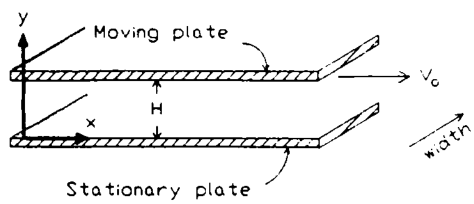
3-1

1. (25 points)
Consider a drag flow (i.e., no pressure variation in the direction of flow) between two horizontal parallel plates separated by a small distance H, with an incompressible Newtonian fluid in the space. One of the plates is moving with a velocity $v_x = V_0$ and the other is stationary. At steady state conditions,
(1) Prove that τ_{yx} is constant across the gap between the plates.
(2) Calculate the velocity profile of the flow.
(3) Find the total volumetric flow rate per unit width.



2. (15 points)
Cake filters separate large amounts of solids from fluid in the form of a filter cake. The thickness of the cake increases in linear proportion to the volume of the filtrate throughout the filtration process causing an increase in the flow resistance. The basic equation for cake filtration can be expressed as:

$$\frac{dV}{dt} = K\frac{\Delta P}{L}$$

where ΔP is the pressure drop across the filter;
V is the volume of the filtrate (i.e., fluid passed through the filter);
L is the thickness of the filter cake;
t is the time;
K is a constant with its value depending on the cross-sectional area of the filter, and the physical properties of the filter and the fluid.

A slurry is filtered at a constant rate of 400 cm^3/min. The following data were obtained:

Pressure Drop (Kg/cm^2)	1.14	2.25	3.25	4.70	5.63	6.75
Total Filtrate (cm^3)	2000	4000	6000	8000	10000	12000

Using the same filter, a constant pressure filtration of 4.2 Kg/cm^2 is carried out for a period of 30 min. What will be the total filtrate collected within this period? Assuming the cake is incompressible and initial flow resistance is negligible.

共三頁

3-2

3. (12 points)

Match the terms in the left column with the proper short definition in the right column. Only one definition is appropriate for each term. (不要抄題，依序寫出配對即可)

(a) Sedimentation	(1) Separating solids according to size
(b) Rotameter	(2) A kind of sieve
(c) Manometer	(3) Carries out sedimentation continuously
(d) Leaching	(4) Indicates pressure
(e) Size classification	(5) Separates solid from gas using a water spray
(f) Cyclone separator	(6) Variable-area flowmeter
(g) Extraction	(7) Particles settle by gravity
(h) Thermometer	(8) Works by expansion of liquid in a tube
(i) Gas scrubber	(9) Swirls a gas to separate solids from it
(j) Screen	(10) Uses centrifugal force to separate materials
(k)Thickener	(11)Separates two miscible liquid by using solvent
(l) Centrifuge	(12)Dissolves soluble matter from solid mixture

4. (28 points)

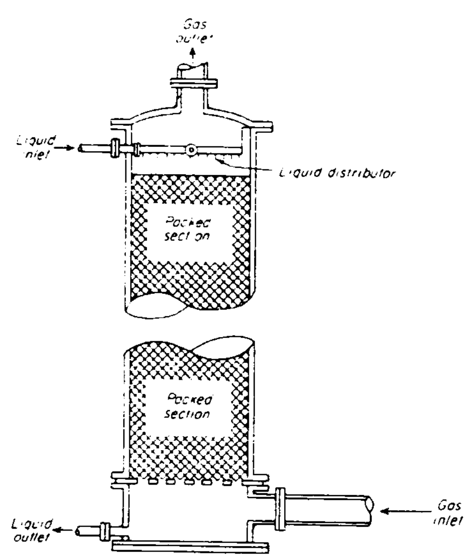
Water (10^5 mol/h) containing 6 ppm of toxic component A (molecular weight 120) is to be purified by stripping with air at 20°C. The product must contain less than 6 ppb of A in water to meet emission standard. This desorption process is carried out in a packed tower as shown in the figure. The operating pressure is 1 atm. The equilibrium data follow Henry's law and the Henry's law constant for A in water at 20°C is 410 atm/(mole fraction).

(a) Obtain the operating-line equation and the equation for column height Z_T

(b) Is $1/K_x \cong 1/k_x$? why.

(c) Calculate the minimum molal flow rate of air (V_{min}) and the number of transfer units(N_{OX}) if the air molal flow rate is 5 times the minimum value. Where N_{OX} is the number of transfer units based on overall driving force in the liquid phase.

(Hint: Is L constant ?)



5. (20 points)

A spherical drop of water, originally 2.0 mm in diameter, fall in quiet, dry air at 50 °C. The velocity of the drop is kept at 3.6 m/s. It was found that natural convection effects are negligible and the mass-transfer coefficient can be evaluated by the following equation:

$$\mathrm{Sh} = 2.0 - 0.552\, \mathrm{Re}^{1/2}\, \mathrm{Sc}^{1/3}$$

where Sh denotes Sherwood number. In some textbooks, it is referred to as the mass-transfer Nusselt number, Nu_{AB}. The gas diffusivity for water vapor in air at 50 °C is 2.7×10^{-5} m²/s. The density and the viscosity of the gas mixture are 1.14 kg/m³ and 1.91×10^{-5} kg/m s, respectively. The vapor pressure of water at 50 °C is 2.33×10^{3} Pa.

(a) Estimate the time that is required to reduce volume of the water drop by 20%.

(b) In the equation for Sherwood number, what represents the value of 2.

(c) Estimate the time that is required to reduce volume of the water drop by 20%, if the water drop is stationary in the air.

(Note: You may use an average mass-transfer coefficient.)