Problem 4

(a) Activated state is more favorable since the Gibbs' free energy at the activated state is lower than the not activated state; Therefore, it take less energy for the gate to go to the activated state from the not activated state than to go from the activated state to the not activated state. $V_m = 0$

In a biological membrane, when the cell is depolarized the potassium ions tends flow outside the membrane, to counteract with the unbalanced state. Therefore more potassium gates tend to open.

(b) $\text{state1} = \Delta G - ZFV - G_c$

$\text{State2} = \Delta G + (1-\lambda) ZFV$

$$\alpha_n = \frac{kT}{h} \exp\left(-\frac{\text{state1}}{RT}\right) = \frac{kT}{h} \exp\left(-\frac{\Delta G}{RT}\right) \exp\left(\frac{ZFV}{RT}\right) \exp\left(\frac{G_c}{RT}\right)$$

$$\beta_n = \frac{kT}{h} \exp\left(-\frac{\text{state2}}{RT}\right) = \frac{kT}{h} \exp\left(-\frac{\Delta G}{RT}\right) \exp\left(\frac{(\lambda-1)ZFV}{RT}\right)$$

$$\frac{\partial n}{\partial t} = (1-n)\alpha_n - n\beta_n =$$

$$\frac{\partial n}{\partial t} = (1-n) \frac{kT}{h} \exp\left(-\frac{\Delta G}{RT}\right) \exp\left(\frac{ZFV}{RT}\right) \exp\left(\frac{G_c}{RT}\right) - n \frac{kT}{h} \exp\left(-\frac{\Delta G}{RT}\right) \exp\left(\frac{(\lambda-1)ZFV}{RT}\right).$$

$$= \frac{KT}{h} \exp\left(-\frac{\Delta G - G_c}{RT}\right) \exp(\lambda Z V) \left[1 - n\left(1 + \exp\left(-ZV - \frac{G_c}{RT}\right)\right)\right]$$

$$y = \boxed{\frac{KT}{h} \exp\left(-\frac{\Delta G - G_c}{RT}\right)} \qquad -ZV - \frac{G_c}{RT} = -Z(V + V_n) \quad V_n = \boxed{-\frac{G_c}{ZRT}}$$

(c). $\frac{\partial n}{\partial t} = 0$ at steady state.

$$(1-n)\alpha_n = n\beta_n$$

$$n_\infty = \frac{\alpha_n}{\alpha_n + \beta_n} \Rightarrow n_\infty =$$

$$\alpha_n = \gamma \exp(\lambda z V).$$

$$\beta_n = \gamma \exp((\lambda - 1) z V - z V_n).$$

$$n_\infty = \frac{1}{1 + \exp(-z(V + V_n))}$$

$$\boxed{\frac{\partial n}{\partial t} = \frac{n_\infty - n}{\tau_\infty}}$$

$$\tau_n = \frac{1}{\alpha_n + \beta_n}.$$

$$\therefore \tau_n = \boxed{\frac{1}{\gamma \exp(\lambda z V)[1 + \exp[z(V + V_n)]]}}.$$