

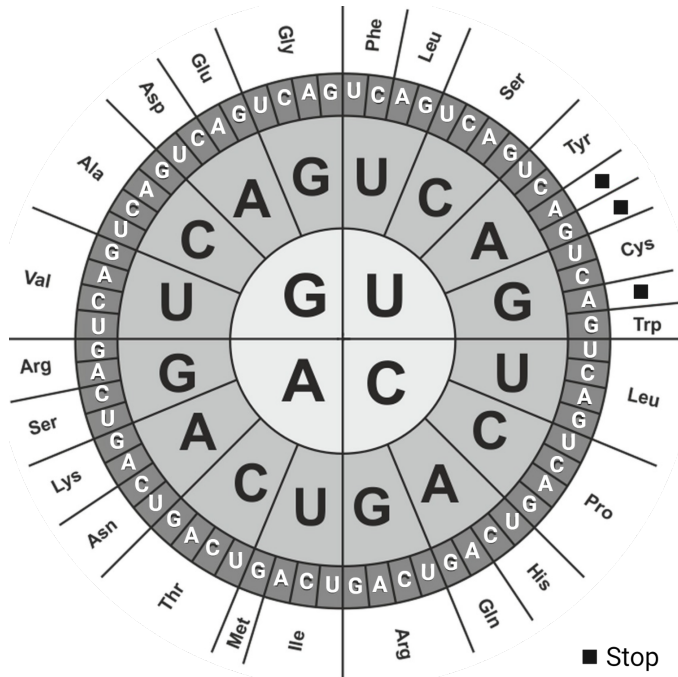
MIE205H W2024

Fundamentals of Biomedical Engineering

QUIZ # 1 EXAMINATION

February 27, 2024

Equations and Codon Chart



$$V_m = 61 \log \frac{P_{K^+}[K^+_{out}] + P_{Na^+}[Na^+_{out}] + P_{Cl^-}[Cl^-_{in}]}{P_{K^+}[K^+_{in}] + P_{Na^+}[Na^+_{in}] + P_{Cl^-}[Cl^-_{out}]}$$

Where: V_m is the membrane potential in mV; $P_{K^+} = 1$; $P_{Na^+} = 0.04$; $P_{Cl^-} = 0.3$; and ions in [] are the respective concentrations

$$E_x = \frac{61}{Z} \log \frac{[X_{out}]}{[X_{in}]}$$

Where: E_x is the Nernst potential in mV; Z = ion valence; and $[X]$ is concentration

$$\Delta G_{Chem} = RT \ln \frac{[X_{out}]}{[X_{in}]}$$

Where: ΔG_{Chem} is the free energy available from the chemical gradient, defined from inside the cell to outside; $R = 8.314 \text{ J/mol K}$; T is taken to be 309.65 K ; and $[X]$ is the concentration

$$\Delta G_{Elec} = ZFV_m$$

Where: ΔG_{Elec} is the free energy available from an electrical potential inside a cell with respect to the outside; V_m is the membrane potential in V; Z = ion charge; and $F = 96485 \text{ C/mol}$

Section 1: Multiple Choice (15 points)

Indicate the answer choice that best completes the statement or best answers the question.

1. In homeostasis, the efferent neurons
 - a. Carry signals from receptors to the brain
 - b. Sense changes in the environment in relation to a set point
 - c. Carry signals from the brain to the effector
 - d. Are cells or proteins which sense & transmit signal
 - e. None of the above

2. The dendrites of a neuron are responsible for
 - a. Transmitting signals away from the neuron cell body (soma)
 - b. Generating ATP for the neuron
 - c. Conducting action potentials down the axons and rapid speeds
 - d. Receiving and integrating incoming signals
 - e. None of the above

3. Which ion's influx is primarily responsible for the depolarization phase of an action potential?
 - a. Calcium
 - b. Chlorine
 - c. Potassium
 - d. Magnesium
 - e. Sodium

4. What triggers an action potential in neurons?
 - a. A decrease in the membrane potential beyond a certain threshold
 - b. An increase in the membrane potential beyond a certain threshold
 - c. The presence of neurotransmitters in the synapse
 - d. The absorption of light by photoreceptors
 - e. The binding of antigens to cell surface receptors

5. What does the resting membrane potential refer to?
 - a. The energy stored in the nuclear membrane in its resting state
 - b. The difference in electrical charge across the cell membrane in its resting state
 - c. The potential energy of the mitochondrial membrane in its resting state
 - d. The potential movement of proteins across the cell membrane in its resting state
 - e. The voltage across the cell membrane during protein synthesis in its resting state

6. What is the role of mRNA in protein synthesis?
- Carries amino acids to the ribosome
 - Serves as the template for DNA replication
 - Stores and carries genetic code sequence from DNA to the ribosome
 - Forms the structure of ribosomes
 - Activates enzyme reactions
7. What is the role of tRNA in protein synthesis?
- Carries amino acids to the ribosome
 - Serves as the template for DNA replication
 - Stores and carries genetic code sequence from DNA to the ribosome
 - Forms the structure of ribosomes
 - Activates enzyme reactions
8. How do voltage-gated ion channels contribute to the propagation of action potentials?
- By pumping ions against their concentration gradients
 - By creating a physical barrier between neurons
 - By activating neurotransmitter release
 - By opening in response to changes in membrane potential to allow ion flow
 - By synthesizing proteins in response to electrical signals
9. Electrical potentials transmitted across chemical synapses may demonstrate gain or attenuation. This is possible because:
- Ions transmitted directly from the presynaptic neuron to the postsynaptic neuron can increase or decrease their charge when moving through connexons
 - Chemical synapses create potentials by an influx of extracellular ions into the postsynaptic cell, the volume of which may exceed or be less than the potential observed in the presynaptic cell
 - As ions are transmitted from the presynaptic neuron to the postsynaptic neuron through the ligand gated channels, extracellular ions may leak into the cells or intracellular ions may leak out of the cells due to the high permeability of these ion channels
 - Adjacent glial cells can act as signal modulators to increase or decrease signal amplitude across the synapse
 - This is incorrect. Electrical potentials transmitted across chemical synapses cannot exhibit gain.
10. Which process involves the reading of mRNA to build amino acid chains?
- DNA replication
 - DNA transcription
 - RNA translation
 - Protein folding
 - Lipid synthesis

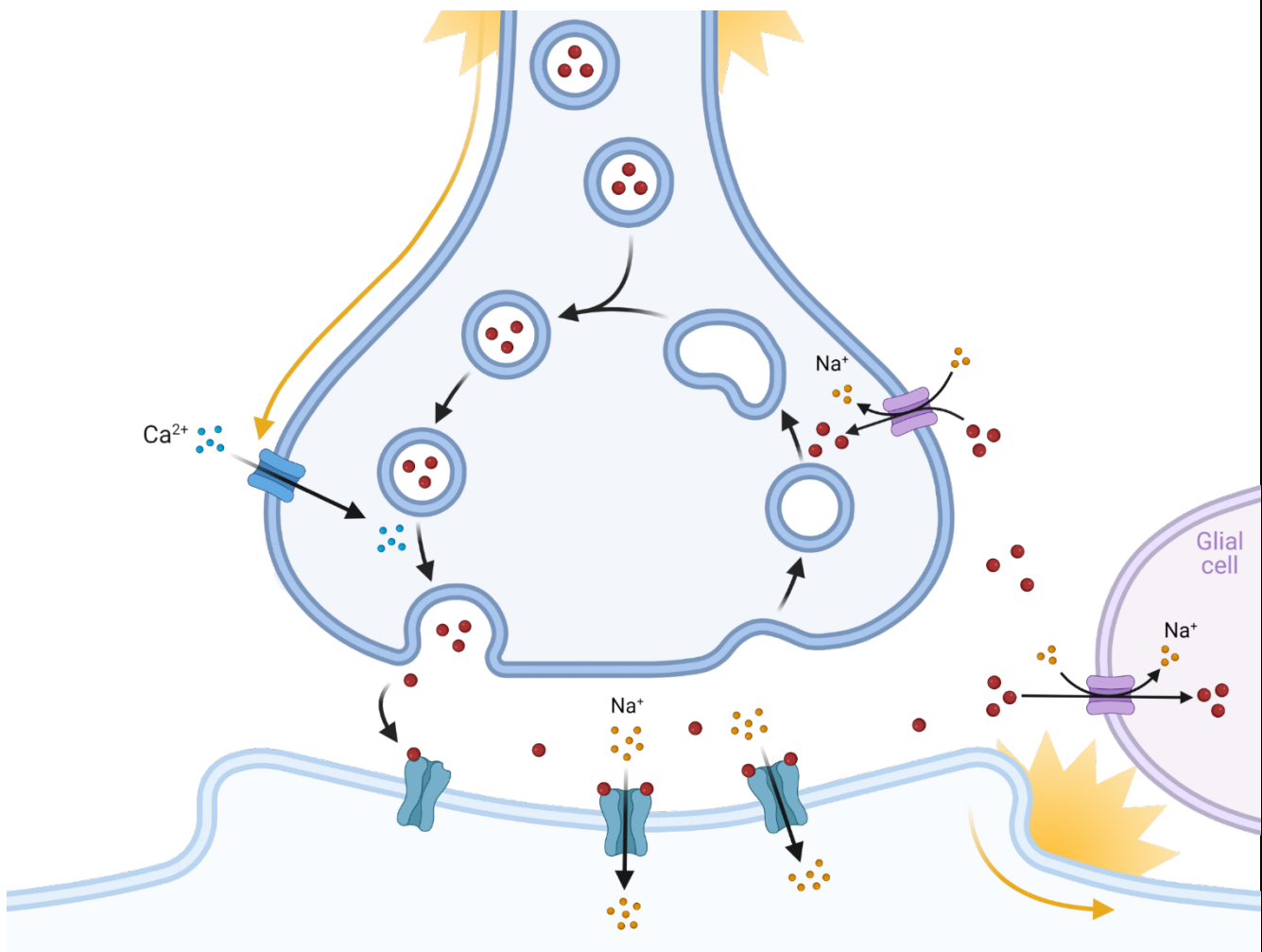
11. Which cell organelle would be most accurately described as the site of protein synthesis?
- a. Nucleus
 - b. Mitochondrion
 - c. Ribosome
 - d. Golgi apparatus
 - e. Endoplasmic reticulum
12. What role does the receptor play when modelling homeostasis in the human body as a negative feedback loop?
- a. It provides the stimulus
 - b. It acts as the effector
 - c. It senses changes in the environment
 - d. It serves as the control center
 - e. It processes the feedback
13. Which technique can be used to measure resting membrane potential?
- a. Centrifugation
 - b. Electrophoresis
 - c. Patch-clamp technique
 - d. PCR amplification
 - e. Western blotting
14. Which of the following best describes the role of the cell membrane?
- a. Synthesis of proteins
 - b. Generation of ATP
 - c. Replication of DNA
 - d. Regulation of cellular transport
 - e. Folding of amino acid chains
15. Which of the following correctly characterizes an important difference between electrical and chemical synapses?
- a. Electrical synapses involve the release of neurotransmitters
 - b. Chemical synapses are faster than electrical synapses
 - c. Electrical synapses allow direct ion flow between cells
 - d. Chemical synapses do not involve ion channels
 - e. Electrical synapses use DNA as a signaling molecule

Section 2: Short Answer (10 points)

Please answer questions using sentences, equations, calculations, diagrams, graphs, etc. as required in question instruction or in order to convey clear answers.

16. a) Draw a diagram showing a key step in the process of signal transmission at a chemical synapse.
b) Briefly describe the process of synaptic transmission at a chemical synapse, including the steps from neurotransmitter release to the response in the postsynaptic neuron.

Synaptic transmission at a chemical synapse involves the release of neurotransmitters from the presynaptic neuron, which cross the synaptic cleft and bind to receptors on the postsynaptic neuron. This binding triggers changes in the postsynaptic neuron, such as the opening of ion channels, leading to a postsynaptic potential that can initiate an action potential if the threshold is reached.



17. If a cell has an intracellular chlorine ion concentration of 20 mMol and an extracellular chlorine ion concentration of 110 mMol:

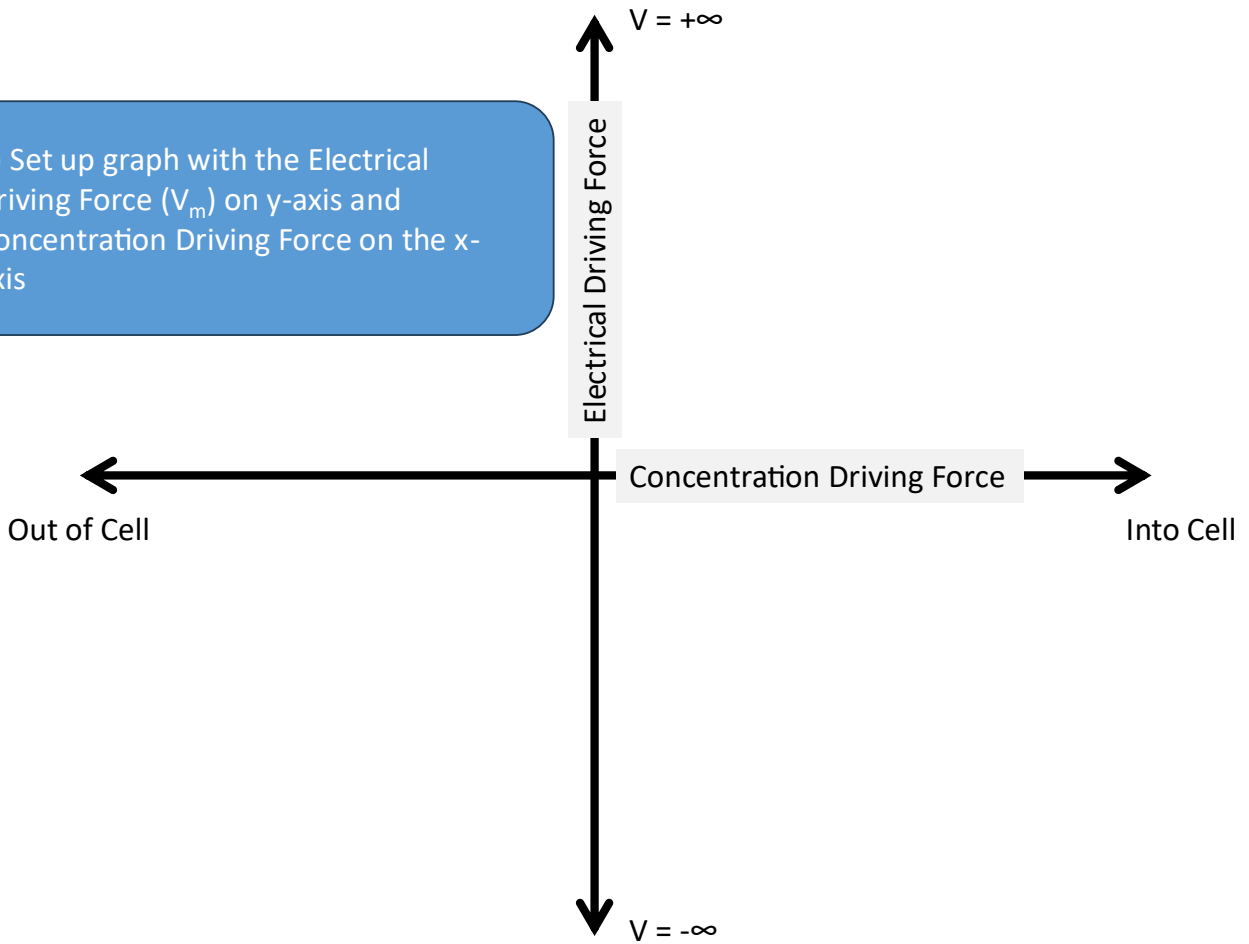
- a) Calculate the equilibrium potential for Chlorine ions arising due to this concentration gradient
- b) Either by graphing the electrochemical gradients or by providing a written explanation that includes references to both potentials arising due to concentration gradients, cell membrane potential, and the interaction of these two factors, determine which way chlorine ions will move in this scenario.

$$E_x = \frac{RT}{Z_x F} \ln \frac{[C_o]}{[C_i]}$$

(Sub in appropriate values)

(See steps on following page)

1) Set up graph with the Electrical Driving Force (V_m) on y-axis and Concentration Driving Force on the x-axis



[K+] = 5 mMol

[K+] = 150 mMol

2) Write concentration inside & outside cell

Out of Cell

Into Cell

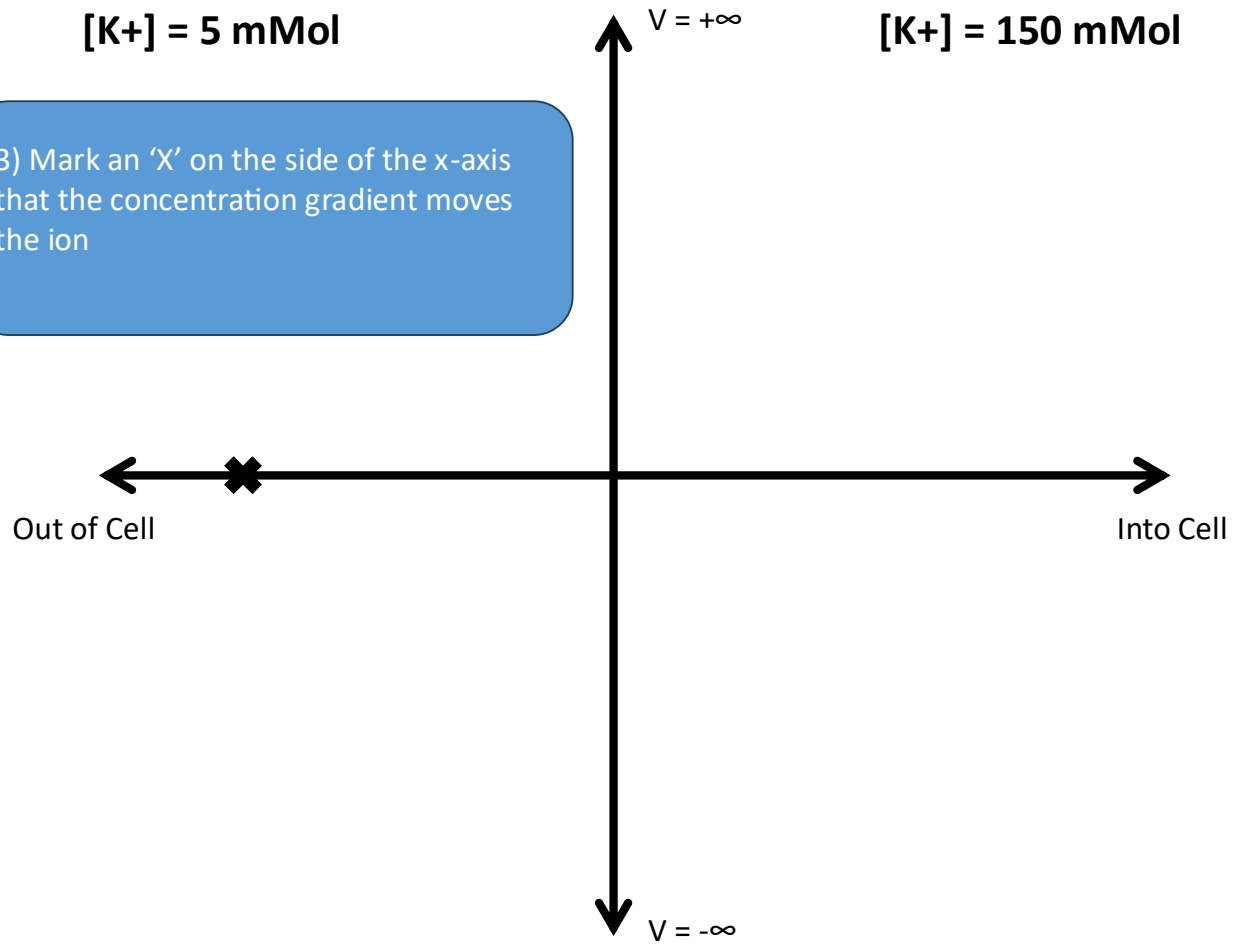
$V = +\infty$

$V = -\infty$

[K+] = 5 mMol

[K+] = 150 mMol

3) Mark an 'X' on the side of the x-axis that the concentration gradient moves the ion



[K+] = 5 mMol

[K+] = 150 mMol

4) Mark an 'X' where E_{ion} is on y-intercept

