This is a 100 min examination with a perfect score of 100%. There are six big problems in total. Please state your question numbers, working steps and calculation methods, and underline your final answers clearly in the answer booklet.

1. (10%) Gas A is diffusing through a straight 8-cm long tube containing Gas B at 25°C and 1.0 atm total pressure. The partial pressure of Gas A at one end of the tube is constant at 85 mm Hg and at the other end is 15 mm Hg. Both ends of the tube open into large mixed chambers at 1.0 atm. The diffusivity of Gas A in Gas B is 0.230 cm^2/sec at 25°C and 1 atm.
(a) (5%) Calculate the flux of Gas A at steady-state, and
(b) (5%) Calculate the flux of Gas B.

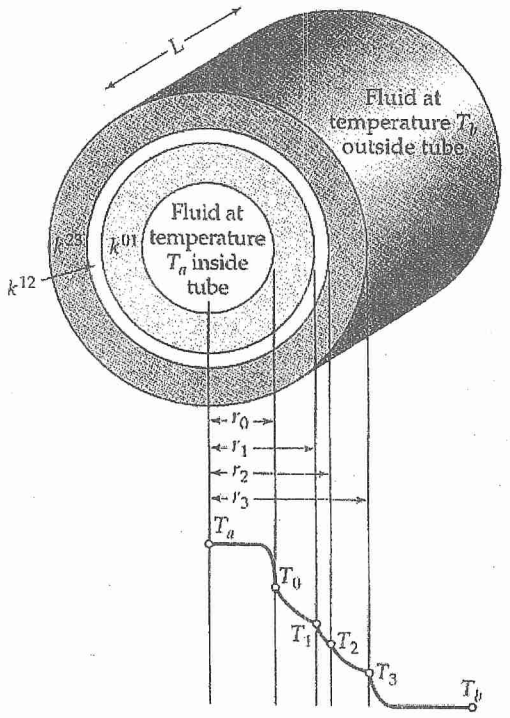
2. (10%) In a continuous distillation column:
(a) (2%) Is the slope of the operating line in the rectifying section larger than the slope of the operating line in the stripping section?
(b) (8%) Please explain this mathematically from the operating line equation point of view.

3. (20%) A sphere with a radius, R_0, is made of sparingly soluble material, 1, so that the sphere's size does not change much with time. However, this material quickly dissolves in the surrounding solvent, so that the solute's concentration at the sphere's surface is saturated, c_1(sat). Because the sphere is immersed in a very large fluid volume, the concentration far from the sphere is zero. Please determine:
(a) (10%) The concentration profile, and
(b) (10%) The dissolution flux at the sphere's surface.

4. (10%) Two large steel plates are 150 mm apart. One of the plates is at 300 ^{0}C, and the other is at 25 ^{0}C. What is the heat transferred between the sheets per unit area? If a third identical steel sheet is inserted in the middle of the two sheets, what is the heat transferred between the sheets per unit area when equilibrium has been reached? Neglect convection effects. Emissivity of steel, ε, is 0.56;
$\sigma = 5.672\times10^{-8}$ W/m^2 K^4. The overall interchange factor between two large parallel plates is

$$\mathcal{F}_{12} = (1/\varepsilon_1 + 1/\varepsilon_2 - 1)^{-1}$$

5. (20%) For heat conduction through composite cylindrical pipe wall shown in the figure, express the overall heat transfer coefficient based on the inner surface U_0 in terms of the thermal conductivity and thickness of each layer, and the individual heat transfer coefficients, h_0 and h_3. Here h_0 is the inside heat transfer coefficient and h_3 is the outside heat transfer coefficient. Please show the derivation.



6. (30%) Amphiphilic molecules are known to self-assemble into structures with long-range order. Of these structures, the bicontinuous phases have attracted considerable attention due to their potential applications in nanotechnology. The bicontinuous structures, in which the amphiphiles and water assemble into separated, continuous networks (or channels), can be regarded as porous matrices. We are interested in understanding the size of the channel of water and are now developing the model and method to measure the property:

(a) (6%) If the channels formed by water can be regarded as tiny pipes with circular cross-section, please exploit the methods of shell balance and equations of change to derive the expression for the mass flow rate (the *Hagen-Poiseuille* equation).

(b) (7%) Nevertheless, the cross-section of the water channel is not actually in a circular shape. Therefore, an equivalent diameter, rather than a circular diameter, must be employed in any further calculation. Assume that the amphiphilic molecules are coarse-grained into rigid objects with a characteristic length, D_p, and the network formed by the amphiphiles is constructed by these objects. Please express the equivalent diameter of the water channels in terms of the sphericity, Φ_s, and characteristic length of the coarse-grained object and the porosity, ε, of the material.

(c) (7%) Based on the results obtained in (a) and (b) and the fact that the correction factor for the tortuosity of the channel is 2.08, please derive the equation for the pressure drop across the water channels, $\frac{\Delta p}{L}$ (the *Kozeny-Carman* equation).

(d) (7%) If the average flow velocity of water approaching the material is 10 nm/s under the pressure gradient of 0.2 bar/nm and the porosity is 0.5 at room temperature, please calculate the size of the water channel (i.e., the equivalent diameter).

(e) (3%) What dimensionless group needs to be maintained constant if a scaled-up mock system is to be constructed to stimulate the flow patterns within the bicontinuous phases?

注意：背面有試題