

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular), November, 2016

B. Tech in Chemical Engineering, V Semester

Roll No.....

CHE503: Process Modelling and simulation

Time: 3 hours

Max. Marks: 100

Instructions to students:

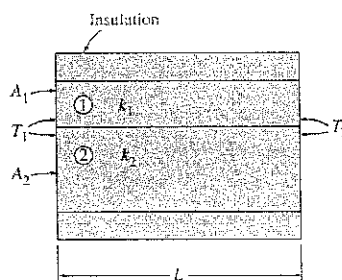
1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A	Objective type multiple choice questions (10 questions @ 1 mark)	10
i.	A lubricant 1000 times more viscous than water would have a viscosity (in Pa-s) (a) 0.01; (b) 0.1; (c) 1; (d) 10	
ii.	The units of resistance to heat transfer are – (a) $\text{J m}^{-2} \text{K}^{-1}$; (b) $\text{J m}^{-1} \text{K}^{-1}$; (c) $\text{W m}^{-2} \text{K}^{-1}$; (d) $\text{W}^{-1} \text{m}^{-2} \text{K}^{-1}$	
iii.	The differential equation – $\frac{d^2 y}{dx^2} + \sin x \frac{dy}{dx} + ye^x = \sinh x$ (a) first order and linear; (b) first order and non-linear; (c) second order and linear; (d) second order and non-linear	
iv.	For a particle settling in water at its terminal settling velocity, which of the following is true? (a) buoyancy = weight + drag; (b) weight = buoyancy + drag; (c) drag = buoyancy + weight; (d) drag = weight	
v.	For an ideal black body (a) absorptivity = 1; (b) reflectivity = 1; (c) emissivity = 0; (d) transmissivity = 1	
vi.	Newton's law of viscosity depends upon the (a) Stress and strain in a fluid, (b) Shear stress, pressure and velocity (c) Shear stress and rate of strain, (d) Viscosity and shear stress	
vii.	The conduction has the units of (a) W/m^2 , (b) W/m , (c) W/(m.K) , (d) $1/\text{K}$	
viii.	If k_s , k_l and k_g are the thermal conductivities of solid, water and air at same temperature, then (a) $k_s > k_l > k_g$, (b) $k_g > k_l > k_s$, (c) $k_s > k_g > k_l$, (d) $k_l > k_s > k_g$	
ix.	Time constant of a mixer is equal to (a) Volume of mixture / volumetric flow rate of solution (b) volumetric flow rate of solution/ volume of mixture (c) volumetric flow rate of solution/ cross sectional area of mixture (d) cross sectional area of mixture/ volumetric flow rate of solution	
x.	Fick's second law of diffusion is (a) $\frac{\partial C_A}{\partial t} = D_{AB} \frac{\partial C_A}{\partial x}$, (b) $\frac{\partial^2 C_A}{\partial t^2} = D_{AB} \frac{\partial C_A}{\partial x}$, (c) $\frac{\partial^2 C_A}{\partial t^2} = D_{AB} \frac{\partial^2 C_A}{\partial x^2}$, (d) $\frac{\partial C_A}{\partial t} = D_{AB} \frac{\partial^2 C_A}{\partial x^2}$	

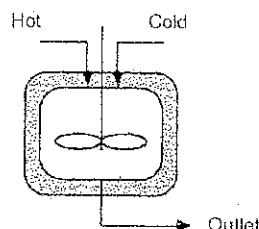
Q.2	Short answer type questions (2 questions @ 5 marks)	10
i.	Define the Reynolds Prandtl, Schmidt, Nusselt and Sherwood's Number and its significance.	
ii.	Explain hydro and thermal fully developed flow.	

Q.3	Derive the design equation for PFR in terms of conversion $V = F_{A0} \int_0^X \frac{dX}{-r_A}$	10
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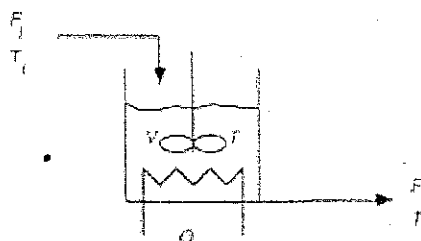
Q.4	Total heat transfer through this combination of materials (state your assumption if needed)	10
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Q.5	Consider a perfectly insulated, well-stirred tank where a hot liquid stream at 60°C is mixed with a cold liquid stream at 10°C (Figure). At what assumption it behave as a lumped parameter model? Explain why.	10
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Q.6A	Consider a perfectly mixed stirred-tank heater, with a single feed stream and a single product stream, as shown in Figure. Assuming that the flow rate and temperature of the inlet stream can vary, that the tank is perfectly insulated, and that the rate of heat added per unit time (Q) can vary, develop a model find the tank temperature as a function of time. State your assumptions.	10
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OR

Q.6A	The differential equation for the variation of the amount of salt X in a tank with time t is given by $\frac{dX}{dt} + \frac{X}{20} = 10$, X is in kg and t is in minutes. Assuming that there is no salt in	10
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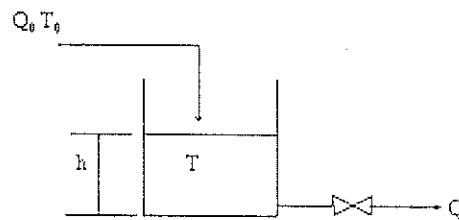
the tank initially, Find the time (in min) at which the amount of salt increases to 100 kg.

- Q.7A** A heated sphere of diameter D is placed in a large amount of stagnant fluid. Consider the heat conduction in the fluid surrounding the sphere in the absence of convection. The thermal conductivity k of the fluid may be considered constant. The temperature at the sphere surface is T_R and the temperature far away from the sphere is T_a . If h is the heat transfer coefficient, then show that the Nusselt number (dimensionless heat transfer coefficient) is given by

$$Nu = \frac{hD}{k} = 2$$

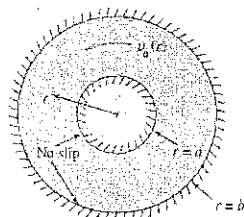
OR

- Q.7B** Water is entering a storage tank at a temperature T_0 and flow rate Q_0 and leaving at a flow rate Q and temperature T . There are negligible heat losses in the tank. L The area of cross section of the tank is AC . Find the model that describes the dynamic variation of water temperature in the tank with time.



- Q.8A** From the Navier-Stokes equations for incompressible flow in polar coordinates (for cylindrical coordinates), find the most general case of purely circulating motion $V_\theta(r), V_r = V_z = 0$, for flow with no slip between two fixed concentric cylinders, as in

Fig.



$$\rho \left(v_r \frac{\partial v_\theta}{\partial r} + \frac{v_\theta}{r} \frac{\partial v_\theta}{\partial \theta} \right) = -\frac{1}{r} \frac{\partial p}{\partial \theta} + \mu \left[\frac{1}{r} \frac{\partial}{\partial r} \left(r \frac{\partial v_\theta}{\partial r} \right) + \frac{1}{r^2} \frac{\partial^2 v_\theta}{\partial \theta^2} - \frac{v_\theta}{r^2} \right]$$

- Q.9A** Express and explain the mathematical modelling of single effect evaporator (both mass and energy balance).

OR

- Q.9B** Express and explain the mathematical modelling of distillation (both mass and energy balance).

