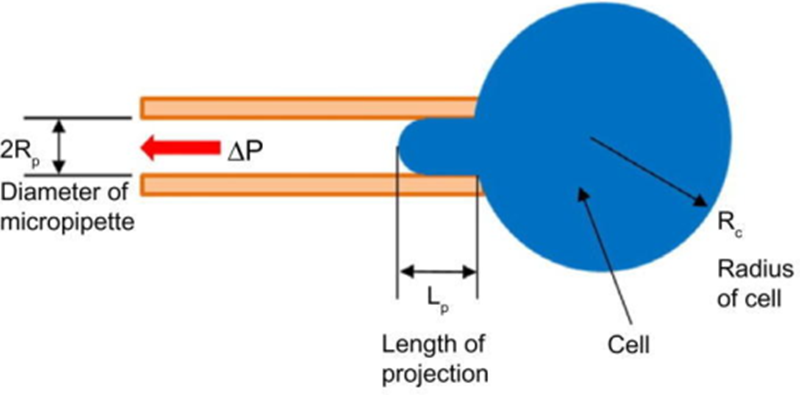
**Homework 1**

1. One method of measuring the cytoplasmic viscosity of cells is to aspirate a portion of the cell into a long micropipette with radius *Rp*, and by looking at the time rate of change of the cell projection length *Lp* (i.e., looking at ) in the micropipette. This length of change depends on the pressure drop across the cell (DP), the micropipette radius (*Rp*), the viscosity of the cell cytoplasm (*mc*), and the radius of the cell (*Rc*). Using the Buckingham Pi theorem determine dimensionless groups that are involved. *(There are multiple acceptable solutions for this problem; all correct solutions will be accepted.)* ***(Ans: you should have at least 2 dimensionless groups; it is recommended that you use DP, Rp, and mc as your basis subset)***

****

**Ans:**

Variables:

; ; ; ;

, ; . There are 2 groups that can be formed.

First, we select a subset of dimensional parameters that include all 3 dimensions. We use

For the first group, we will pair the subset with the rate of change of cell projection length

The product must give us a dimensionless number

So, the first group is

For the second group, we combine the subset with

So, the second group is

Using the two dimensionless numbers, we can conclude that some relationship occurs among the values such as

1. The rate at which metallic ions are electroplated from a dilute electrolytic solution onto a rotating disk electrode is governed by the mass diffusion rate of ions in the disk. You have identified six variables that may control the process: mass transfer coefficient *k* (has SI units of m/s), diffusion coefficient *Dij* (has SI units of m2/s), disk diameter *d*, angular velocity *w* (has units of rad/s), fluid density *r*, and the fluid dynamic viscosity *m*. Determine the dimensionless numbers that can be formed using these variables. Hints: use the disk diameter, fluid density, and angular velocity as your repeating parameter; radians is not considered a unit. **(Ans: one of your answers should be a modified form of the Reynolds number that uses the tangential velocity d\*w instead of V.)**

**Ans:**

Variables:

groups can be formed.

We select as the repeating parameters.

Starting with mass transfer coefficient k

The first group,

For the second group we combine the subset with

The second group,

For the third group we combine the subset with

The third group,

1. In a hollow fiber hemodialyzer, blood flows from an artery through the insides of a bundle of cellulose acetate fibers, and a dialyzing fluid (consisting of water and a few dissolved salts) flows on the outside of the fibers. Water and waste products, such as urea, pass through the walls of the fibers, and the slightly purified blood returns to a vein. Consider a patient who is experiencing kidney failure that is connected to such a device. Blood enters from the arterial side at a flow rate of 200 mL/min with a urea concentration of 2.1 mg/mL. Blood returns to the vein at a flow rate of 195 mL/min with a urea concentration of 1.2 mg/mL. Assume the dialyzing fluid enters the hemodialyzer at a flow rate of 1500 mL/min (with no urea initially present). Assume that the dialyzing fluid and the plasma have the same density (assume it is comparable to water). Determine the (**A**) the rate of urea removal, and **(B)** the concentration of urea in the dialysate leaving the hemodialyzer. If a patient has 5 L of blood and we want to drop the urea concentration from 2.7 mg/mL to 1.1 mg/mL, **(C)** determine the time the patient must be dialyzed if the same dialysis machine is used (hint: use your answer from part A). Assume the total blood volume does not change. **(Ans: A = 186 mg/min)**

**Ans:**

Rate of removal is

Urea to remove is

Required time is

1. Drug D has a maximum solubility of 3.2 g D per 100 g of water at 75oC. At 4oC, the solubility decreases to 0.44 g D per 100 g of water. (**A**) Determine the amount of water present if you initially have a saturated drug solution (i.e., the maximum amount of drug is dissolved in the solvent) at 75oC with 800 g of drug in it. Assume this drug solution is cooled to 4oC where some of the drug will form a solid precipitate. The solution is passed through a separator that removes solid precipitate. (**B**) Determine the mass of solid drug precipitate that was obtained, and (**C**) the percent of drug D that was recovered from the initial solution. **(Ans: C = 86.25%)**

**Ans:**

At 75oC

3.2g is dissolved per 100 g of water

800 g is dissolved per of water

At 4oC

100g of water stores 0.44g drug

25000 g of water stores of drug

Solid mass

Recovered percentage

1. Two different solutions, A and B, are separated by a semipermeable membrane. Assume the membrane has a MWCO (molecular-weight cut-off) of 100,000 Da (Dalton which is the mass of one molecule and is numerically equivalent to the molecular weight, g/mol). Any molecules with a molecular weight below the MWCO will pass through; anything larger will not. Solution A consists of albumin (80 g/L; MW=69,000 g/mol) and fibrinogen (40 g/L; MW=340,000 g/mol). Solution B consists of albumin (10 g/L), globulins (50 g/L; MW=150,000), and fibrinogen (20 g/L). Assume the solvents for both solutions are water. If the hydrodynamic pressure of solution A is 700 mmHg, **(A)** determine the hydrodynamic pressure of solution B so that there is a net-zero flow of water across the membrane. **(B)** If the membrane MWCO is lowered to 50 kDa, determine the hydrodynamic pressure of solution B to maintain a net-zero flow of water across the membrane (assume the hydrodynamic pressure of A is still the same). Assume for both cases that the temperature of the entire system is at 37oC. **(Ans: A=705.3 mmHg)**

**Ans:**

Albumin can pass through the membrane, and doesn’t contribute to osmotic pressure.

For 50 kDa

1. At 50oC, liquid A has a vapor pressure of 268 mmHg. At 50oC, liquid B has a vapor pressure of 236.2 mmHg. For a liquid at 50oC composed of A and B, with A having a mole fraction of 0.25, determine **(A)** the vapor pressure of the mixture at 50oC and **(B)** the composition of a vapor bubble in equilibrium with the liquid at 50oC (hint: the pressure found in part A would be the pressure of the vapor). **(Ans: yA = 0.274)**

**Ans:**

Using Rault’s law,

For chemical composition of bubble