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B.E. CHEMICAL 4TH YEAR DATE:20.01.22

SUBJECT: TRANSPORT PHENOMENA TIME: 60 MIN

Q1. (a) Consider the flow of an incompressible Newtonian fluid between two coaxial cylinders. The surfaces of the inner and outer cylinders are maintained at $T = T_0$ and $T = T_b$, respectively. We can expect that *T* will be a function of *r* alone. As the outer cylinder rotates, each cylindrical shell of fluid "rubs" against an adjacent shell of fluid. This friction between adjacent layers of the fluid produces heat; that is, the mechanical energy is degraded into thermal energy. The volume heat source resulting from this "viscous dissipation," which can be designated by S_v, appears automatically in the shell balance. The velocity distribution is then $v_z = v_b(x/b)$, where $v_b = \Omega R$. (CO2) (4)

(b) You are asked to decide whether the apparent decrease in viscosity in ball-point pen inks during writing results from "shear thinning" (decrease in viscosity because of non-Newtonian effects) or "temperature thinning" (decrease in viscosity because of temperature rise caused by viscous heating). If the temperature rise is less than 1K, then "temperature thinning" will not be important. Estimate the temperature rise and the following estimated data: (CO1) (2.5)

Clearance between ball and holding cavity	$5*10^{-5}$ in.
Diameter of ball	1 mm
Viscosity of ink	10^4 cp
Speed of writing	100 in./min
Thermal conductivity of ink (rough guess)	$5*10^{-4}$ cal/s.cm.^{0}C

Q2. Consider the diffusion system shown in which liquid A is evaporating into gas B. We imagine there is some device that maintains the liquid level at $z= z_1$. Right at the liquid-gas interface, the gas-phase concentration of A, expressed as mole fraction, is x_M. This is taken to be the gas-phase concentration of A corresponding to equilibrium with the liquid at the interface. That is, x_{A1} is the vapor pressure of A divided by the total pressure, provided that A and B form an ideal gas mixture and that the solubility of gas B in liquid A is negligible. A stream of gas mixture A-B of concentration x_{A2} flows slowly past the top of the tube, to maintain the mole fraction of A at x_{A2} for $z=z_2$. The entire system is kept at constant temperature and pressure. Gases A and B are assumed to be ideal by neglecting the term $x_A(N_A + N_B)$. (CO3) (6)

Q3. (a) Show that only one diffusivity is needed to describe the diffusional behaviour of a binary mixture. (CO3) (2)

(b) Estimate D_{AB} for a dilute solution of TNT (2,4,6-trinitrotoluene) in benzene at 20°C, viscosity for pure benzene = 0.705, V_A = 140 cm^3 /g-mole (for TNT) , ψ_B = 1.0 (for benzene. (CO1)