NEET PG Physiology Sample Paper-1

Duration: 15 Minutes **Maximum Marks: 68**

Instructions

- This paper contains **17** Multiple Choice Questions.
- Each correct answer carries **+4** mark. Incorrect answer: **−1** marks. Only **one** correct option.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A 24-year-old medical student is participating in an experiment evaluating cell membrane permeability. He identifies a specialized membrane protein that moves an uncharged solute across the cell membrane down its concentration gradient without the expenditure of metabolic energy. Which of the following transport mechanisms is best illustrated by this process?

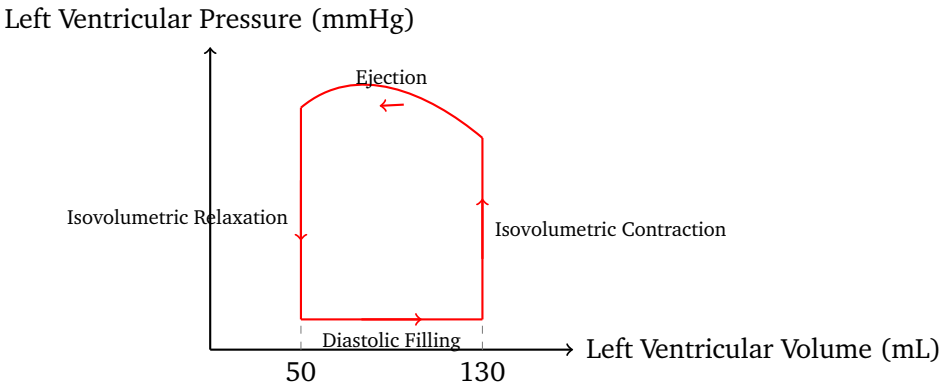
(A) Primary active transport

(B) Simple diffusion through lipid bilayer

(C) Facilitated diffusion

(D) Secondary co-transport

Q2. During a routine physiological assessment, a 45-year-old male is found to have an ejection fraction of 60%, an end-diastolic volume of 130 mL, and a heart rate of 72 beats per minute. Which of the following changes would most likely result in an acute increase in his stroke volume?



(A) Increased carotid sinus baroreceptor discharge frequency

(B) An increase in myocardial contractility via beta-1 adrenergic stimulation

(C) A sudden rise in mean arterial pressure to 140 mmHg

(D) A decrease in central venous pressure

Q3. A researcher is measuring pulmonary volumes and capacities in a healthy female volunteer during a standard spirometry evaluation. The volunteer breathes in as deeply as possible and then forcefully exhales as much air as possible into the spirometer. Which of the following parameters is directly measured by this maximum expiratory effort?

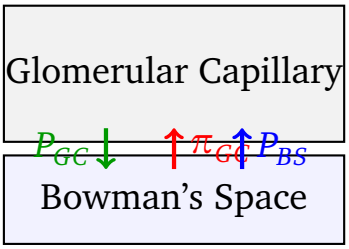
(A) Total lung capacity

(B) Functional residual capacity

(C) Vital capacity

(D) Residual volume

Q4. A 52-year-old woman with a history of chronic renal disease is evaluated for electrolyte disturbances. Laboratory results indicate a significant reduction in the glomerular filtration rate. Under normal physiological conditions, which of the following forces acting across the glomerular capillary wall is the primary driver favoring filtration?



(A) Glomerular capillary hydrostatic pressure

(B) Bowman's space hydrostatic pressure

(C) Glomerular capillary oncotic pressure

(D) Bowman's space oncotic pressure

Q5. A 34-year-old female presents to the clinic complaining of heat intolerance, weight loss despite an increased appetite, and palpitations. Physical examination reveals a diffuse, non-tender enlargement of the thyroid gland and mild exophthalmos. Which of the following biochemical mechanisms best explains her symptoms?

(A) Downregulation of beta-adrenergic receptor density in cardiac tissue

(B) Increased expression and activity of sodium-potassium ATPase pumps

(C) Inhibition of the basal metabolic rate via uncoupling proteins

(D) Decreased transcription of myosin heavy chain genes

Q6. A 28-year-old male is involved in a motor vehicle accident and suffers a localized lesion affecting the right lateral spinothalamic tract at the level of the T8 spinal segment. Which of the following sensory deficits is most likely to be observed during a neurological examination?

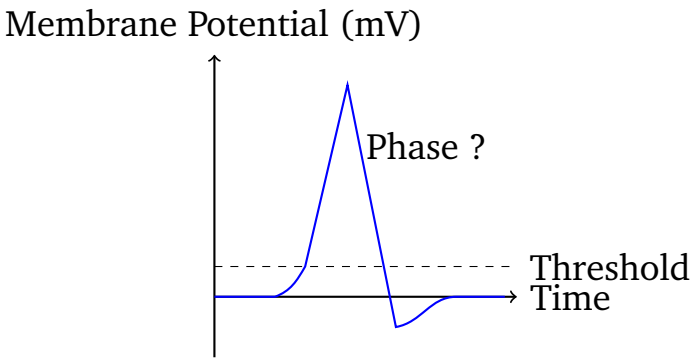
(A) Loss of conscious proprioception on the right side below T8

(B) Loss of pain and temperature sensation on the left side below T8

(C) Loss of discriminative fine touch on the left side below T8

(D) Loss of pain and temperature sensation on the right side below T8

Q7. An experimental drug is applied to an isolated nerve fiber. The drug is known to specifically and reversibly block voltage-gated sodium channels. Which of the following phases of the action potential will be selectively abolished by the application of this drug?



(A) Rapid depolarization phase

(B) Repolarization phase

(C) After-hyperpolarization phase

(D) Resting membrane potential stability

Q8. An intensive care unit team is managing a patient with acute respiratory distress syndrome. Arterial blood gas analysis shows severe hypoxemia. The attending physician explains that mismatching of ventilation and perfusion is the primary cause. In a healthy individual standing upright, how do ventilation and perfusion vary from the apex to the base of the lung?

(A) Both ventilation and perfusion are highest at the apex

(B) Ventilation is highest at the apex, while perfusion is highest at the base

(C) Both ventilation and perfusion are highest at the base, but perfusion increases more steeply

(D) Both ventilation and perfusion are uniform throughout the entire lung field

Q9. A 63-year-old male is admitted to the hospital following a syncopal episode. An electrocardiogram reveals a prolonged PR interval measuring 0.28 seconds with a constant morphology, and every P wave is followed by a QRS complex. Which of the following statements regarding the electrical conduction system of this patient is most accurate?

(A) There is an intermittent failure of conduction through the Bundle of His

(B) The physiological delay within the atrioventricular node is abnormally prolonged

(C) Conduction velocity through the Purkinje fibers is significantly increased

(D) The sinoatrial node is firing at an abnormally slow intrinsic rate

Q10. A laboratory scientist isolates a segment of the nephron to study water permeability under varying hormonal conditions. When antidiuretic hormone is added to the basolateral bathing solution, a significant increase in water permeability is observed on the apical membrane. Which specific segment of the nephron was most likely isolated?

(A) Descending thin limb of the loop of Henle

(B) Thick ascending limb of the loop of Henle

(C) Early distal convoluted tubule

(D) Medullary collecting duct

Q11. A 41-year-old female undergoes a total thyroidectomy for a malignant nodule. On the second postoperative day, she complains of tingling sensations around her mouth and muscle cramps in her hands. A positive Chvostek sign is elicited. A deficiency in which of the following hormones is responsible for her current clinical presentation?

(A) Calcitonin

(B) Parathyroid hormone

(C) Thyroxine

(D) Triiodothyronine

Q12. A neurophysiology study investigates the function of the cerebellum in coordinating motor movements. A primate model is trained to perform complex, rapid voluntary hand tracking tasks. Damage to the cerebrocerebellum (neocerebellum) in this model is most likely to produce which of the following clinical signs?

(A) Resting tremor that disappears with voluntary movement

(B) Severe truncal ataxia and wide-based gait instability

(C) Intention tremor and dysmetria during targeted limb movements

(D) Rigidity characterized by a cogwheel resistance pattern

Q13. A 19-year-old athlete is participating in a high-intensity treadmill run. As her skeletal muscles contract vigorously, local metabolic changes cause significant vasodilation of the arterioles supplying the active muscle beds. Which of the following local chemical alterations is a potent stimulator of this metabolic hyperemia?

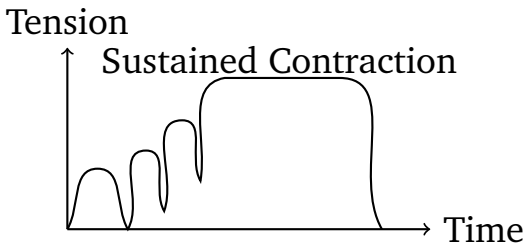
(A) Increased local pH

(B) Decreased extracellular potassium concentration

(C) Increased extracellular adenosine concentration

(D) Decreased local carbon dioxide tension

Q14. An investigator performs an experimental study on skeletal muscle contraction using isolated amphibian muscle fibers. The fiber is stimulated at progressively increasing frequencies. At a high frequency of stimulation, individual twitch contractions fuse into a sustained, smooth maximal contraction. What is the primary intracellular mechanism underlying this phenomenon of tetanus?



(A) Complete depletion of adenosine triphosphate stores

(B) Sustained elevation of sarcoplasmic calcium levels due to repetitive release

(C) Accelerated reuptake of calcium by the SERCA pumps

(D) Enhanced binding of ATP to the myosin head groups

Q15. During a high-altitude expedition to a base camp located at 4,500 meters above sea level, a climber experiences hyperventilation due to the low ambi-

ent partial pressure of oxygen. Which of the following acid-base configurations is most consistent with the climber's acute physiological compensation?

(A) Decreased arterial PCO_2 and increased arterial pH

(B) Increased arterial PCO_2 and decreased arterial pH

(C) Decreased arterial PCO_2 and decreased arterial pH

(D) Normal arterial PCO_2 and increased arterial pH

Q16. A 23-year-old medical student is studying the cardiac cycle and analyzes a ventricular pressure-volume loop. He notices that during one specific phase of the cycle, ventricular pressure rises sharply while ventricular volume remains completely unchanged at its maximum value. This phase corresponds to which of the following events?

(A) Isovolumetric relaxation

(B) Rapid ventricular ejection

(C) Isovolumetric contraction

(D) Diastasis

Q17. A 38-year-old patient with severe hypertension is prescribed a medication that blocks the actions of aldosterone at its receptor sites. Which of the following alterations in renal handling of electrolytes is expected to occur as a direct result of this pharmacological intervention?

(A) Increased reabsorption of sodium and increased secretion of potassium

(B) Decreased reabsorption of sodium and decreased secretion of potassium

(C) Increased excretion of sodium and increased excretion of potassium

(D) Decreased excretion of sodium and decreased excretion of potassium

Detailed Solutions

Q1.

Solution

Concept:

Cell membrane transport mechanisms are classified by energy requirements and structural components. Passive transport moves solutes down a concentration gradient without cellular energy expenditure. When an uncharged substance utilizes a dedicated carrier or channel protein to move across the lipid bilayer down its gradient, the process is termed facilitated diffusion.

Solution:

(a) The problem describes an uncharged solute moving down its concentration gradient, eliminating active transport mechanisms which move solutes against a gradient using energy.

(b) Primary active transport relies directly on ATP hydrolysis, while secondary active transport couples solute movement against its gradient to an electrochemical gradient. Neither applies here.

(c) Simple diffusion involves molecules passing directly through the lipid bilayer without assistance from membrane proteins. This mechanism typically applies to small, nonpolar, or lipophilic molecules like gases and steroid hormones.

(d) Facilitated diffusion utilizes specific integral membrane proteins, such as channels or transporters, to allow polar or charged molecules to cross the hydrophobic core of the cell membrane.

(e) Because the student identifies a specialized membrane protein mediating transport down a gradient without metabolic energy input, the process is definitively classified as facilitated diffusion.

Final Answer: The transport mechanism is Facilitated Diffusion.

Answer: (C) Go Back to Question 1

Q2.

Solution

Concept:

Stroke volume is determined by preload, contractility, and afterload. Preload is the degree of myocardial stretch before contraction, directly related to end-diastolic volume. Contractility is the intrinsic strength of cardiac muscle contraction at a given preload. Afterload represents the resistance the heart must overcome to pump blood into the aorta.

Solution:

(a) Stroke volume can be calculated as the difference between end-diastolic volume and end-systolic volume. Increasing stroke volume requires increasing preload, increasing contractility, or decreasing afterload.

(b) Increased carotid sinus baroreceptor discharge occurs in response to high blood pressure, leading to increased parasympathetic activity and decreased sympathetic outflow, which reduces contractility and stroke volume.

(c) A sudden rise in mean arterial pressure increases afterload. Higher afterload increases the resistance against ventricular ejection, which increases end-systolic volume and decreases overall stroke volume.

(d) A decrease in central venous pressure reduces venous return to the heart, which lowers right ventricular filling, subsequently reducing left ventricular end-distolic volume, preload, and stroke volume.

(e) Activation of beta-1 adrenergic receptors via sympathetic stimulation activates a cyclic AMP pathway that enhances calcium entry into myocytes, augmenting myocardial contractility, decreasing end-systolic volume, and increasing stroke volume.

Final Answer: The change is An increase in myocardial contractility via beta-1 adrenergic stimulation.

Answer: (B) Go Back to Question 2

Q3.

Solution

Concept:

Spirometry measures lung volumes and capacities to evaluate respiratory function. Lung volumes are distinct, non-overlapping subdivisions of total air capacity, while lung capacities consist of two or more combined volumes. Vital capacity represents the maximum volume of air a person can exhale after a maximum inhalation effort.

Solution:

(a) The patient performs a maximal inspiratory effort to reach total lung capacity, followed by a maximal, forceful expiratory effort down to residual volume. The volume of air exhaled during this maneuver is the vital capacity.

(b) Total lung capacity includes the residual volume, which is the air remaining in the lungs after a maximal exhalation. Because residual volume cannot be exhaled into a spirometer, total lung capacity cannot be measured directly by standard spirometry.

(c) Functional residual capacity is the volume of air remaining in the lungs after a normal, passive tidal exhalation. It is the sum of expiratory reserve volume and residual volume, requiring gas dilution methods to measure.

(d) Residual volume acts as a cushion to prevent lung collapse and maintain continuous gas exchange between breaths. Because it cannot be cleared from the respiratory tract by voluntary effort, spirometry cannot assess it.

(e) Vital capacity combines tidal volume, inspiratory reserve volume, and expiratory reserve volume. Since all these components involve moveable air, the entire volume is directly captured and quantified by a spirometer during a forced exhalation.

Final Answer: The parameter is Vital capacity.

Answer: (C) Go Back to Question 3

Q4.

Solution

Concept:

Glomerular filtration is driven by Starling forces operating across the glomerular capillary wall. These forces include hydrostatic pressures and oncotic pressures within the glomerular capillaries and Bowman's space. The balance between forces favoring filtration and forces opposing filtration determines the net filtration pressure.

Solution:

(a) Glomerular capillary hydrostatic pressure is the blood pressure within the glomerular capillaries. It is maintained at a relatively high level due to the high-resistance efferent arteriole, acting as the primary force pushing fluid out of the capillary into Bowman's space.

(b) Bowman's space hydrostatic pressure is the fluid pressure within the initial segment of the nephron. This pressure opposes filtration by exerting a force that drives fluid back into the glomerular capillaries.

(c) Glomerular capillary oncotic pressure is exerted by non-filterable plasma proteins remaining in the capillary blood. As water is filtered, protein concentration rises, creating an osmotic force that pulls water back into the capillary, opposing filtration.

(d) Bowman's space oncotic pressure is normally negligible because the glomerular filtration barrier restricts the passage of large proteins. Therefore, virtually no proteins enter Bowman's space to exert an outward osmotic force.

(e) Under normal physiological conditions, the high hydrostatic pressure within the glomerular capillary overrides the opposing forces of capillary oncotic pressure and Bowman's space hydrostatic pressure, serving as the principal driver of ultrafiltration.

Final Answer: The force is Glomerular capillary hydrostatic pressure.

Answer: (A) Go Back to Question 4

Q5.

Solution

Concept:

Thyroid hormones, thyroxine and triiodothyronine, regulate the basal metabolic rate, body temperature, and tissue responsiveness to catecholamines. Hyperthyroidism results from excessive circulating levels of thyroid hormones, accelerating metabolic processes and up-regulating beta-adrenergic receptors throughout the body, particularly in the cardiovascular system.

Solution:

(a) The patient presents with classic signs of hyperthyroidism, including heat intolerance, weight loss with increased appetite, tachycardia, thyroid enlargement, and exophthalmos, consistent with Graves' disease or toxic diffuse goiter.

(b) Excess thyroid hormones enter target cells and bind to nuclear receptors, altering gene transcription. A primary action is stimulating transcription of the gene encoding the sodium-potassium ATPase pump across various tissues.

(c) Increased expression and activity of sodium-potassium ATPase pumps leads to high consumption of adenosine triphosphate. Hydrolysis of ATP generates substantial heat, explaining the patient's elevated basal metabolic rate and heat intolerance.

(d) Thyroid hormones also upregulate beta-1 adrenergic receptors in cardiac tissue, enhancing responsiveness to circulating epinephrine and norepinephrine, which produces palpitations, tachycardia, and a hyperdynamic circulatory state.

(e) Rather than inhibiting metabolic rates or downregulating cardiac receptors, excess thyroid hormone enhances metabolic cycles and cardiac sensitivity, leading to the clinical manifestations seen in hyperthyroid states.

Final Answer: The biochemical mechanism is Increased expression and activity of sodium-potassium ATPase pumps.

Answer: (B) Go Back to Question 5

Q6.

Solution

Concept:

The spinal cord contains distinct ascending pathways for sensory processing. The dorsal column-medial lemniscal system transmits fine touch, vibration, and proprioception ipsilaterally before decussating in the medulla. The lateral spinothalamic tract transmits pain and temperature sensations, decussating in the spinal cord near the level of entry.

Solution:

(a) Sensory fibers for pain and temperature enter the spinal cord via dorsal root ganglia, synapse in the dorsal horn, and decussate within one to two spinal segments through the anterior white commissure.

(b) After decussating, these secondary neurons ascend in the contralateral lateral spinothalamic tract. Consequently, the right lateral spinothalamic tract carries pain and temperature information originating from the left side of the body.

(c) A lesion localized to the right lateral spinothalamic tract at the T8 level interrupts ascending signals from the left side. This produces a loss of pain and temperature sensation on the left side below T8.

(d) Proprioception and fine touch travel via the dorsal columns. A lateral tract lesion leaves the dorsal columns intact, preserving fine touch and proprioception on both sides of the body.

(e) Because the tract has already crossed over from the opposite side of the body, injuries to the spinothalamic tract result in sensory deficits on the contralateral side, rather than the ipsilateral side.

Final Answer: The sensory deficit is Loss of pain and temperature sensation on the left side below T8.

Answer: (B) Go Back to Question 6

Q7.

Solution

Concept:

An action potential involves transient changes in membrane potential driven by voltage-gated ion channels. The resting membrane potential sits near the potassium equilibrium potential. When a stimulus depolarizes the membrane to threshold, voltage-gated sodium channels open rapidly, driving the membrane potential toward the sodium equilibrium potential.

Solution:

(a) The rapid depolarization phase is caused by the sudden, massive influx of sodium ions into the intracellular space through voltage-gated sodium channels, which open rapidly in response to threshold depolarization.

(b) Blocking voltage-gated sodium channels prevents sodium influx. Without this inward positive current, the membrane cannot undergo the rapid upstroke or reversal of potential that characterizes the depolarization phase.

(c) The repolarization phase follows depolarization and is driven by the closure of sodium channel inactivation gates and the opening of voltage-gated potassium channels, allowing potassium efflux to restore electronegativity.

(d) After-hyperpolarization occurs because voltage-gated potassium channels close slowly, temporarily dragging the membrane potential closer to the potassium equilibrium potential than the normal resting level.

(e) Applying a voltage-gated sodium channel blocker like tetrodotoxin completely abolishes the rapid upstroke phase of the action potential. This prevents propagation of the nerve impulse without directly altering resting potassium permeability.

Final Answer: The phase is Rapid depolarization phase.

Answer: (A) Go Back to Question 7

Q8.

Solution

Concept:

Gravity exerts a significant influence on pulmonary physiology in an upright individual. Hydrostatic pressure gradients affect intravascular pressures within the pulmonary circulation, while gravity pulls lung tissue downward, altering pleural pressure and alveolar expansion from the apex to the base.

Solution:

(a) Gravity causes a progressive increase in hydrostatic pressure in the lower regions of the lung, dilating pulmonary capillaries, reducing regional vascular resistance, and significantly increasing blood perfusion toward the base.

(b) Gravity also pulls the lung down, making intrapleural pressure less negative at the base than at the apex. Alveoli at the apex are highly stretched and less compliant, while basal alveoli are compressed and more compliant.

(c) Because basal alveoli undergo greater volume changes during ventilation, absolute ventilation is higher at the base of the lung than at the apex in an upright posture.

(d) While both ventilation and perfusion increase from top to bottom, perfusion increases much more steeply than ventilation. This causes the ventilation-perfusion ratio to be high at the apex and low at the base.

(e) Mismatching of these parameters compromises arterial oxygenation. In a healthy upright person, both parameters peak at the base, but the perfusion gradient is more pronounced due to heavy hydrostatic influences on blood mass.

Final Answer: The variation is Both ventilation and perfusion are highest at the base, but perfusion increases more steeply.

Answer: (C) Go Back to Question 8

Q9.

Solution

Concept:

The electrocardiogram records the electrical activity of the heart over time. The P wave represents atrial depolarization, while the QRS complex represents ventricular depolarization. The PR interval measures the time from the onset of atrial activation to the onset of ventricular activation, primarily reflecting the conduction delay within the atrioventricular node.

Solution:

(a) A normal PR interval ranges from 0.12 to 0.20 seconds. This patient exhibits a prolonged PR interval of 0.28 seconds, indicating a delay in the transmission of electrical impulses from the atria to the ventricles.

(b) Since every P wave is followed by a QRS complex and the interval remains constant, there are no dropped beats. This pattern is diagnostic of a first-degree atrioventricular block.

(c) The principal site of physiological delay in the cardiac conduction system is the atrioventricular node. This delay allows the atria to contract and fully empty their blood volume into the ventricles before ventricular systole begins.

(d) Pathological prolongation of this specific interval signifies that conduction through the atrioventricular node is slower than normal, lengthening the transit time for the cardiac impulse without causing a complete block.

(e) Intermittent failure of conduction characterizes second-degree blocks, while altered sinoatrial node firing rates affect the PP interval and overall heart rate rather than selectively isolating and prolonging the PR interval.

Final Answer: The statement is The physiological delay within the atrioventricular node is abnormally prolonged.

Answer: (B) Go Back to Question 9

Q10.

Solution

Concept:

Water reabsorption in the renal tubule occurs via transcellular or paracellular pathways. Certain segments are constitutively permeable to water, others are completely impermeable, and specific distal segments exhibit variable water permeability regulated by antidiuretic hormone via aquaporin channels.

Solution:

(a) The proximal convoluted tubule and the descending thin limb of the loop of Henle express aquaporin-1 channels constitutively on their membranes, allowing high, unregulated water reabsorption independent of antidiuretic hormone levels.

(b) The thick ascending limb of the loop of Henle and the early distal convoluted tubule are structurally impermeable to water because they lack water channels on both apical and basolateral membranes, allowing solute separation.

(c) The late distal convoluted tubule and the collecting ducts express aquaporin-2 channels inside intracellular vesicles. These segments are water-impermeable in the baseline state, preventing water reclamation.

(d) Binding of antidiuretic hormone to basolateral V2 receptors stimulates a G-protein cAMP cascade. This induces exocytosis of aquaporin-2 vesicles, inserting water channels into the apical membrane to increase permeability.

(e) Because the isolated segment exhibits a marked increase in apical water permeability exclusively following hormone exposure, it must be a responsive segment, specifically corresponding to the collecting duct system.

Final Answer: The segment is Medullary collecting duct.

Answer: (D) Go Back to Question 10

Q11.

Solution

Concept:

The parathyroid glands regulate calcium homeostasis primarily through the secretion of parathyroid hormone. Surgical excision or accidental injury to these glands during a total thyroidectomy results in acute hypoparathyroidism. This causes a sudden drop in serum ionized calcium levels, inducing neuromuscular hyperexcitability known as hypocalcemic tetany.

Solution:

(a) The patient presents with classic neuromuscular hallmarks of hypocalcemia, including perioral paresthesia, painful carpopedal spasms, and a positive Chvostek sign, which is a twitching of the facial muscles elicited by tapping the facial nerve.

(b) Parathyroid hormone acts directly on bone tissue to promote calcium resorption and on the renal tubules to enhance calcium reabsorption while facilitating phosphate excretion. It also stimulates the production of active vitamin D.

(c) Total thyroidectomy carries an intrinsic structural risk of inadvertent damage or vascular compromise to the posterior parathyroid glands. The acute absence of parathyroid hormone leads to unregulated urinary calcium loss and minimal osseous mobilization.

(d) Extracellular calcium ions stabilize voltage-gated sodium channels on excitable membranes. When extracellular calcium levels fall, the threshold for firing action potentials drops closer to the resting potential, provoking spontaneous axonal discharges.

(e) Calcitonin is produced by thyroid parafollicular cells and lowers calcium levels, but its postoperative deficiency does not cause hypocalcemia. Thyroid hormone deficits present as myxedema over weeks, rather than acute neuromuscular tetany.

Final Answer: The hormone deficiency is Parathyroid hormone.

Answer: (B) Go Back to Question 11

Q12.

Solution

Concept:

The cerebellum is anatomically and functionally split into three primary functional zones. The vestibulocerebellum regulates balance and eye movements. The spinocerebellum controls axial posture and execution of limb movements. The cerebrocerebellum or neocerebellum interacts extensively with the cerebral cortex to plan, program, and sequence complex voluntary motor pathways.

Solution:

(a) The cerebrocerebellum receives dense cortical inputs via pontine nuclei and projects back to the motor cortex via the dentate nucleus and thalamus, specializing in the timing, spatial coordination, and smooth velocity regulation of skilled movements.

(b) Damage to this neocerebellar region interrupts the predictive calculation of target trajectories. This causes a characteristic breakdown of coordinated movement, presenting clinically as dysmetria, which is the misjudging of distance during motor tasks.

(c) This deficit also produces an intention tremor, where oscillatory movements emerge and exacerbate as the affected limb approaches its intended target. This contrasts sharply with the resting tremors seen in basal ganglia disease.

(d) Truncal ataxia, characterized by a wide-based unsteady gait, is instead caused by damage to the midline structures, specifically the flocculonodular node of the vestibulocerebellum or the vermis of the spinocerebellum.

(e) Cogwheel rigidity and bradykinesia are classic extrapyramidal signs that signify a breakdown in dopamine signaling within the nigrostriatal pathway of the basal ganglia, rather than structural damage to the cerebellar cortex.

Final Answer: The clinical sign is Intention tremor and dysmetria during targeted limb movements.

Answer: (C) Go Back to Question 12

Q13.

Solution

Concept:

Metabolic regulation of local blood flow matches tissue perfusion to metabolic demand. During periods of elevated cellular work, active skeletal muscle cells consume oxygen rapidly and release byproduct chemicals into the local interstitial fluid. These metabolic factors act directly on vascular smooth muscle to cause local vasodilation.

Solution:

(a) Active hyperemia occurs during exercise when skeletal muscle contractions stimulate metabolic production of vasodilatory substances, overriding baseline sympathetic vasoconstrictor tone to optimize delivery of oxygen and energetic substrates.

(b) As adenosine triphosphate is metabolized at high rates during cellular work, intracellular adenosine monophosphate increases. This AMP is subsequently degraded to adenosine, which diffuses out of the cell into the surrounding tissue spaces.

(c) Extracellular adenosine acts via specific purinergic receptors on vascular smooth muscle cells, triggering an intracellular signaling cascade that prompts hyperpolarization, relaxation of the arterial wall, and subsequent local vasodilation.

(d) Other potent metabolic vasodilators produced during high-intensity skeletal muscle activity include hydrogen ions, which cause a drop in local pH, elevated carbon dioxide tension, increased lactate, and elevated extracellular potassium ions.

(e) Decreases in local carbon dioxide or increases in tissue pH are typical of hypometabolic or hyperventilated states, both of which trigger vasoconstriction rather than the local vasodilation required by exercising muscles.

Final Answer: The chemical alteration is Increased extracellular adenosine concentration.

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept:

Skeletal muscle contraction relies on excitation-contraction coupling driven by intracellular calcium dynamics. A single action potential triggers a discrete release of calcium from the sarcoplasmic reticulum, producing a momentary muscle twitch. Tetanus occurs when high-frequency stimulation prevents muscle relaxation between successive inputs.

Solution:

(a) When a muscle fiber is stimulated repeatedly at a high frequency, the interval between successive electrical impulses becomes significantly shorter than the duration of a single mechanical muscle contraction-relaxation cycle.

(b) Each action potential causes a rapid efflux of calcium through ryanodine receptors into the sarcoplasm. Under high-frequency stimulation, a new action potential arrives before the sarcoplasmic calcium from the previous pulse can be resequestered.

(c) The primary mechanism driving this continuous fusion of contractile force is the sustained elevation of sarcoplasmic calcium levels, which keeps troponin C permanently saturated and cross-bridge cycles continuously active.

(d) The sarcoplasmic reticulum calcium ATPase pumps continuously attempt to transport calcium back into the longitudinal tubules, but their maximum clearing capacity is overwhelmed by the high frequency of electrical inputs.

(e) Tetanus represents a physiological summit of mechanical force generation. It is not caused by cellular depletion of ATP or altered myosin binding kinetics, but rather by sustained, uninterrupted access to actin binding sites.

Final Answer: The mechanism is Sustained elevation of sarcoplasmic calcium levels due to repetitive release.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:

The respiratory system regulates arterial carbon dioxide tension and influences systemic acid-base balance. Changes in alveolar ventilation modify the rate of carbon dioxide elimination. Hyperventilation occurs when ventilation exceeds metabolic demand, driving down blood carbon dioxide concentrations and shifting chemical equilibria.

Solution:

(a) At an altitude of 4,500 meters, the ambient atmospheric pressure drops significantly, lowering the partial pressure of oxygen. This change decreases arterial PO_2 and activates peripheral chemoreceptors in the carotid and aortic bodies.

(b) Activation of these peripheral chemoreceptors triggers an immediate reflex increase in alveolar ventilation. The resulting hyperventilation drives a rapid expiratory clearance of carbon dioxide from the pulmonary alveoli.

(c) According to the carbonic acid equilibrium equation, a reduction in arterial carbon dioxide drives a depletion of carbonic acid and hydrogen ions in the blood, causing systemic pH to rise above baseline levels.

(d) This combination of a low arterial partial pressure of carbon dioxide paired with a elevated systemic arterial pH defines an uncompensated or acute respiratory alkalosis, which is the classic initial response to high-altitude hypoxia.

(e) Metabolic compensations, which involve a compensatory reduction in renal bicarbonate reabsorption to bring blood pH back toward the normal range, require several days of continuous exposure to mature completely.

Final Answer: The configuration is Decreased arterial PCO_2 and increased arterial pH.

Answer: (A)

Go Back to Question 15

Q16.

Solution

Concept:

The cardiac cycle consists of distinct electrical and mechanical phases that can be tracked using a ventricular pressure-volume loop. This loop graphs changes in intraventricular pressure against changes in chamber volume across a single heartbeat, bounded by key valvular events.

Solution:

(a) The phase described begins immediately after the mitral valve closes, at the point of maximum ventricular filling, which represents the end-diastolic volume. At this moment, both the mitral and aortic valves are shut.

(b) As ventricular myocardium depolarizes and contracts, internal pressure rises abruptly. Because both valves remain closed, no blood can enter or leave the chamber, keeping the ventricular volume completely constant.

(c) This specific window of the cardiac cycle, marked by soaring pressures alongside a locked volume, is termed isovolumetric contraction. It continues until intraventricular pressure exceeds aortic pressure, forcing the aortic valve open.

(d) Once the aortic valve opens, ventricular volume drops sharply as blood is expelled into the systemic circulation during the ejection phase, causing the loop to trace leftward toward its end-systolic volume.

(e) Isovolumetric relaxation occurs at the opposite side of the pressure-volume loop, where ventricular pressure drops rapidly after the aortic valve closes while the chamber volume remains fixed at its minimum value.

Final Answer: The phase is Isovolumetric contraction.

Answer: (C)

Go Back to Question 16

Q17.

Solution

Concept:

Aldosterone is a mineralocorticoid hormone synthesized in the zona glomerulosa of the adrenal cortex. It regulates blood volume and systemic blood pressure by acting on principal cells and intercalated cells located within the late distal convoluted tubule and cortical collecting ducts.

Solution:

(a) Aldosterone diffuses into renal principal cells and binds to cytoplasmic mineralocorticoid receptors. This induces transcription of apical epithelial sodium channels, basolateral sodium-potassium ATPase pumps, and apical potassium channels.

(b) The physiological output of normal aldosterone activation is an increase in sodium reabsorption from the tubular fluid back into the blood, paired with a simultaneous increase in potassium secretion into the urine.

(c) Administering a drug that blocks aldosterone receptors blocks these transport pathways. This suppresses apical epithelial sodium channel expression and diminishes basolateral sodium-potassium ATPase activity within the collecting duct.

(d) As a direct result of this receptor blockade, renal reabsorption of sodium ions drops, causing a rise in urinary sodium excretion. Concurrently, the driver for potassium secretion is removed, dropping urinary potassium excretion.

(e) This class of medications, which includes spironolactone and eplerenone, acts as potassium-sparing diuretics. They reduce systemic fluid volume while mitigating the risk of hypokalemia by preventing urinary potassium wasting.

Final Answer: The alteration is Decreased reabsorption of sodium and decreased secretion of potassium.

Answer: (B)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	C	4	A	5	B
6	B	7	A	8	C	9	B	10	D
11	B	12	C	13	C	14	B	15	A
16	C	17	B						