Midterm #1 Solutions

① A) $\Pi = g C \sigma R T$

$g_{K^+} = 2 \quad g_{SO_4^{2-}} = 1$

$\sigma_{K^+} = 0.2 \quad \sigma_{SO_4^{2-}} = 0.5$

$\Pi_A = g_{K^+} C_A \sigma_{K^+} RT + g_{SO_4^{2-}} C_B \sigma_{SO_4^{2-}} RT$

$\Pi_A = 2.2 \text{ atm}$ hypertonic

$\Pi_B = 0.44 \text{ atm}$ hyperosmotic

$\Delta\Pi = \Pi_A - \Pi_B = \boxed{1.76 \text{ atm}}$ flow into vesicle

$\text{Force} = \Pi \cdot A$

$\text{Area} = 2\pi rh + 2\pi r^2 = 3.77 \times 10^{-13} \text{ m}^2$

$\text{Force} = 1.76 \text{ atm} \cdot 3.77 \times 10^{-13} \text{ m}^2 = \boxed{6.64 \times 10^{-13} \text{ atm} \cdot \text{m}^2} \approx 6.8 \times 10^{-8} \text{ N}$

B) $J = PA\Delta C$

$\Delta C = 100 \frac{\text{mmol}}{\text{L}}$

$P = \frac{KD}{\Delta x}$

$D = \frac{k_B T}{6\pi r \eta} = 5.195 \times 10^{-10} \frac{\text{m}^2}{\text{s}}$

$P = 0.08312 \frac{\text{m}}{\text{s}}$

$A = 3.77 \times 10^{-13} \text{ m}^2$ (from part A)

$J = 0.08312 \frac{\text{m}}{\text{s}} \cdot 3.77 \times 10^{-13} \text{ m}^2 \cdot 100 \frac{\text{mmol}}{\text{L}} \cdot \frac{1000 \text{L}}{1 \text{m}^3} = \boxed{3.13 \times 10^{-9} \frac{\text{mol}}{\text{s}}}$

(2) A) @ 37°C $E_{eq} = \frac{-60mV}{z} \log_{10}\left(\frac{[C_i]}{[C_e]}\right)$

$E_{Na^+} = \frac{-60mV}{+1} \log_{10}\left(\frac{25}{140}\right) = \boxed{44.89mV}$

$E_{K^+} = \frac{-60mV}{+1} \log_{10}\left(\frac{50}{4}\right) = \boxed{-65.81mV}$

$E_{Cl^-} = \frac{-60mV}{-1} \log_{10}\left(\frac{20}{105}\right) = \boxed{-43.21mV}$

$E_{Ca^+} = \frac{-60mV}{+2} \log_{10}\left(\frac{0.001}{3}\right) = \boxed{104.31mV}$

B) $E_m = \frac{g_1}{g_T}E_1 + \frac{g_2}{g_T}E_2 + \ldots + \frac{g_N}{g_T}E_N$

$g_T = 10+6+3+1 = 20$

$E_m = \frac{10 \cdot 44.89mV - 6 \cdot 65.81mV - 3 \cdot 43.21mV + 1 \cdot 104.31mV}{20}$

$\boxed{E_m = 1.436mV}$

C) $I_1 = g_1(E_m - E_{eq,1})$

$\frac{I_{Na^+}}{I_{K^+}} = \frac{10(44.89mV)}{6(-65.81mV)} = \boxed{-1.137}$

(3) A) $EF = \frac{SV}{LVEDV} \Rightarrow SV = EF \cdot LVEDV = 0.6 \cdot 150mL$

$\boxed{SV = 90mL}$

$CO = SV \cdot HR = 90\frac{mL}{beat} \cdot 80\frac{beat}{min} = \boxed{7.2\frac{L}{min}}$

$MW = \Delta P \cdot CO = 150mmHg \cdot 7.2\frac{L}{min} = \boxed{1080\frac{mmHg \cdot L}{min}}$

B) $\frac{\Delta P}{L} = \frac{8\eta}{\pi r^4} Q$

$\eta = 4 \times 10^{-3}\ Pa \cdot s$

$r = 0.015m$

$Q = 7.2\frac{L}{min} \cdot \frac{1m^3}{1000L} \cdot \frac{1min}{60s} = 1.2 \times 10^{-4}\frac{m^3}{s}$

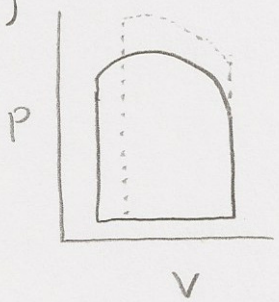
$\frac{\Delta P}{L} = \frac{8 \cdot 4 \times 10^{-3} Pa \cdot s \cdot 1.2 \times 10^{-4}\frac{m^3}{s} \cdot 0.4}{\pi \cdot (0.015m)^4} = \boxed{9.657\frac{Pa}{m}}$

C) $Q = \frac{\Delta P \pi r^4}{L 8\eta}$

largest → 81 : 16 : 1 ← smallest

$Q \propto r^4$ so $Q_3 = 3^4 = 81$, $Q_2 = 2^4 = 16$, $Q_1 = 1^4 = 1$

D)



↑resistance ⇒ need greater pressure to eject and lower volume ejected due to resistance.

E) $P = \frac{2HT}{r} \Rightarrow T = \frac{P \cdot r}{2H} = \frac{150mmHg \cdot 0.05m}{2 \cdot 0.01m} = \boxed{375mmHg}$

(4) A) At rest $\frac{dV_m}{dt} = 0$

$$0 = \frac{1}{\tau}\left[g_{Na^+}E_{Na^+} - g_{Na^+}V_m + g_{K^+}E_{K^+} - g_{K^+}V_m\right]$$

$$V_m = \frac{g_{Na}E_{Na} + g_K E_K}{g_{Na} + g_K} = \boxed{-64.21\,mV}$$

B) $V(l) = (50\,mV)\,e^{l/\lambda}$

$l = 10\,mm$

$\lambda = 20\,mm$

$$V(10mm) = (50\,mV)\,e^{10/20} = \boxed{30.33\,mV}$$

C) Neuronal action potentials have no opposing Ca^{2+} current.

(5) A) $J_v = K_f\left[(P_c - P_i) - (\tilde{\pi}_c - \tilde{\pi}_i)\right]$

$$\tilde{\pi}_i = -\left[(P_c - P_i) - \tilde{\pi}_c - \frac{J_v}{K_f}\right] = \boxed{1\,mm\,Hg}$$

B) Increase in oncotic pressure due to loss of fluid.

C) ① ↓ protein => ↓ $\tilde{\pi}_c$ => ↑ Flow out

② ↑ permiability => ↑ K_f => ↑ Flow out

③ heart failure => ↑ P_c => ↑ Flow out

(6) A) Frank-Starling principle states that if LVEDV is increased (1L Saline), preload is increased and so CO is increased.

B) Diuretics - ↓ blood volume - decrease preload

ACE inhibitors - block Ang I to Ang II - decrease afterload

Digoxin - Inhibition of Na^+/K^+ ATPase pump - increase contractility

C) Contractility is correlated to intracellular Ca^{2+} concentration. If Ca^{2+} can not be pumped out of cell, relaxation does not occur and there is greater contractility.

D) Purkinje Fibers, Atrial internodal tracts, AV node

E) Increased - Positive staircase effect

F) Carotid Sinus - Short Term - Neurogenic

Kidneys - Long Term - Hormonal → Renin