53 (FPT 403) TPEN

2018

TRANSFER PROCESS ENGINEERING

Paper : FPT 403

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions from **seven.***

1. *(a)* Write Fick's 1st and 2nd law, define all terms and conditions.

   (b) What is diffusive and convective mass transfer ? Write flux for each care and net flux.

   (c) Write diffusivity range of solute in gas and liquid.

(d) How diffusivity of solute changes with pressure, temperature, molecular size, molecular weight ?

(e) Write SI unit of Flux, diffusion, coefficient, mass transfer coefficient, volumetric oxygen transfer coefficient.

4+6+2+4+4=20

2. (a) How volumetric oxygen transfer coefficient $(k_L a)$ is improved in aerobic fermentation ?

(b) Fill up the blanks :

(i) In absorption solute is transferred from _____ to _____

(ii) In adsorption solute is transferred from _____ to _____

(iii) In leaching solute is transferred from _____ to _____

(iv) In liquid-liquid extraction solute is transferred from _____ to _____

(c) Interphase mass transfer :

The equilibrium distribution of a solute and water at low concentration at a particular temperature is given by $y = 1{\cdot}2x$. At a certain position, the concentration of solute A in bulk air is 0·04 *mol* fraction and that in bulk liquid phase is 0·025. The individual mass transfer coefficient for transport are

$K_y = 7{\cdot}2 kmol/m^2h(Ay)$ and

$K_x = 4{\cdot}6 kmol/hm^2(Ay)$.

Calculate :

(i) Flux N_A

(ii) Overall gas phase and liquid phase driving force for mass transfer.

(iii) Interphase concentration in gas and liquid.

(iv) Overall mass transfer coefficients K_x and K_y.

(v) Which resistance controls the mass transfer here ?

3+4+13=20

3. *(a)* Absorption of a solute in a counter current multistage contact process :

It is desired to absorb 90% of solute in a gas containing 1·0 *mol*% solute in air in a counter current stage tower. The total inlet gas flow to the tower is 30 *kg mol / h*, total inlet pure liquid to be used to absorb the solute is 90 *kg mol* liquid/*h*. The process is to operate isothermally at 300*K* and total pressure of 101·3*KPa*. The equilibrium relation for the solute in the gas-liquid is $Y_A = 2{\cdot}53\,X_A$.

Determine the number of theoretical stages required for separation.

(b) Write Fourier's law of heat conduction.

15+5=20

4. *(a)* What is conductive, convective and radiative heat transfer process ?

(b) How thermal conductivity varies for gas, liquid and solid ?

(c) Calculate heat loss per m^2 of surface area for an insulating wall composed of 25·4*mm* thick fiber insulating board, where inside temperature is 352·7*K* and outside temperature is 297·1*K*. Thermal conductivity of insulating board is 0·048*w/mk*.

9+6+5=20

5. What is log mean temperature difference ? How is it relevant in heat exchanger ?

Milk having $C_{pm} = 2{\cdot}3\,kj/kg\ K$ is being cooled in a double pipe counter current heat exchanger from $371{\cdot}9K$ to $349{\cdot}7K$ and flows inside the tube at a rate of $3630kg/h$. A flow of $1450kg$ water$/h$ enters at $288{\cdot}6K$ for cooling and flows through the outside tube. Calculate the water outlet temperature and heat transfer area if the overall $v_i = 340w/m^2k$.

Area requirement for parallel flow will be more or less ? Why ? Justify. 20

6. Slabs of meat $0{\cdot}0635m$ thick are to be frozen in an air-blast freezer at $244{\cdot}3K$ ($-28{\cdot}9°C$). The meat is initially at the freezing temperature of $270{\cdot}4K$ ($-2{\cdot}8°C$). The meat contains 75% moisture. The heat transfer coefficient is $h = 17{\cdot}0w/m^2K$. The physical properties are $\rho = 1057\,kg/m^3$ for unfrozen meat $K = 1{\cdot}038\ w/mK$ for frozen meat. Calculate the freezing time. 20

7. *(a)* Write Newton's law of viscosity and define all terms.

(b) How viscosity of gas and liquid change with pressure and temperature and why ?

(c) How momentum flux and fluid linear velocity varies with radial distance ?

8+8+4=20