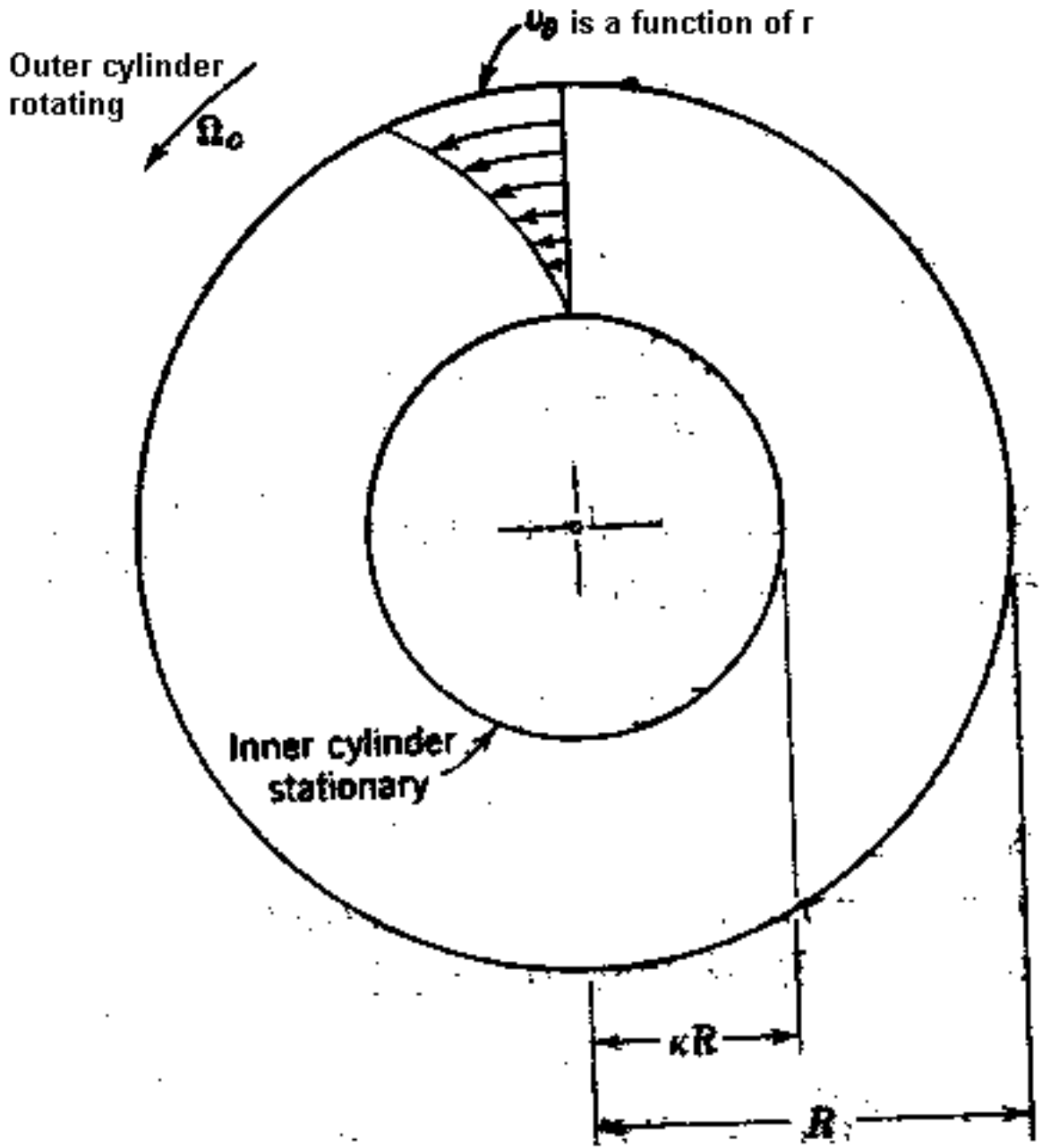
1. Define the fluxes of momentum, mass and heat associated with molecular motion in terms of momentum, mass and heat concentrations. (10%)

2. What are (i) Reynolds number (ii) Schmidt number (iii) Prandtl number
Why use these numbers in describing transport properties? (20%)

3. Determine the velocity and shear stress distributions for the tangential laminar flow of an incompressible fluid between two vertical coaxial cylinders, the outer one of which is rotating with an angular velocity. End effects may be neglected. (20%)



4. If the rate of heat production, due to electrical dissipation, of wire (which cross section is circular and its radius is R) is represented by the uniform heat production by electric dissipation Se, the thermal conductivity by k (which is assumed independent of temperature), the temperature (T) profile at steady state in radial direction of the wire can be expressed in terms of r (radial distance) (30%)

(i) Derived the equation for the temperature (T) profile in terms of r if Se, R, k and To (surface temperature of wire) are given

(ii) Derive the equation to calculate the temperature at the axis of the wire

(iii) Derive the equation for obtaining the average temperature of the wire

5. Cultures of human immunodeficiency viruses (HIV) are to be grown for virus research and testing. HIVs are grown in a liquid medium containing lymphocyte cells serving as the hosts for the viruses. Tightly sealed plastic roller bottles (11 cm diameter x 22 cm high) with 2000ml capacity are filled with 500 ml of split culture and placed on their sides. They are then rolled from side to side at the rate of 1 revolution per minute for a total of 3-4 d incubation time to maintain a thoroughly mixed medium and to keep the cells from the settling. Write a mass balance for oxygen for this system to see whether the oxygen contained in the bottle can be supplied to the cells at an adequate rate. (20%)