Name: [redacted]

Quiz-II BT 306 Bioseparation Engineering Date: 16.04.2024

Answer all questions **Total Marks: 5+5=10**

Each question carries equal marks.

Instructions: The answer must show the (i) base equations and the condition validation (if needed), **Mark: 1,** (ii) unit for each value in the steps. **Mark: 1,** and (iii) the final correct answer derived from the correct steps and calculations **Mark: 3.**

1. In an adsorption study, 80 cm^3 of activated carbon as adsorbent adsorbs upto 7.8×10^{-6} mol of lipase enzyme per cubic centemeter of the adsorbent. This adsorption follows Langmuir isotherm, with a constant K of 1.9×10^{-5} mol/liter. What concentration in 1.2 liters of feed solution will exhaust 80 % of the activated carbon capacity?

ANS: Given :- $q_0 = 7.8 \times 10^{-6}$ mol/cm^3.

Langmuir isotherm, $K = 1.9 \times 10^{-5}$ mol/Litre $= 1.9 \times 10^{-5} \times 10^{-3}$ mol/cm^3

To find : y_F ~~y = 80~~ 80 % exhaustion, $\therefore y = 0.2\, y_F$ — (A)

Solution :- We know that, for Langmuir isotherm,

$$q = \frac{q_0 y}{K + y} = \frac{7.8 \times 10^{-6}\, y}{1.9 \times 10^{-8} + y}$$

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Substituting (A) $\Rightarrow$

$$q = \frac{(7.8 \times 10^{-6})(0.2\, y_F)}{[1.9 \times 10^{-8} + 0.2\, y_F]} \quad \text{—(1)}$$

We know that, $y_F H + q_F W = y H + q W$

Where, y_F = conc^n of feed, H = amt of feed, q_F = conc^n of absorbent, W = amt of adsorbent

y = final conc^n of feed, q = final conc^n of adsorbent

$$\therefore (y_F \times 1.2 \times 10^{3}\, cm^3) + 0 = y \times (1.2 \times 10^{3}\, cm^3) + q \times 80 \quad \cdots (q_F = 0)$$

Substituting (A) $\Rightarrow$ $(y_F \times 1.2 \times 10^{3}) = 0.24 \times 10^{3}\, y_F + 80\, q$

$$q = \frac{(0.96 \times 10^{3})\, y_F}{80} \quad \text{—(2)}$$

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Substituting (2) in (1),

$$\frac{(0.96 \times 10^{3})\, \cancel{y_F}}{80} = \frac{(7.8 \times 10^{-6}) \times 0.2\, \cancel{y_F}}{(1.9 \times 10^{-8} + 0.2\, y_F)}$$

$$1.824 \times 10^{-5} + 192\, y_F = 12.48 \times 10^{-5}$$

$$192\, y_F = 10.656 \times 10^{-5}$$

$$\boxed{y_F = 55.5 \times 10^{-8} \text{ mol/cm}^3}$$

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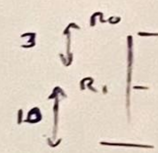
2. Bacterial cells are collected from a fermentation broth using a laboratory bottle centrifuge consisting of number of cylinders rotated perpendicularly to the axis of rotation. During the operation the distance between the surface of liquid and the axis of rotation is 3 cm, and the distance from the bottom of the cylinder to the axis is 10 cm. The diameter of the yeast cells (assuming spherical) are 8 μm and density of 1.10 g/cm³. The fluid has closely similar physical property with that of water. The centrifuge is to be operated at 500 r/min. Calculate the time required to complete the separation of the cells from the fermentation broth.

ANS: Given:- $R_0 = 10\,cm$, $R_1 = 3\,cm$, $\rho_s = 1.10\,g/cm^3$

$d = 8\times10^{-4}\,cm$



Sol^n: ($\mu = 0.1\,g/cm.sec$, $\rho = 1\,g/cm^3$) -- of water

For Tube centrifugation, we know that,

$$\cancel{v_\omega = \frac{d^2(\rho_s-\rho)}{18\mu} r\omega^2}$$

$$\cancel{v_\omega = \frac{(8\times10^{-4})^2 (1.10-1)}{18\times\mu}\left(\frac{2\pi\times500}{60}\right)^2}$$

$$\frac{dr}{dt} = v_g\left(\frac{r\omega^2}{g}\right) \quad -- \left(v_g = \frac{d^2(\rho_s-\rho)g}{18\mu}\right)$$

$$\frac{dr}{dt} = \frac{d^2(\rho_s-\rho)r\omega^2}{18\mu}$$

$$\int_{R_1}^{R_0+R_1}\left(\frac{dr}{r}\right) = \left(\frac{d^2(\rho_s-\rho)\omega^2}{18\mu}\right)\int_0^t dt$$

$$\ln\left(\frac{R_0+R_1}{R_1}\right) = \left[\frac{d^2(\rho_s-\rho)\omega^2}{18\mu}\right]t$$

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$$\ln\left(\frac{13}{10}\right) = \left[\frac{8\times10^{-4}}{18\times\cancel{10}}(\cancel{1.1}-1)\times\left(\frac{2\pi\times500}{60}\right)^2\right]t$$

$$0.262 = \left(\frac{8}{18}\times10^{-4}\times 2741.556\right)t$$

mis

$$0.262 = \overset{0.1218}{\cancel{2.143}}\times t$$

$$\boxed{\cancel{t = 0.119\ sec}}\quad 2.151$$

$$\boxed{t = 2.154\,sec}$$