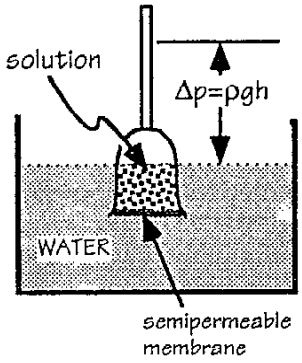
MCB 136 Spring 1993
First Mid-term Exam

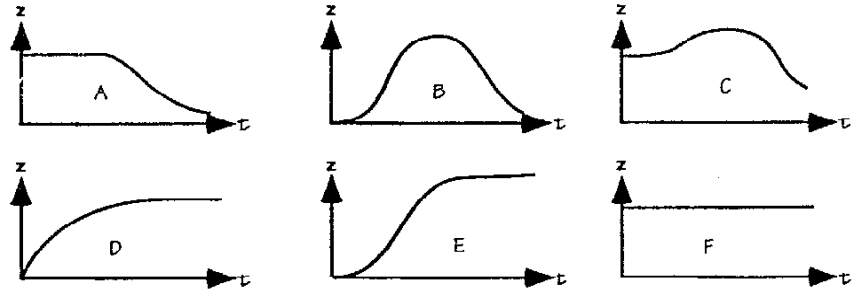
Name _____

| Formulas & units: | These values may be used in calculations: |
|---|---|
| erg = dyne·cm | 2.3 RT·F$^{-1}$·log 10 ≈ 60 mV (RT·F$^{-1}$·ln 10 ≈ 60 mV) |
| dyne = g·cm·sec$^{-2}$ | RT ≈ 2.5·10$^{10}$ erg·mol$^{-1}$ |
| $x^2 = 2\,D\,t$ | R = 8.3 joule·mol$^{-1}$·K$^{-1}$ = 8.3·10$^{7}$ erg·mol$^{-1}$·K$^{-1}$ |
| $J_{net} = P \cdot A \cdot \Delta c$ | F = 9.65·10$^{4}$ coulomb·mol$^{-1}$ |
| $\Delta\Pi = RT\,\phi\,i\,\Delta c$ | log 2 = 0.30 |
| $\Delta P = \rho\, g\, h$ | $g$ = 980 cm·sec$^{-2}$ |

A. Computations and Short Answer




1. A thistle tube is filled with 0.1L of water and placed in a large pan of water so that the liquid levels are equal. The opening of the thistle is covered with a semipermeable membrane that has a very small hole in it. At time = 0 an amount of NaCl is dropped into the top of the tube that will bring the solution to a 1 mM concentration, and the height of the water, z, is recorded as a function of time.
a. Which of the 6 alternatives below do you think the curve will look like? Why?




b. If the hole were not there, how high would the solution in the tube rise above the surrounding water level when equilibrium is reached? [Use RT = 2.5 x 10$^{10}$ erg/mol, $\phi$ = 1, and $g$ = 980 cm/sec$^2$].

Name _____

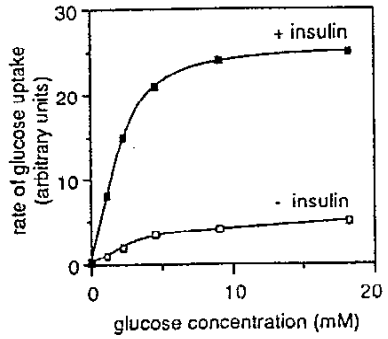
2. It takes a 1.5 nm sphere 0.05 sec to diffuse across a cell 1 μm in diameter.
(a) Calculate its diffusion coefficient by the Einstein relation.

(b) Diffusion coefficients generally scale as 1/size. How long will it take a 15 nm sphere to diffuse the same distance?

(c) How long will it take the 15 nm sphere to diffuse across a cell that is 10 μm in diameter?

3. Insulin is a small protein hormone that binds to a receptor in the plasma membrane of fat cells, dramatically increasing the rate of glucose uptake into the cells. The increase occurs within minutes and is not blocked by inhibitors of protein synthesis. The two experiments described below suggest a possible mechanism for the insulin effect. In the first experiment, the initial rate of glucose uptake in control and insulin-treated cells was measured with the results shown. In the second experiment, the concentration of glucose transporter in the fractionated membranes from control and insulin-treated cells was measured using the binding of radioactive cytochalasin B as the assay, as shown in the table.

Expt. 1. Rate of glocose uptake into fat cells in the presence and absence of insulin




Expt. 2. Amount of glucose transporter associated with plasma membranes and internal membranes of fat cells in the presence and absence of insulin

| | Bound $^3$H-Cytochalasin B (cpm/mg vesicle protein) | |
|---|---|---|
| Membrane Fraction | Untreated Cells (− Insulin) | Treated Cells (+ Insulin) |
| Plasma membrane | 890 | 4480 |
| Internal membranes | 4070 | 480 |

a. Deduce the mechanism by which glucose transport is increased in insulin-treated cells.

b. Transport processes, like enzyme reactions, can be characterized by the kinetic parameters $K_m$ and $J_{max}$. Does insulin alter either of these kinetic properties of glucose uptake by the cells? How can you tell from the data?

Name _____

4. In a particular postsynaptic neuron, the resting membrane potential is - 60mV. Concentrations of various ions are listed below.

| Ion | Concentration inside | Concentration outside |
|---|---|---|
| $K^+$ | 140 mM | 7 mM |
| $Na^+$ | 15 mM | 150 mM |
| $Cl^-$ | 11 mM | 110 mM |

a. Calculate the equilibrium potentials of $Na^+$, $K^+$, and $Cl^-$.

b. This cell may be stimulated to trigger its own action potentials depending on the nature of many incoming signals. Some of the presynaptic terminals making contact with this cell liberate a neuro-transmitter that causes a *specific* increase in $Cl^-$ permeability of the post-synaptic membrane. Will this transmitter depolarize or hyperpolarize the post-synaptic membrane?

c. Do you think the transmitter is likely to function as an excitatory or inhibitory transmitter?

(Explain your answers.)

Name _____

II. True or False (Indicate T or F)

_____ 1. For an action potential to be initiated, the rapidly increasing $Na^+$ conductance must become greater than the slowly increasing $K^+$ conductance.

_____ 2. Immediately after an action potential, the membrane is relatively unresponsive to another stimulus because the $K^+$ conductance is greater than in the resting state **and** more $Na^+$ *slow* gates are closed than in the resting state.

_____ 3. During the hyperpolarization ("undershoot") stage following the action potential peak, the driving force for $K^+$ is reversed and a slight inward $K^+$ flux then moves the membrane potential up toward the resting potential.

_____ 4. The end-plate potential (EPP) at the neuromuscular junction lasts longer than the depolarization phase of the action potential, because inactivation of the ion channel depends on diffusion of acetylcholine out of the synaptic cleft.

_____ 5. A high enough concentration of the proper substrate for a membrane transport protein can overcome the inhibitory effect of a competitive inhibitor.

III. Multiple Choice (Circle the most appropriate answer)

1. ATP supplies energy for the Na pump by phosphorylating the H,K-ATPase on an aspartate residue in the presence of _____ (G, G-proteins; Na, sodium); the aspartyl-phosphate becomes dephosphorylated in the presence of _____ (P, phosphodiesterase; Na, sodium; K, potassium).

a. G, Na
b. G, P
c. G, K
d. Na, K
e. Na, P
f. Na, Na

2. The P-type ATPases are a family of _____ (I, intrinsic; E, extrinsic) membrane proteins that are involved in the tranport of _____ (C, cations; NaG, Na and glucose), all of which are inhibited by _____ ($VO_4$, vanadate; Ou, ouabain).

a. I, NaG, $VO_4$
b. I, C, $VO_4$
c. I, C, Ou
d. I, NaG, Ou
e. E, C, $VO_4$
f. E, NaG, Ou

3. The plasma membrane of a liver cell, that has a measured surface area of 800 $\mu m^2$, would have enough _____ (PL, phospholipid; Pr, protein) to form a monolayer of _____ $\mu m^2$ (400; 800; 1600).

a. PL, 400
b. PL, 800
c. PL, 1600
d. Pr, 400
e. Pr, 800
f. Pr, 1600

4. Intrinsic membrane proteins are held within a membrane by _____ (CV, covalent; NC, non-covalent) bonding associations with the lipid bilayer, and can be removed by _____ (Sal, high salt; DT, detergent; SH, strong reducing agents).

a. CV, Sal
b. CV, DT
c. CV, SH
d. NC, Sal
e. NC, DT
f. NC, SH

5. Cyclic AMP activates cAMP-dependent _____ (AC, adenylate cyclase; PKA, protein kinase A) by binding to its _____ (G, G-protein; R, regulatory subunits; C, catalytic subunits).

a. AC, G
b. PKA, G
c. AC, R
d. PKA, R
e. AC, C
f. PKA, C

Name _____

6. Compared to an unmyelinated axon, a myelinated axon has _____(I, increased; S, the same; D, decreased) average membrane capacitance and _____(I, S, D) average resistance to transmembrane ion flux.

a. I, I
b. D, D
c. D, I
d. I, S
e. I, D
f. D, S

IV. Predict Changes and Relationships

1. Would you predict that the following agents cause an increase _I_, decrease _D_, or no change _0_ in the level of cyclic AMP (cAMP) in cardiac muscle cells in culture.

____ An inhibtor of phosphodiesterase

____ Depletion of cellular ATP

____ Depletion of cellular GTP

____ Cholera toxin

____ Activation of $G_i$-protein

____ Inactivation of $G_s$-protein

2. Intestinal brush-border vesicles containing the Na/glucose co-transporter, prepared in media low in $Na^+$, were tested for glucose uptake in these three external media: A) 0.1 M NaCl, B) 0.1 M NaSCN, and C) 0.1 M KSCN, all with 1 mM radiolabeled glucose. Samples were removed every 30 seconds for determination of vesicular glucose content. Given that the vesicular membranes are much more permeable to $SCN^-$ than to $Cl^-$, rank the three tests, using the symbols >, <, and = (e.g., "A > B = C"), in terms of the following results:

Initial rate of glucose uptake _____

Maximum glucose content _____

Glucose content at equilibrium _____

3. Select from the following choices in answering questions 1 - 6. (Each answer may be used more than once or not at all. Use the letters, a – e.)

a. ATP b. ADP & $P_i$ c. ADP d. $P_i$ e. No ATP or $P_i$

According to the Huxley model of actin-myosin interaction in skeletal muscle contraction:

Weak binding of myosin to actin occurs when _____ is (are) bound to myosin.

After the ~11nm "power" stroke, actin is released when _____ bind(s) to myosin.

Myosin binds actin most strongly when _____ is (are) bound to myosin.

The shift from weak to strong actin-myosin binding occurs as myosin releases _____.

The "power" stroke occurs when _____ is (are) released from myosin.