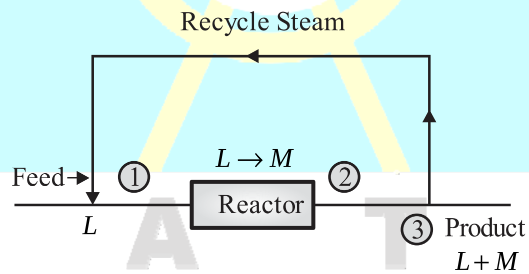


The mass flow rate of the recycle stream is 20 % of that of the product steam. The overall conversion of L (based on mass units) in the process is 30 % . Assuming steady state operation, the-pass conversion of L (based on mass units) through the reactor is

(A) 34.2 % (B) 30 % (C) 26.3 % (D) 23.8 %

Ans. **(C)**

Sol.



Given :

recycle stream is 20 % over all conversion of $L = 30\%$ on over all loop single pass conversion -

$$\frac{\text{Amount of } L \text{ at point (1)} - L \text{ at (2)}}{L \text{ at point (1)}}$$

Point (3) work at a splitter so composition are same

Recycle steam $= 0.2 \times F$

0.7 unrecycled steam of L

$$R = 0.2 \times 0.7F = 0.14\text{ F}$$

At point (1)

$$F + R = \text{ Mixed feed}$$

Mixed feed $= F + 0.14F = 1.14\text{F}$

Product contain $L = 0.7F$

So, point (2)

$$\Rightarrow \qquad 0.7F + 0.14F = 0.84\ \text{F}\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

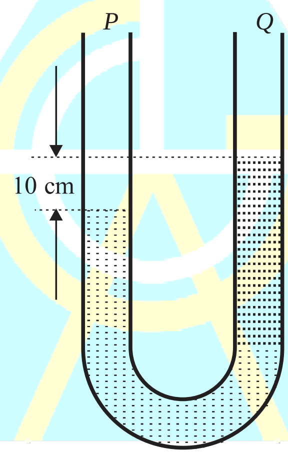
Single pass conversion

$$= \frac{1.14F - 0.8F}{1.14F}$$

$$= 0.2631 = 26.31\ \%$$

Hence, the correct option is (C).

Q.38 A U-tube manometer contains two manometric fluids of densities $1000\ \text{kg m}^{-3}$ and $600\ \text{kg m}^{-3}$. When both the limbs are open to atmosphere, the difference between the two levels is 10 cm at equilibrium, as shown in the figure.



The rest of the manometer is filled with air of negligible density. The acceleration due to gravity is $9.81\ \text{m s}^{-2}$ and atmospheric pressure is $100\ \text{kPa}$. How much absolute pressure (in kPa) has to be applied on the limb 'P' to raise the fluid in the limb 'Q' by another $20\ \text{cm}$?

(A) 100.175 (B) 103.924 (C) 547.231 (D) 833.206

Ans. **(A)**

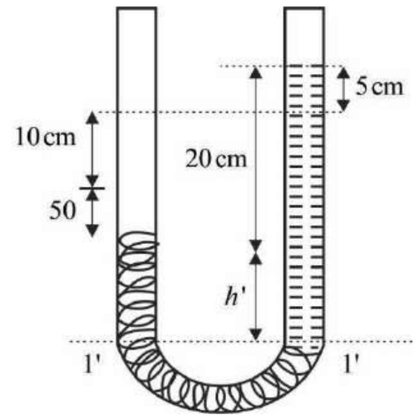
Sol. First find h

$$P_1 = P_2$$

$$P_{atm} + \delta_1 gh = P_{atm} + \delta_2 g(.1 + h)$$

$$1010 \times h = 600 \times 9.01(0.1 + h)$$

$$h = 0.149\ \text{m} \approx 15\ \text{cm}$$



From figure, $h^1 = 10 \text{ cm} = 0.1 \text{ m}$

$$P_1' = P_2'$$

$$P_{abs} + \delta_1 g h^1 = P_{atm} + \delta_2 g(h^1 + 0.2)$$

$$P_{abs} = 100.104 \text{ KPa}$$

Hence, the correct option is (A).

Q.39 A pure gas obeys the equation of state given by

$$\frac{PV}{RT} = 1 + \frac{BP}{RT}$$

Where P is the pressure, T is the absolute temperature, V is the molar volume of the gas, R is the universal gas constant, and B is a parameter independent of T and P. The residual molar Gibbs energy, G^R, of the gas is given by the relation

$$\frac{G^R}{RT} = \int_0^P (Z-1)\frac{dP}{P}$$

Where Z is the compressibility factor and the integral is evaluated at constant T. If the value of B is $1 \times 10^{-4}\, \text{m}^3\text{mol}^{-1}$, the residual molar enthalpy (in J mol^{-1}) of the gas at 1000 kPa and 300 K is

(A) 100 (B) 300 (C) 2494 (D) 30000

Ans. **(A)**

Sol.

$$z = 1 + \frac{B_0 P}{RT}$$

$$B_0 = 10^{-4}$$

$T = 300 \text{ k}, P = 1000 \text{ KPa}$

$$\frac{G^R}{RT} = \int_0^P (z-1)\frac{dP}{P}$$

Given $\frac{PV}{RT} = 1 + \frac{BP}{RT}$, $\left(z = \frac{PV}{RT}\right)$

$$\frac{G^R}{RT} = \frac{BP}{RT}$$

$$\Rightarrow \qquad G^R = BP$$

$$G^R = 100$$

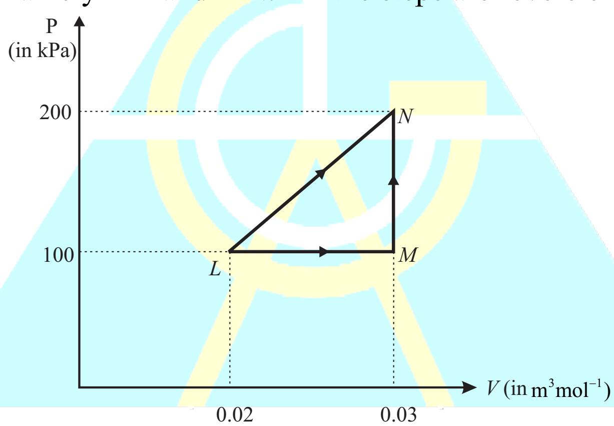
$$\frac{H^R}{RT} = -T\left[\frac{\partial(G^R/RT)}{\partial T}\right]_P = -T\left[\frac{\partial(BP/RT)}{\partial T}\right]_P$$

$$= -T\left\{-\frac{BP}{RT^2}\right\}$$

$$G^R = H^R = 100$$

Hence, the correct answer is 100.

Q.40 Consider one mole of an ideal gas in a closed system. It undergoes a change in state from L to N through two different non- isothermal processes, as shown in the P-V diagram (where P is the pressure and V is the molar volume of the gas). Process I is carried out in a single step, namely LN, whereas process II is carried out in two steps, namely LM and MN. All the steps are reversible.



The net heat flowing into the system for process I is Q_I and that for process II is Q_{II}. The value of $Q_I - Q_{II}$ (in J) is

(A) 250 (B) 500 (C) 1000 (D) 1500

Ans. **(B)**

Sol.

$$W_{net} = \frac{1}{2}(0.03-0.02)\times 100 \rightarrow \frac{\text{m}^3}{\text{mol}}\times \text{kPa}$$

$$= 0.01\times 50 = 0.5 \text{ KJ}$$

$$W_{net} = Q_{net} = \text{ For a cycle}$$

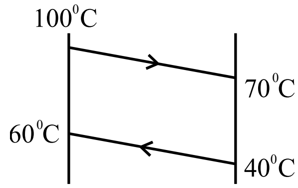
$$Q_I - Q_{II} = 500 \text{ J/mol}$$

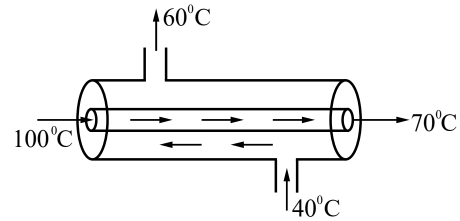
Hence, the correct option is (B).

Q.41 A fluid is heated from 40^0C to 60^0C in a countercurrent, double pipe heat exchanger. Hot fluid enters at 100^0C and exits at 70^0C. The log mean temperature difference, i.e. LMTD (in ^0C), is _______(round off to 2 decimal places).

Ans. 34.76

Sol.

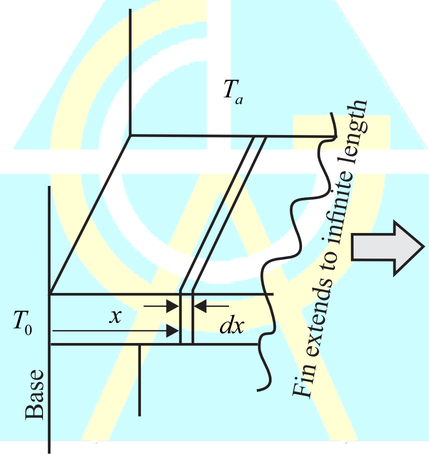




$$LMTD = \frac{(100-60)-(70-40)}{\ln\left(\frac{100-60}{70-40}\right)}$$

$$\text{LMTD} = 34.76^0\text{C}$$

Q.42 Consider an infinitely long rectangular fin exposed to a surrounding fluid at a constant temperature $T_a = 27^0\text{C}$.



The steady state one dimensional energy balance on an element of the fin of thickness dx at a distance x from its base yields

$$\frac{d^2\theta}{dx^2} = \text{m}^2\theta$$

Where $\theta = T_s - T_a, T_x$ is the temperature of the find at the distance x from its base in ${}^0\text{C}$. The value of m is $0.04\ \text{cm}^{-1}$ and the temperature at the base is $T_0 = 227^0\text{C}$. The temperature (in ${}^0\text{C}$) at $x = 25$ cm is _____(rounded off to 1 decimal place).

Ans. 100.57

Sol. $T_a = 27^0\text{C},\ \text{T}_0 = 227^0\text{C}, T(x)\big|_{x=0.25} = ?$

$$\frac{d^2\theta}{dx^2} = m^2\theta$$

Given $\rightarrow$ $m = 0.04\,\text{cm}^{-1} \Rightarrow m = 4\,m^{-1}$

$$\frac{d^2\theta}{dx^2} - m^2\theta = 0$$

$$\frac{\theta(x)}{\theta_0} = \frac{T(x) - T_a}{T_0 - T_a} = e^{-mx}$$

$$\frac{T(x) - 27}{227 - 27} = e^{-4x}$$

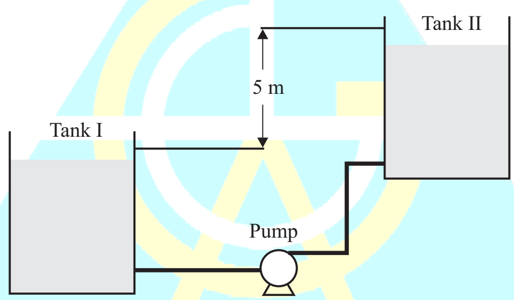
$$T(x)\big|_{x=0.25} = 27 + 200\,e^{-4(0.25)}$$

$$T(x)\big|_{x=0.25} = 27 + 200\,e^{-1}$$

$$T(x)\big|_{x=0.25} = 27 + \frac{200}{e}$$

$$T(x)\big|_{x=0.25} = 100.57^0\text{C}$$

Q.43 Liquid water is pumped at a volumetric flow rate of 0.02 $m^3 s^{-1}$ from Tank to Tank II, as shown in the figure.



Both the tanks are open to the atmosphere. The total frictional head loss for the pipe system is 1.0 m of water.

In addition, use the following data and assumptions

- Density of water of 1000 kg m^{-3}
- Acceleration due to gravity is 9.81 $m s^{-2}$
- Efficiency of the pump if 100 %
- The liquid surfaces in the tanks have negligible velocities

The power supplied (in W) by the pump to lift the water is _____ (round off to 1 decimal place).

Ans. **1177.2**

Sol. Appling benefice at point (1) and point (2)

$$\frac{P_1}{\delta g} + \frac{V_1^2}{2g} + hw = \frac{P_1}{\delta g} + \frac{V_1^2}{2g} + hf + (Z_2 - Z_1)$$

$$h_w = 1 + 5 = 6$$

$$P = Q\delta g h_w$$

$$P = 0 \cdot 02 \times 1000 \times 9.81 \times 6 = 1177.2 \text{ W}$$

Hence, the correct answer is 1177.2

Q.44 An elementary liquid phase reversible reaction $P \rightarrow Q$ is carried out in an ideal continuous stirred tank reactor (CSTR) operated at steady state. The rate of consumption of P, $-r_P$ (in mol liter liter^{-1}minute^{-1}), is given by

$$-r_P = C_P - 0.5C_Q$$

Where C_P and C_Q are the concentrations (in mol liter^{-1}) of P and Q, respectively. The feed contains only the reactant P at a concentration of 1 mol liter^{-1}, and conversion of P at the exit of the CSTR is 75 % of the equilibrium conversion. Assume that there is no volume change associated with the reaction, and the temperature of the reaction, and the temperature of the reaction mixture is constant throughout the operation. The space time (in minutes) of CSTR is ___ (round off to 1 decimal place).

Ans. 2

Sol. $(-r_p) = C_p - 0.5C_Q$

$C_{p_0} = 1$ mol/l

$X_p = 75\%$ of Xe (equilibrium conversion)

For MFR

$$\tau = \frac{C_{p_0} X_p}{(-r_p)}$$

$$\tau = \frac{C_{p_0} X_p}{C_p - 0.5C_Q}$$

$$C_P = C_{P_0}(1 - X_P)$$

$$C_Q = C_{P_0} X_P$$

$$\tau = \frac{X_P}{(1 - X_P) - 0.5X_P}$$

At equation $(-r_p) = 0$

$$\frac{1}{0.5} = \frac{C_{Q_e}}{C_{P_e}}$$

$$2 = \frac{C_{P_0} X_{P_e}}{C_{P_0}(1 - X_{P_e})}$$

$$X_{P_e} = \frac{2}{3}$$

Actual conversion

$$X_P = 0.75 \times \frac{2}{3} = 0.5$$

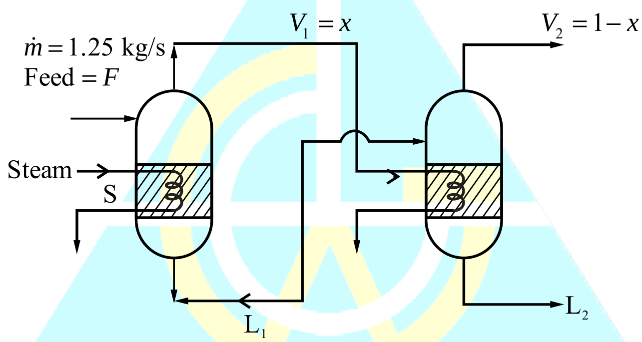
$$\tau=\frac{0.5}{(1-0.5)-0.5\times0.5}$$

$$\tau=\frac{0.5}{0.5-0.25}=\frac{0.50}{0.25}=2\text{ min}$$

Q.45 An aqueous suspension at 60^0C is fed to the first effect of a double effect forward feed evaporator with a mass flow rate of 1.25 kg s^{-1}. The sum of the rates of water evaporated from the first and second effects is 1.0 kg s^{-1}. Temperatures of the exit streams from the first and the second effects are 100^0C and $60\ ^0C$, respectively. Consider the specific heat of the aqueous suspension, and the latent heat of phase change for water to be $4\text{ kJ kg}^{-1}\text{K}^{-1}$ and 2200 kJ kg^{-1}, respectively, over this temperature range. The steam economy (in kg per kg) is____(round off to 2 decimal places).

Ans. **1.7774**

Sol.



$$T_F=60^0C, T_1=100^0C, T_2=60^0C$$

$$\lambda_V=2200\text{ kJ/kg}, C_P=4\text{ kJ/kg}$$

Given $\rightarrow V_1+V_2=1\text{ kg/s}$

$$F=L_1+V_1$$

$$1.25=L_1+x\Rightarrow L_1=(1.25-x)\text{ kg/s}$$

Energy balance on Ist stage

$$FC_p(T_1-T_F)+V_1\lambda_V=S\lambda_S$$

$$1.25(4\times10^3)(100-60)+x(2200\times10^3)=S(2200\times10^3)$$

$$200000+2200000x=2200000S$$

$$11x-11S+1=0$$

$$11x=-1+11S \qquad \ldots\text{(i)}$$

Energy balance on II stage

$$L_1CP(T_2-T_1)+V_2\lambda_V=V_1\lambda_S$$

$$(1.25-x)(4)(60-100)+(1-x)(2200)=x(2200)$$

$$4240x=2000$$

$$x=0.4716\text{ kg/s}$$

On substituting this value in equation (i)

$$11(0.4716) = -1 + 11S$$

$$S = 0.5626\,\text{kgs}$$

Economy of Evaporatar $= \frac{V}{S} = \frac{1\,\text{kg/s}}{0.5626\,\text{kg/s}}$

Economy of $= 1.7774$

Q.46 A vertically held packed bed has a height of $1\,\text{m}$, and a void fraction of 0.1, when there is not flow through the bed. The incipient (miniumum) fluidization is set in by injection of a fluid of density $1\,\text{kg}\,\text{m}^{-3}$. The particle density ($\rho_p$) of the solids is 3000 kg m^{-3}. Acceleration due to gravity is $9.81\,\text{m s}^{-2}$. The pressure drop (in Pa) across the height of the bed is ___(round off to nearest integer).

Ans. **26478.17**

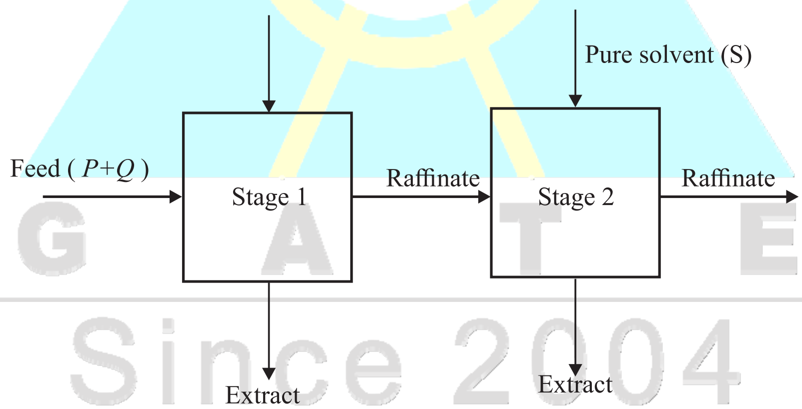
Sol. For minimum fluidization

$$\frac{\Delta P}{L} = (1-\xi_m)(\delta_p - \delta)g$$

$$\Delta p = (1-.1)(3000-1)-.01\times 1$$

$$\Delta p = 26478.17 \text{ Pa}$$

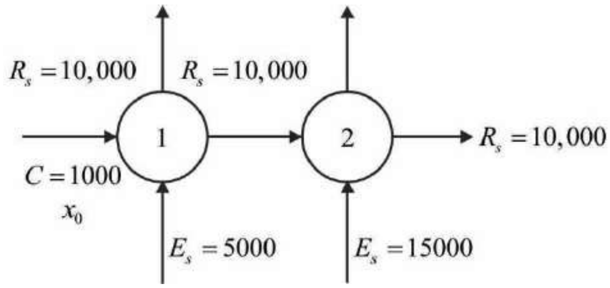
Q.47 Two ideal cross- current stages operate to extract P from a feed containing P and Q, as shown below.



The mass flow rates of P and Q to stage 1 are $1,000\ \text{kg}\,\text{h}^{-1}$ and $10,000\ \text{kg}\,\text{h}^{-1}$, respectively. Pure solvent (S) is injected at mas flow rates of $5,000\ \text{kg}\,\text{h}^{-1}$ and $15,000\ \text{kg}\,\text{h}^{-1}$ to stages 1 and 2, respectively. The components Q and S are immiscible. The equilibrium relation is given by $Y^* = 1.5\ X$, where X is the mass of P per unit mass of Q in the raffinate, and Y^* is the mass of P per unit mass of S in the extract, which is in equilibrium with the raffinate. The mass flow rate of P (in $\text{kg}\,\text{h}^{-1}$) in the raffinate from state 2 is ____(round off to nearest integer).

Ans. **176**

Sol.



$y = 1.5\,x$ [On Solute free]

Let x amount left in the Raffinate remaining from stage – 1 then in the extract, it will be $(1000 - x)$

$$\left(\frac{1000 - x}{5000}\right) = 1.5\frac{x}{(10{,}000)}$$

$$2000 - 2x = 1.5x$$

$$3.5x = 2000$$

$$x = \frac{2000}{3.5}$$

$$x = 571.428$$

Similarly, $\left(\frac{571.428 - x}{15000}\right) = 1.5\frac{x}{10{,}000}$

$$1142.057 - 2x = 4.5x$$

$$1142.057 / 6.5 = x$$

Amount of solute $x = 175.024$

In Raffinate = 176

Hence, the correct answer is 176.

Q.48 Consider a vertically falling film of water over an impermeable wall. The film is in contact with a static pool of non-reactive pure gas. The gas diffuses into the water film over the entire height of the falling film. The height of the film is 1.0 m, and its thickness is 10^{-4} m. The velocity of eater, averaged over the film thickness, is 0.01 m s^{-1}. The gas concentration (in kg m^{-3}), averaged over the film thickness is

$$\overline{C_{Ay}} = C_{A_i}(1 - e^{-30y})$$

Where y is the vertical positon in meters measured from the top of the wall.

In addition, use the following data and assumptions

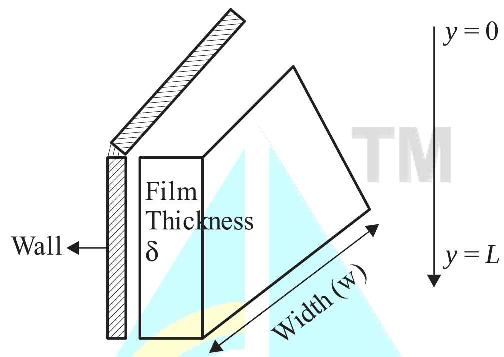
- The flow is fully developed
- The width of the film is much larger than the thickness of the film, and the dissolved gas concentration is invariant over this width
- The solubility of the gas in water, C_{A_i}, is constant

- Pure water enters at $y = 0$
- The evaporation of water is negligible

The mass transfer coefficient on the liquid side (in $mm\ s^{-1}$), averaged over the entire height of the falling film is ____(round off to 3 decimal places).

Ans. **0.03**

Sol.



Thickness of film $= 10^{-4}$ m

$\bar{V}$ (Average velocity) = 0.01 m/s

Width of film = 'w', height (L) = 1m

$$\bar{C}_{Ay} = C_{Ai}(1 - e^{-30y})$$

Which means at $y = 0, \bar{C}_{Ay} = 0$

At $y = L = 1\text{m}$ $\bar{C}_{Ay} = C_{Ai}(1 - e^{30})$

Convective rate of mass transfer of pure gas into water film = mass transfer rate at $y = L$ – Mass transfer rate at $y = 0$

$$K_L(C_{Ai} - \bar{C}_{Ay})A = w_A\big|_{y+dy} - w_A\big|_y$$

Where, K_L is mass transfer coefficient A is Area over the differential block and is given by (wdy). Clearly for the gas, the available area of Cross section (wdy) Now, rate of mass transfer = Flux × Area

Talking about area of mass transfer then we can say over the entire thickness of film, mass transfer is taking place which means area of mass transfer is (wδ).

$$K_L(C_{Ai} - \bar{C}_{Ay})(wdy) = \left(N_A\big|_{y+dy} - N_A\big|_y\right)(w\delta)$$

Now, flux can be defined as $N_A = C_A(u_A - 0)$ [Basic definition]

Hence, $$K_L(C_{Ai} - \bar{C}_{Ay})(wdy) = \left(\bar{C}_A\big|_{y+dy} - \bar{C}_A\big|_y\right)\bar{v}(w\delta)$$

$$K_L(C_{Ai} - \bar{C}_{Ay})dy = \left(\bar{C}_A\big|_{y+dy} - \bar{C}_A\big|_y\right)$$

Can be written as $d\bar{C}_A$

$$K_L dy = \bar{V}\delta \frac{d\bar{C}_A}{C_{Ai} - C_{Ay}}$$

Integrating both sides,]

$$K_L \cdot L = \delta\bar{V}\left[-\ln(C_{A_i} - C_A(y)\right]_0^{\bar{C}_A(y=1)}$$

$$K_L = \frac{\delta\bar{V}}{L}\ln\left[\frac{C_{A_i}}{\bar{C}_{A_i} - \bar{C}_A(y=1)}\right]$$

given $\bar{C}_A(y) = C_{A_i}(1 - e^{-30y})$

$$\bar{C}_A(1) = C_{A_i}(1 - e^{-30})$$

$$C_{A_i} - C_A(y=1) = e^{-30} \cdot C_{A_i}$$

Now $K_L = \frac{\delta\bar{V}}{L}\ln\left[\frac{C_{A_i}}{C_{A_i} \cdot e^{-30}}\right]$

$$K_L = \frac{\delta\bar{V}}{L}\ln e^{30}$$

$$K_L = \frac{10^{-4} \times 0.01}{1} \times 30$$

$$K_L = 3 \times 10^{-5} \text{ m/sec}$$

$\Rightarrow$ $K_L = 0.03$ mm/sec

Hence, the correct answer is 0.03.

Q.49 An exothermic, aqueous phase, irreversible, first order reaction, $Y \rightarrow Z$ is carried out in an ideal continuous stirred tank reactor (CSTR) operated adiabatically at steady state. Rate of consumption of Y (in mol liter^{-1}minute^{-1}) is given by

$$-r_Y = 10^9 e^{-\frac{6500}{T}} C_Y$$

Where C_Y is the concentration of Y (in mol liter^{-1}), and T is the temperature of the reaction mixture (in K). Reactant Y is fed at 50^0C. Its inlet concentration is 1.0 mol liter^{-1},and its volumetric flow rate is 1.0 liter minute^{-1}.

In addition, use the following data and assumptions

- Heat of the reaction $= -42000$ J mol^{-1}
- Specific heat capacity of the reaction mixture $= 4.2$ g^{-1} K^{-1}
- Density of the reaction mixture $= 10000$ g liter^{-1}

- Heat of the reaction, specific heat capacity and density of the reaction mixture do no vary with temperature
- Shaft work is negligible

If the conversion of Y at the exit of the reactor is 90 %, the volume of the CSTR (in liter) is ____(round off to 2 decimal places).

Ans. **2.8**

Sol. $-r_y = 10^9 e^{\frac{-6500}{T}} c_y$

$T_0 = 323.15$ K

For MER $T = \dfrac{C_{y0} X_y}{(-r_y)} = \dfrac{V}{V_0}$

Energy balance

Energy inlet – Energy out = Energy due to reaction

$$v_0 \rho_0 C_p (T_1 - T_0) - v_0 \rho_0 C_p (T_2 - T_0) - v_0 C_{y_0} x_y \Delta H_i$$

$$= 1\times1000\times4.2(323.15-0) - 1\times1000 \times4.2\times(T_2 - 0) = 1\times1\times(-42000)$$

$$T_2 = 332.15 \text{ K}$$

$$-r_y = 10^9 e^{\frac{-6500}{T}} c_y$$

$$-r_y = 3.1702\, c_y$$

$$\frac{V}{1} = \frac{1\times0.9}{(3.1702)\, c_y \cdot (1 - x_{y_0})}$$

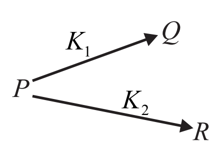
$$V = 2.8 \text{ liter}$$

Hence, the correct answer is 2.8

Q.50 The liquid phase irreversible reactions, $P \xrightarrow{k_1} Q$ and $P \xrightarrow{k_2} R$, are carried out in an ideal continuous stirred tank reactor (CSTR) operating isothermally at steady state. The space time of the CSTR is 1 minute. Both the reactions are first order with respect to the reactant P, and k_1 and k_2 denote the rate constants of the two reactions. At the exit of the reactor, the conversion of reactant P is 60 %, and the selectivity of Q with respect to R is 50 %. The value of the first order rate constant k_1 (in minute^{-1}) is ____(correct up to one decimal places).

Ans. **0.5**

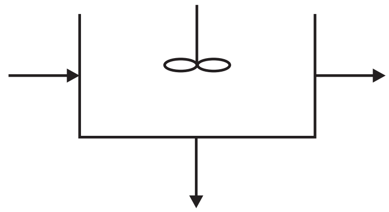
Sol.



$$X_p = 0.6$$

$$K_1 = ?$$

For MFR



Concentration in the tank will be same as that of at outlet

$$\bar{S} = S$$

$$S = \frac{r_Q}{r_R} = \frac{K_1 C_p}{K_2 C_2} \qquad K_2 = 2K_1$$

$$\tau_m = \frac{C_p X_p}{(-r_p)} = \frac{C_p X_p}{K_1 C_p + K_2 C_p} \qquad \tau_m = \frac{C_p X_p}{(K_1 + K_2) C_p} = \frac{X_p}{(K_1 + K_2)(1 - X_p)}$$

$$1 = \frac{0.6}{(K_1 + K_2)(0.4)}$$

$$K_1 + K_2 = \frac{3}{2}$$

$$3K_1 = \frac{3}{2}$$

$$K_1 = 0.5 \text{ min}$$

Q.51 A catalytic gas phase reaction $P \rightarrow Q$ is conducted in an isothermal packed bed reactor operated at steady state. The reaction is irreversible and second order with respect to the reactant P. The feed is pure P with a volumetric flow rate of 1.0 liter minute^{-1} and concentration of 2.0 mol liter^{-1}.

In addition, use the following assumptions

- The reactant the product are ideal gases
- There is no volume change associated with the reaction
- Ideal plug flow conditions prevail in the packed bed

When the mass of catalyst in the reactor is 4 g, the concentration of P measured at the exit is 0.4 mol liter^{-1}. The second order rate constant (in $\text{liter}^2\ g_{catalyst}^{-1}\ \text{mol}^{-1}\ \text{minute}^{-1}$) is ____ (correct up to one decimal place).

Ans. **0.5**

Sol.

$$W = 48$$

$$C_{A_0} = 2 \text{ mol/l} \left\{ F_{A_0} = C_{A_0}.v_0 = 2\text{mol/l} \times 1 \text{ l/min} = 2 \text{ mol/min} \right.$$

$$C_A = 0.4 \text{ mol/l}$$

$$C_A = C_{A_0} \Rightarrow 2(1-x_n) = 0.4$$

$\Rightarrow$ $$1 - x_A = 0.2 \quad \Rightarrow \quad x_A = 0.8$$

For PRR –

$$\frac{W}{F_{A_0}} = \int_0^{x_A} \frac{dx_A}{-r_A}$$

$$\frac{4}{2} = \int_0^{0.8} \frac{dx_A}{KC_A^2} = \int_0^{0.8} \frac{dx_A}{KC_{A_0}^2} = \frac{1}{KC_{A_0}^2}\left[\frac{x_A}{1-x_A}\right]_0^{0.8}$$

$$2 = \frac{1}{K(2)^2}\left[\frac{0.8}{1-0.8} - \frac{0}{1-0}\right]$$

$$K = \frac{1}{2\times 4}\left[\frac{0.8}{0.2}\right]$$

$\Rightarrow$ $$K = \frac{1}{2}$$

$\Rightarrow$ $$K = 0.5$$

Q.52 Flow of water through an equal percentage valve is 900 liter h^{-1} at 30 % opening, and 1080 liter h^{-1} at 35 % opening. Assume that the pressure drop across the valve remains constant. The flow rate (in liter h^{-1}) through the valve at 45 % opening is ______(round off to nearest integer).

Ans. **1555.09**

Sol. $f = R^{l-1}$ $$900 \longrightarrow 30\%$$

$$1080 \longrightarrow 35\%$$

$$\frac{1080}{900} = R^{.35-.30}$$

$\Rightarrow$ $$1.2 = R^{.05}$$

$$\ln(1.2) = .05\ln R$$

$$0.1023 = 0.05\ln R$$

$$\ln R = 3.646$$

$$R = 38.32$$

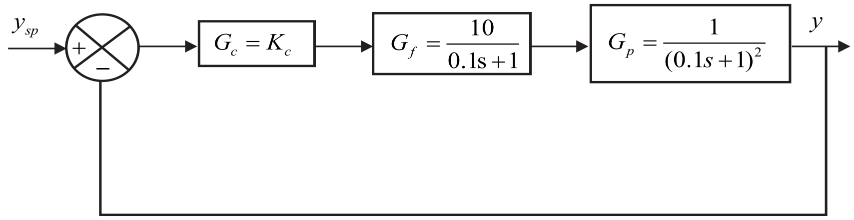
$$\frac{f}{900} = R^{.45-.3}$$

$\Rightarrow$ $$\frac{f}{900} = R^{0.15}$$

$$f = 900\times(38.32)^{0.15}$$

$$f = 1555.092 \text{ L/h}$$

Q.53 Consider the following closed loop system.



$G_c, G_f,$ and G_p are the transfer functions of the controller, the final control element and the process, respectively. y and y_{sp} are the response and its set point, respectively. For a gain margin of 1.6, the design value of K_C is _____(correct up to one decimal place).

Ans. **0.5**

Sol. T.F $\quad A.R = G_{open} = G_C G_f G_p G_M$

$$= K_C \times \frac{10}{(0.1s+1)} \times \frac{1}{(0.1s+1)^2}$$

T.F $\quad \text{A.R} = \frac{10\,\text{Kc}}{(0.1s+1)^3}$

$$A.R_2 = \frac{10K_C}{\left[(0.1)^2 w^2 + 1\right]^{\frac{3}{2}}}$$

$$\phi = -100 = 3\tan^{-1}(0.1\text{w})$$

$$w = 17.3$$

$$A.R\Big|_{w=w_{co}} = \frac{10K_C}{\left[(0.1)^2 \times (17.3)^2 + 1\right]^{\frac{3}{2}}}$$

$$A.R = \frac{10K_C}{7.97}$$

$$GM = \frac{1}{AR}\Big|_{w=w_0}$$

$$1.6 = \frac{7.92}{10K_C}$$

$$K_C = \frac{7.97}{10\times 1.6}$$

$$K = 0.5$$

Q.54 Given $\frac{dy}{dx} = y - 20$ and $y\big|_{x=0} = 40,$ the value of y at $x = 2$ is _______ (round off to nearest integer).

Ans. **168**

Sol. **Given :** $\frac{dy}{dx} = y - 20$

Variable separable method :

$$\frac{dy}{y-20} = dx$$

$$\ln|y-20| = x + C$$

$$\ln|20| = C$$

$\therefore$ $$\ln|y-20| = x + \ln 20$$

$$\ln(y-20) = 2 + \ln 20$$

$$(y-20) = e^{(2+\ln 20)}$$

$$y = e^{2+\ln 20} + 20$$

$$y = 167.78$$

$$y \approx 168$$

Q.55 Consider the following data set.

x	1	3	5	15	25
$f(x)$	6	8	10	12	5

Calculate the value of $\int_1^{25} f(x)\,dx$ by Simpson $\left(\frac{1}{3}\right)^{rd}$ method _______.

Ans. **242**

Sol. Simpson $\left(\frac{1}{3}\right)^{rd}$ method

$$\int_a^b f(x)dx = \frac{h}{3}\{(y_0 + y_n) + 4(y_1 + y_3 + -----+ y_n) + 2(y_2 + y_4 + -----+ y_{n-2})\}$$

Where

$$h = \frac{(b-a)}{n} \{\text{h represents equal interval b/w b and a}\} \int_1^{25} f(x)dx = \int_1^5 f(x)dx + \int_5^{25} f(x)dx$$

$\Rightarrow$ $$h = \frac{5-1}{2} = 2$$

x	1	3	5
y	6	8	10
	y_0	y_1	y_n

$\Rightarrow \quad h = \frac{25-5}{2} = 10$

x	5	15	25
y	10	12	5
	y_0	y_1	y_n

$$\int_1^5 f(x)dx = \frac{h}{3}\{(y_0 + y_n) + 4(y_1) + 2(0)\} = \frac{2}{3}\{6 + 10 + 4\times 8 + 2\times 0\} = \frac{2}{3}\times 48 = 32$$

$$\int_5^{25} f(x)dx = \frac{h}{3}\{(y_0 + y_n) + 4(y_1) + 2(0)\} = \frac{10}{3}\{10 + 5 + 4\times 12 + 2\times 0\} = \frac{10}{3}\times 63 = 210$$

$\therefore$ Adding this two integral :

$$\int_1^{25} f(x)dx = 32 + 210 = 242$$

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