

NEET PG Physiology Sample Paper-3

Duration: 15 Minutes

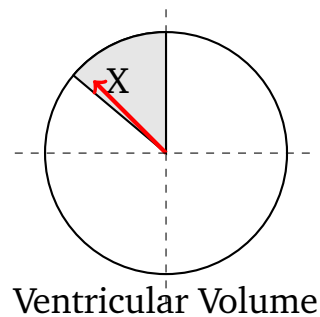
Maximum Marks: 68

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 53-year-old male with a history of chronic kidney disease presents with profound muscle weakness and cardiac arrhythmias. An ECG reveals peaked T waves and a prolonged PR interval. Which of the following transport mechanisms is primarily responsible for maintaining the physiological resting membrane potential against the concentration gradient altered in this patient?
- (A) Facilitated diffusion via GLUT-4 transporters
(B) Primary active transport via Na⁺-K⁺ ATPase
(C) Secondary active transport via Na⁺-glucose cotransporter
(D) Simple diffusion through voltage-gated sodium channels
- Q2.** During an experimental study on myocardial contractility, a researcher uses a stylized schematic to analyze the electrical and mechanical relationships of the cardiac cycle. Based on the mechanical and electrical vectors represented in the physiological model below, which of the following events corresponds to the period immediately following the closure of the atrioventricular valves?





- (A) Isovolumetric relaxation
- (B) Isovolumetric contraction
- (C) Rapid ejection phase
- (D) Diastasis

Q3. A 28-year-old female presents to the endocrine clinic with complaints of heat intolerance, weight loss despite an increased appetite, and palpitations. Physical examination reveals exophthalmos and a diffuse goiter. Laboratory findings confirm elevated free T_3 and T_4 levels. Which of the following cellular changes is most directly induced by the chronic binding of thyroid hormone to its intracellular receptors in cardiac myocytes?

- (A) Decreased transcription of the sarcoplasmic reticulum Ca^{2+} ATPase (SERCA2) pump
- (B) Increased expression of phospholamban in its unphosphorylated state
- (C) Upregulation of beta-1 adrenergic receptors and myosin heavy chain alpha expression
- (D) Downregulation of ryanodine receptors (RyR2)

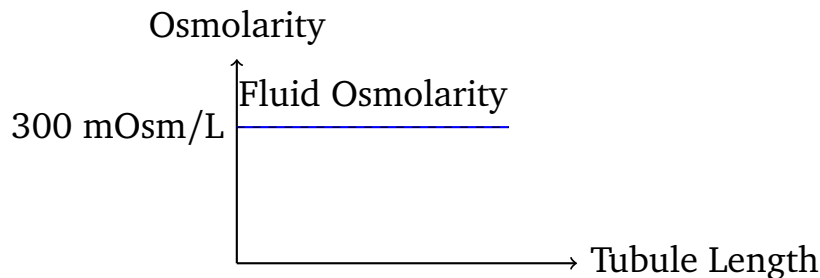
Q4. A 60-year-old male with a 40 pack-year smoking history undergoes pulmonary function testing as part of a preoperative evaluation. The results reveal a significant reduction in the forced expiratory volume in 1 second (FEV_1) to forced vital capacity (FVC) ratio ($FEV_1/FVC < 70\%$). Which of the following physiological changes is most characteristic of compliance and elastic recoil in this patient's respiratory system?

- (A) Increased lung compliance and decreased elastic recoil



- (B) Decreased lung compliance and increased elastic recoil
- (C) Decreased chest wall compliance and normal elastic recoil
- (D) Increased lung compliance and increased elastic recoil

Q5. A medical student is studying the relationship between tubular fluid flow, hydrostatic pressure, and solute reabsorption along the nephron using a simplified tubular functional model. If the functional pressure profile shifts according to the vectors shown in the diagram below, which segment of the nephron is primarily responsible for the massive, iso-osmotic reabsorption of filtered water, sodium, and organic solutes?

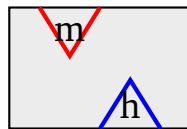


- (A) Thick ascending limb of the loop of Henle
 - (B) Distal convoluted tubule
 - (C) Proximal convoluted tubule
 - (D) Medullary collecting duct
- Q6.** A 52-year-old female is evaluated for severe postural hypotension and progressive autonomic failure. During a tilt-table test, her blood pressure drops significantly without a compensatory increase in heart rate. Under normal physiological conditions, which of the following sequences represents the correct baroreceptor reflex response to a sudden decrease in arterial blood pressure upon standing?
- (A) Increased baroreceptor firing → Increased nucleus tractus solitarius (NTS) activation → Decreased sympathetic outflow
 - (B) Decreased baroreceptor firing → Decreased NTS activation → Increased sympathetic outflow and decreased parasympathetic outflow



- (C) Increased baroreceptor firing → Decreased caudal ventrolateral medulla (CVLM) inhibition → Decreased vagal tone
- (D) Decreased baroreceptor firing → Increased rostral ventrolateral medulla (RVLM) inhibition → Increased vagal tone

Q7. A neurophysiology researcher records action potentials from a single cortical pyramidal neuron. During the absolute refractory period of the action potential, the structural status of the voltage-gated sodium channels is analyzed according to the simplified three-state kinetic gate framework illustrated below. What is the precise state of the activation (m) and inactivation (h) gates during this phase?



Refractory State

- (A) Activation gates are closed; inactivation gates are open
- (B) Activation gates are open; inactivation gates are closed
- (C) Both activation and inactivation gates are closed
- (D) Both activation and inactivation gates are open
- Q8.** A 34-year-old male presents with severe polyuria (up to 10 liters of urine per day) and intense thirst. A water deprivation test is performed, during which urine osmolarity remains fixed at 150 mOsm/L. Administration of exogenous desmopressin (dAVP) results in a prompt rise in urine osmolarity to 550 mOsm/L. This patient's primary physiological defect involves which of the following cellular processes?
- (A) Defective expression of Aquaporin-2 channels in the apical membrane of principal cells
- (B) Failure of hypothalamic osmoreceptors to synthesize or release arginine vasopressin
- (C) Mutation in the G-protein coupled V2 receptor in the basolateral membrane



(D) Defective clathrin-coated pit endocytosis of water channels in the medullary collecting duct

Q9. A healthy 24-year-old medical student participates in an exercise physiology lab. While running on a treadmill at maximum VO_2 , her minute ventilation increases dramatically. Which of the following arterial blood gas profiles and physiological adaptations is expected in this individual during high-intensity aerobic exercise compared to resting states?

(A) Significant drop in arterial PaO_2 and an increase in arterial PaCO_2

(B) Unchanged arterial PaO_2 , unchanged or slightly decreased arterial PaCO_2 , and decreased arterial pH

(C) Elevated arterial PaO_2 and markedly elevated arterial PaCO_2

(D) Unchanged arterial PaO_2 , elevated arterial PaCO_2 , and elevated arterial pH

Q10. A 23-year-old male is brought to the emergency department after sustaining a stab wound to the mid-thoracic spine. Neurological examination reveals ipsilateral loss of voluntary motor function and proprioception below the level of the lesion, accompanied by contralateral loss of pain and temperature sensation starting two segments below the lesion. Which of the following spinal cord pathways is correctly matched with its decussation site and physiological function affected in this patient?

(A) Lateral corticospinal tract: decussates in the spinal cord segment of entry; carries voluntary motor fibers

(B) Dorsal column-medial lemniscal system: decussates in the medulla; carries fine touch and proprioception

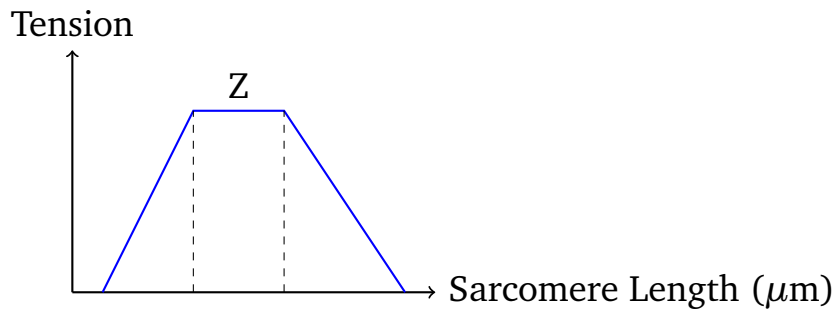
(C) Lateral spinothalamic tract: decussates in the medulla; carries pain and temperature sensation

(D) Anterior spinothalamic tract: decussates at the level of the midbrain; carries crude touch

Q11. An investigator isolates a single skeletal muscle fiber to determine the re-



relationship between resting sarcomere length and isometric active tension production. The results are plotted to create a classic length-tension curve. Based on the mechanical alignment coordinates represented in the diagram below, which zone corresponds to the maximum overlap between actin and myosin filaments resulting in optimal cross-bridge formation?



- (A) Lengths below $1.5 \mu\text{m}$ where thin filaments collide with the opposite Z-disc
- (B) Lengths between $2.0 \mu\text{m}$ and $2.2 \mu\text{m}$ where the central bare zone is optimal
- (C) Lengths greater than $3.6 \mu\text{m}$ where actin and myosin are completely separated
- (D) Lengths between $2.5 \mu\text{m}$ and $3.0 \mu\text{m}$ where titin filaments are over-stretched

Q12. A 67-year-old male with long-standing poorly controlled hypertension presents to the cardiology clinic. An echocardiogram reveals concentric left ventricular hypertrophy. Which of the following changes in cardiac tissue physics and vascular mechanics best explains the compensatory mechanism of ventricular remodeling according to the Law of Laplace?

- (A) Increased wall thickness reduces transmural ventricular wall stress caused by elevated afterload
- (B) Increased ventricular radius reduces the pressure required to eject blood during systole
- (C) Decreased wall thickness minimizes energy expenditure and myocardial oxygen demand



(D) Increased wall stress directly enhances the velocity of shortening of the sarcomeres

Q13. A patient undergoing an intensive medical evaluation is found to have an abnormally low plasma oncotic pressure due to severe hepatic synthetic dysfunction. Assuming capillary hydrostatic pressure remains constant, which of the following alterations in Starling forces and fluid dynamics will occur across the systemic microvascular beds?

(A) Increased net fluid filtration out of the capillaries, leading to interstitial edema

(B) Decreased net fluid filtration, leading to intravascular volume expansion

(C) Increased absorption of interstitial fluid into the venous end of the capillary

(D) Decreased lymphatic flow due to reduction in interstitial hydrostatic pressure

Q14. During a routine high-altitude trekking expedition to an elevation of 4500 meters, a climber experiences hyperventilation, mild dizziness, and a headache. A blood gas analysis reveals respiratory alkalosis with a compensatory renal response. Which of the following transport mechanisms in the intercalated cells of the distal nephron is adjusted over the next few days to compensate for this acid-base disturbance?

(A) Upregulation of apical H^+ -ATPase pumps in Type A intercalated cells

(B) Downregulation of basolateral Cl^- - HCO_3^- exchangers in Type A intercalated cells

(C) Increased activity of apical Cl^- - HCO_3^- exchangers (pendrin) in Type B intercalated cells

(D) Decreased excretion of ammonium (NH_4^+) ions in the proximal convoluted tubule

Q15. A 35-year-old female presents to her physician with a moon face, central obesity, supraclavicular fat pads, and abdominal striae. Her plasma adreno-



corticotrophic hormone (ACTH) level is undetectable, and cortisol levels are markedly elevated and fail to suppress with a high-dose dexamethasone suppression test. Which of the following underlying physiological mechanisms is most likely responsible for her clinical presentation?

- (A) An ACTH-secreting pituitary adenoma (Cushing's disease)
- (B) Ectopic secretion of ACTH by a small cell lung carcinoma
- (C) An autonomous cortisol-secreting unilateral adrenal adenoma
- (D) Autoimmune destruction of the adrenal cortex (Addison's disease)

Q16. A researcher utilizes a specialized whole-body plethysmograph to measure lung volumes in a cohort of healthy volunteers. The physiological components under analysis are structured according to the standard classical pulmonary capacity matrix. Which options correctly defines Functional Residual Capacity (FRC)?

- (A) The volume of air remaining in the lungs after a maximum expiratory effort
- (B) The volume of air inspired or expired with each normal breath
- (C) The volume of air remaining in the lungs at the end of a normal passive expiration
- (D) The maximum volume of air that can be inspired from the end-expiratory level

Q17. A 55-year-old male presents with an unsteady, wide-based gait and a coarse intention tremor. On examination, he exhibits dysmetria, dysdiadochokinesia, and scanning speech. When asked to perform the finger-to-nose test, his hand shakes progressively as it nears target. A lesion which functional zones of the central nervous system would account for this constellation of signs?

- (A) Substantia nigra pars compacta
- (B) Cerebellar cerebrocerebellum and spinocerebellum
- (C) Ventromedial nucleus of the hypothalamus
- (D) Putamen and globus pallidus externus



Detailed Solutions

Q1.

Solution

Concept: The resting membrane potential (RMP) of physiological cells is fundamentally established by the asymmetric distribution of sodium (Na^+) and potassium (K^+) ions across the plasma membrane. Under chronic kidney disease states, impaired renal excretion leads to extracellular hyperkalemia. This narrows the concentration gradient for potassium, driving the RMP closer to threshold, which clinically manifests as severe muscle weakness, peaked T waves, and prolonged PR intervals on electrocardiography due to voltage-gated sodium channel inactivation.

Solution:

- (a) The physiological maintenance of the intracellular and extracellular concentration gradients for sodium and potassium ions is driven by the $\text{Na}^+ - \text{K}^+$ ATPase pump located in the cell membrane.
- (b) This energy-dependent primary active transport mechanism utilizes ATP hydrolysis to extrude three sodium ions out of the cell against their electrochemical gradient while importing two potassium ions into the intracellular compartment.
- (c) By continuously operating against passive leak currents, this specific electrogenic pump maintains the high intracellular potassium concentration necessary to generate the hyperpolarized resting state via potassium leak channels.
- (d) Facilitated diffusion (such as via GLUT-4) and secondary active transport (such as via Na^+ -glucose cotransporters) do not directly utilize metabolic energy to move ions against these primary concentration gradients or establish the absolute negative baseline electrical potential.
- (e) Simple diffusion through voltage-gated sodium channels is a passive process that allows sodium influx during the depolarizing phase of an action potential, rather than maintaining the standard baseline physiological resting state.

Final Answer: Primary active transport via $\text{Na}^+ - \text{K}^+$ ATPase.

Answer: (B)

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Q2.

Solution

Concept: The cardiac cycle comprises distinct mechanical and electrical phases coordinating blood flow through the heart chambers. Closure of the atrioventricular (mitral and tricuspid) valves marks the anatomical end of diastole and the onset of ventricular systole. This closure prevents retrograde flow into the atria and is clinically auscultated as the first heart sound (S_1). Immediately following this event, ventricular pressure rises sharply while all four cardiac valves remain completely closed.

Solution:

- (a) Immediately after the atrioventricular valves close, the ventricular myocardium begins contracting forcefully around a fixed volume of blood because the semilunar (aortic and pulmonic) valves have not yet opened.
- (b) This specific mechanical period is defined as isovolumetric contraction, where ventricular pressure rises steeply while the ventricular blood volume remains completely constant.
- (c) In the provided schematic vector model, region X highlights a phase of high tension development prior to the ejection phase, matching the physical definition of an isovolumetric state during early systole.
- (d) Rapid ejection only commences once the rising intraventricular pressure exceeds the systemic diastolic pressure in the aorta, forcing the aortic valve to open.
- (e) Isovolumetric relaxation and diastasis are diastolic phases that occur following the closure of the semilunar valves at the end of systole, and during late ventricular filling, respectively.

Final Answer: Isovolumetric contraction.

Answer: (B)

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Q3.

Solution

Concept: Thyroid hormones (T_3 and T_4) exert strong chronotropic and inotropic effects on the cardiovascular system by binding to nuclear thyroid hormone receptors in cardiac myocytes. This complex acts as a transcription factor, modulating gene expression of structural and regulatory proteins. In hyperthyroidism (Graves' disease), excess free thyroid hormones lead to clinical symptoms of tachycardia, increased cardiac output, palpitations, and heightened sympathetic sensitivity.

Solution:

- (a) The primary molecular action of thyroid hormone in cardiac muscle includes the direct transcriptional upregulation of genes encoding specific proteins involved in calcium handling and mechanical contraction.
- (b) It explicitly increases the transcription and expression of the sarcoplasmic reticulum Ca^{2+} ATPase (SERCA2) pump and upregulates the expression of alpha-myosin heavy chain (fast ATPase activity) while downregulating beta-myosin heavy chain.
- (c) Simultaneously, it enhances the sensitivity of the myocardium to catecholamines by upregulating the density of surface beta-1 adrenergic receptors, contributing to hyperthyroid palpitations and tachycardia.
- (d) Phospholamban, which acts as an inhibitor of the SERCA2 pump in its unphosphorylated state, is downregulated or highly phosphorylated by thyroid hormone action, thereby increasing calcium reuptake speed and accelerating relaxation (lusitropy).
- (e) Ryanodine receptors (RyR2) are crucial calcium-release channels on the sarcoplasmic reticulum; their expression is actually enhanced, not downregulated, to facilitate rapid calcium release during excitation-contraction coupling.

Final Answer: Upregulation of beta-1 adrenergic receptors and myosin heavy chain alpha expression.

Answer: (C)

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Q4.

Solution

Concept: Pulmonary function testing helps differentiate between obstructive and restrictive lung diseases based on lung compliance and elastic recoil dynamics. A reduced FEV_1/FVC ratio less than 70% is the hallmark diagnostic criteria for obstructive lung pathology, such as emphysema and chronic bronchitis. Long-standing tobacco exposure destroys alveolar walls and enzymatic breakdown of elastin fibers, altering the internal structural architecture of the lung parenchyma.

Solution:

- (a) Destruction of alveolar septa and loss of structural elastin fibers reduce the inherent radial traction that holds small airways open during forced expiration.
- (b) This architectural breakdown directly causes a significant decrease in the elastic recoil of the lung tissue, impairing the lung's passive ability to collapse inward and expel air.
- (c) Because the tissue loses its resistive structural network, the lungs become highly distensible and easily stretchable, which physically translates to an increased lung compliance.
- (d) This physiological combination results in air trapping, pulmonary hyperinflation, increased residual volume, and a severely compromised expiratory flow rate (FEV_1).
- (e) Restrictive diseases, conversely, are typically characterized by a normal or elevated FEV_1/FVC ratio accompanied by decreased lung compliance and increased elastic recoil due to interstitial fibrosis.

Final Answer: Increased lung compliance and decreased elastic recoil.

Answer: (A)

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Q5.

Solution

Concept: The nephron processes glomerular filtrate via selective reabsorption and secretion across distinct segments. Total fluid osmolarity changes along the tubule depending on the relative permeability of each segment to solutes versus water. A flat osmolarity profile that remains perfectly horizontal at 300 mOsm/L implies that water and solutes are being reabsorbed in exactly equal proportions, preventing any concentration or dilution of the remaining tubular fluid.

Solution:

- (a) The proximal convoluted tubule (PCT) is responsible for reabsorbing approximately 65% of the total filtered load of water, sodium, potassium, and chloride, along with nearly 100% of filtered glucose and amino acids.
- (b) Because the apical and basolateral membranes of the PCT possess high water permeability via constitutively open Aquaporin-1 channels, water follows solute reabsorption instantly.
- (c) This structural feature ensures that fluid reabsorption remains strictly iso-osmotic relative to the surrounding interstitium and systemic plasma, maintaining a constant tubular fluid osmolarity of approximately 300 mOsm/L as represented in the model diagram.
- (d) The thick ascending limb of the loop of Henle is highly impermeable to water but actively reabsorbs solutes via the $\text{Na}^+ - \text{K}^+ - 2\text{Cl}^-$ cotransporter, causing tubular fluid osmolarity to drop significantly (diluting segment).
- (e) The distal convoluted tubule and medullary collecting ducts alter fluid osmolarity dynamic levels depending on systemic antidiuretic hormone concentration to concentrate or dilute urine.

Final Answer: Proximal convoluted tubule.

Answer: (C)

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Q6.

Solution

Concept: The baroreceptor reflex is a key homeostatic negative feedback loop responsible for maintaining stable systemic arterial blood pressure. High-pressure baroreceptors located in the carotid sinuses and aortic arch monitor changes in mean arterial pressure and pulse pressure via mechanical stretch. Orthostatic stress causes transient venous pooling in the lower extremities, dropping venous return, end-diastolic volume, stroke volume, cardiac output, and arterial pressure.

Solution:

- (a) Standing up causes an immediate decrease in blood pressure, which reduces mechanical stretch on the carotid sinus and aortic arch baroreceptors.
- (b) This reduction in stretch causes a significant drop in the baseline firing frequency of afferent signals traveling along the glossopharyngeal and vagus nerves to the nucleus tractus solitarius (NTS) in the medulla.
- (c) Under resting conditions, the NTS excites the caudal ventrolateral medulla (CVLM), which in turn inhibits the rostral ventrolateral medulla (RVLM). The NTS also directly excites the nucleus ambiguus to drive parasympathetic outflow.
- (d) Decreased afferent input to the NTS reduces its excitatory output to the CVLM, thereby lifting the inhibition off the RVLM, leading to an increase in sympathetic tone.
- (e) Concurrently, parasympathetic (vagal) outflow from the nucleus ambiguus decreases. The net systemic result is a compensatory rise in total peripheral resistance and heart rate to restore normal mean arterial pressure.

Final Answer: Decreased baroreceptor firing → Decreased NTS activation → Increased sympathetic outflow and decreased parasympathetic outflow.

Answer: (B)

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Q7.

Solution

Concept: Voltage-gated sodium (Na^+) channels are membrane proteins crucial for the generation and propagation of action potentials in excitable tissues. According to the classic Hodgkin-Huxley model, these channels operate via a fast extracellular activation gate (m) and a slower intracellular inactivation gate (h). The structural cycling through these conformation states governs the excitability threshold and absolute directionality of electrical signals along an axon.

Solution:

- (a) During the baseline resting membrane potential, the activation gate (m) is fully closed, and the inactivation gate (h) is open, leaving the channel closed but fully responsive to depolarization.
- (b) Upon reaching a threshold potential, the activation gate opens rapidly, allowing a massive influx of sodium ions down their electrochemical gradient, causing the characteristic rapid upstroke of the action potential.
- (c) At the peak of the action potential, the slower time-dependent inactivation gate (m) closes mechanically, blocking further influx of sodium ions despite the continued open position of the activation gate.
- (d) The state where activation gates are wide open but inactivation gates are closed corresponds precisely to the absolute refractory period, preventing any subsequent electrical stimulation from triggering another action potential.
- (e) De-inactivation and resetting of the channel back to the resting configuration can only occur after the membrane repolarizes to a sufficiently negative potential driven by potassium efflux.

Final Answer: Activation gates are open; inactivation gates are closed.

Answer: (B)

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Q8.

Solution

Concept: Diabetes insipidus (DI) is a metabolic disorder characterized by an inability to concentrate urine, leading to severe polyuria and polydipsia. It is broadly categorized into central DI, where there is a lack of antidiuretic hormone (ADH/vasopressin) secretion from the posterior pituitary, and nephrogenic DI, where the renal principal cells fail to respond to circulating ADH. A water deprivation test differentiates DI from primary polydipsia, and subsequent exogenous dAVP administration localizes the core defect.

Solution:

- (a) This patient presents with persistent low urine osmolarity (150 mOsm/L) during water restriction, ruling out primary polydipsia and confirming a diagnosis of true diabetes insipidus.
- (b) The administration of exogenous desmopressin (dAVP) caused a significant increase in urine osmolarity up to 550 mOsm/L, demonstrating that the kidney's renal medullary collecting ducts possess normal functional responsiveness.
- (c) This response pattern diagnoses central diabetes insipidus, a condition directly caused by a structural failure of the magnocellular neurosecretory cells in the hypothalamus to synthesize, transport, or release arginine vasopressin.
- (d) If the condition were nephrogenic diabetes insipidus, the administration of desmopressin would fail to increase urine osmolarity due to defective V2 receptors or downstream Aquaporin-2 trafficking mutations.
- (e) Defective expression or endocytosis mechanisms would result in resistance to exogenous hormones, which contradicts this patient's rapid response to desmopressin.

Final Answer: Failure of hypothalamic osmoreceptors to synthesize or release arginine vasopressin.

Answer: (B)

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Q9.

Solution

Concept: Exercise physiology involves homeostatic adjustments across the respiratory and cardiovascular systems to match metabolic demands. During high-intensity aerobic exercise, oxygen consumption (VO_2) and carbon dioxide production (VCO_2) increase significantly within skeletal muscle tissue. To clear excess carbon dioxide and deliver adequate oxygen, minute ventilation raises steeply driven by primary neural drive and motor inputs.

Solution:

- (a) In a healthy individual exercising at maximum capacity, the alveolar ventilation increases in step with metabolic carbon dioxide production.
- (b) This physiological coupling keeps the arterial partial pressure of oxygen (PaO_2) completely stable at normal resting levels (approximately 100 mmHg) during aerobic workloads.
- (c) Arterial partial pressure of carbon dioxide ($PaCO_2$) remains unchanged or slightly decreases during high intensities due to compensatory alveolar hyperventilation triggered by peripheral chemoreceptors detecting lactic acid.
- (d) Anaerobic metabolism triggers at high exercise intensities, producing lactic acid which releases free hydrogen ions into the bloodstream, lowering the arterial blood pH below 7.4.
- (e) A profile with an elevated $PaCO_2$ or dropped PaO_2 would indicate severe hypoventilation, respiratory mismatch, or intrinsic pulmonary disease, which is not expected in a healthy trained individual.

Final Answer: Unchanged arterial PaO_2 , unchanged or slightly decreased arterial $PaCO_2$, and decreased arterial pH.

Answer: (B)

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Q10.

Solution

Concept: The Brown-Séquard syndrome results from a functional hemisection of the spinal cord, presenting with predictable neuroanatomical deficits. Understanding the specific organization, ascending or descending paths, and exact sites of decussation for each major spinal tract is essential to correctly localize the clinical presentation of lesions.

Solution:

- (a) Spinal cord hemisection destroys the ipsilateral dorsal column-medial lemniscal system, which carries fine touch, conscious proprioception, and vibration sensation.
- (b) These specific primary afferents enter the spinal cord and ascend ipsilaterally in the dorsal columns before decussating in the caudal medulla; a lesion thus causes ipsilateral loss of proprioception.
- (c) The lateral spinothalamic tract carries pain and temperature information. These secondary neurons cross immediately within the anterior white commissure of the spinal cord within one to two segments of entry.
- (d) A spinal hemisection thus interrupts the already crossed fibers from the opposite side, manifesting as a contralateral loss of pain and temperature sensation starting a few segments below the injury level.
- (e) The lateral corticospinal tract decussates in the medullary pyramids, so a spinal lesion downstream results in ipsilateral lower motor sign profiles and voluntary motor paralysis below the lesion level.

Final Answer: Dorsal column-medial lemniscal system: decussates in the medulla; carries fine touch and proprioception.

Answer: (B)

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Q11.

Solution

Concept: The mechanical properties of skeletal muscle contraction are governed by the sliding filament theory, which establishes a precise relationship between baseline sarcomere length and isometric active tension generation. The structural limits of force production are determined by the physical degree of overlap between thin actin and thick myosin filaments within the multi-protein myofibrillar matrix.

Solution:

- (a) Active tension generation is directly proportional to the total number of actin-myosin cross-bridges that can form simultaneously during muscle excitation.
- (b) On the classic length-tension curve represented in the experimental diagram, the optimal plateau region labeled Z spans precisely between $2.0 \mu\text{m}$ and $2.2 \mu\text{m}$.
- (c) Within this optimal range, structural overlap between the actin filaments and the myosin heads is maximized, while avoiding overlapping collisions of actin filaments from opposite ends.
- (d) At sarcomere lengths below $2.0 \mu\text{m}$, thin filaments begin to crumple and collide at the central bare zone, which physically disrupts cross-bridge binding and reduces overall tension.
- (e) At lengths exceeding $2.2 \mu\text{m}$, the thin filaments are progressively pulled away from the thick filaments, reducing cross-bridge formation until total filament separation occurs at $3.6 \mu\text{m}$ where active tension drops to absolute zero.

Final Answer: Lengths between $2.0 \mu\text{m}$ and $2.2 \mu\text{m}$ where the central bare zone is optimal.

Answer: (B)

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Q12.

Solution

Concept: Ventricular remodeling in chronic hypertension is a structural adaptation governed by fundamental physical laws of fluid mechanics. The Law of Laplace describes the exact biomechanical relationship between transmural pressure, chamber radius, and wall thickness relative to the total wall stress experienced by the working myocardium.

Solution:

- (a) The Law of Laplace is mathematically defined as $\text{Wall Stress} = (\text{Pressure} \times \text{Radius}) / (2 \times \text{Wall Thickness})$, demonstrating that stress is inversely proportional to wall thickness.
- (b) Sustained systemic hypertension imposes a high afterload on the left ventricle, forcing the myocardium to generate much higher intraventricular pressures to open the aortic valve.
- (c) To normalize this pathological elevation in transmural wall stress and prevent wall failure, cardiac myocytes undergo concentric hypertrophy, adding sarcomeres in parallel.
- (d) This concentric growth patterns an increase in left ventricular wall thickness while keeping the internal chamber radius relatively constant, thereby minimizing myocardial oxygen demand.
- (e) Eccentric hypertrophy, conversely, occurs in volume overload states where the chamber radius expands significantly, which physically compounds wall stress if not matched by proportional thickness.

Final Answer: Increased wall thickness reduces transmural ventricular wall stress caused by elevated afterload.

Answer: (A)

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Q13.

Solution

Concept: Microvascular fluid dynamics and transcapillary exchange are dictated by Starling forces, which govern the net balance of hydrostatic and oncotic pressures across systemic capillary walls. Disruptions in protein balance modify these forces, altering the equilibrium between vascular filtration and lymphatic drainage networks.

Solution:

- (a) Severe hepatic synthetic dysfunction causes a profound reduction in systemic albumin synthesis, leading to clinical hypoalbuminemia and a marked drop in plasma oncotic pressure.
- (b) Plasma oncotic pressure is the primary inward force that retains water inside the vascular space and drives fluid reabsorption at the venous end of capillaries.
- (c) When plasma oncotic pressure falls, the outward force of capillary hydrostatic pressure becomes unopposed along the entire length of the microvascular bed.
- (d) This pressure imbalance results in a massive increase in net fluid filtration out of the capillaries into the surrounding extracellular matrix, overwhelming local lymphatic clearance.
- (e) Accumulation of this filtered fluid within the interstitial matrix expands the extracellular volume, presenting clinically as diffuse peripheral dependent edema and ascites.

Final Answer: Increased net fluid filtration out of the capillaries, leading to interstitial edema.

Answer: (A)

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Q14.

Solution

Concept: Renal acid-base regulation serves as a vital secondary homeostatic mechanism during respiratory disturbances. High-altitude exposure triggers hypoxemia, which activates peripheral chemoreceptors to induce hyperventilation, causing excess carbon dioxide clearance and acute respiratory alkalosis. The kidneys compensate over subsequent days by altering bicarbonate handling.

Solution:

- (a) Acute respiratory alkalosis reduces systemic hydrogen ion concentrations, which shifts the chemical equilibrium and requires the kidneys to excrete excess bicarbonate to normalize blood pH.
- (b) Type B intercalated cells in the cortical collecting duct are specialized for base secretion and are functionally up-regulated during persistent alkalotic states.
- (c) These cells express pendrin, an apical Cl^- - HCO_3^- exchanger, which actively secretes bicarbonate ions directly into the tubular lumen for urinary excretion.
- (d) Simultaneously, the basolateral H^+ -ATPase pumps in Type B cells pump hydrogen ions into the interstitium to retain acid within the systemic circulation.
- (e) Type A intercalated cells, which express apical H^+ -ATPase pumps and basolateral Cl^- - HCO_3^- exchangers to rescue bicarbonate, are conversely down-regulated to limit acid excretion.

Final Answer: Increased activity of apical Cl^- - HCO_3^- exchangers (pendrin) in Type B intercalated cells.

Answer: (C)

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Q15.

Solution

Concept: The hypothalamic-pituitary-adrenal (HPA) axis operates through a highly regulated negative feedback loop where cortisol suppresses its upstream secretagogues. Clinical hypercortisolism (Cushing's syndrome) presents with central obesity, moon facies, and proximal muscle wasting, requiring diagnostic suppression testing to identify the core lesion.

Solution:

- (a) This patient presents with hallmark features of Cushing's syndrome, characterized by autonomous or driven overproduction of glucocorticoids by adrenal cortical tissue.
- (b) Laboratory evaluation reveals completely undetectable plasma adrenocorticotrophic hormone (ACTH) levels, indicating that the pituitary gland is structurally intact and responding normally to high feedback.
- (c) The failure of high-dose dexamethasone to suppress cortisol production confirms that the source of hypercortisolism is entirely autonomous and independent of upstream hypophyseal control.
- (d) This exact physiological profile points to a primary autonomous cortisol-secreting unilateral adrenal adenoma located within the zona fasciculata of the adrenal cortex.
- (e) Pituitary adenomas (Cushing's disease) and ectopic ACTH-secreting tumors present with elevated or inappropriately normal ACTH levels, failing to match this patient's suppressed profile.

Final Answer: An autonomous cortisol-secreting unilateral adrenal adenoma.

Answer: (C)

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Q16.

Solution

Concept: Pulmonary volumes and capacities are distinct physiological compartments measured to evaluate thoracic mechanics and baseline gas exchange surface availability. Functional Residual Capacity (FRC) represents a critical equilibrium point where the inward elastic recoil of the lungs perfectly balances the outward elastic recoil of the chest wall.

Solution:

- (a) Functional Residual Capacity is defined as the absolute volume of air remaining in the respiratory tract at the end of a normal, passive quiet expiration.
- (b) Mathematically, FRC is computed as the sum of the Expiratory Reserve Volume (ERV) and the Residual Volume (RV), and it cannot be measured using simple spirometry alone.
- (c) This specific baseline volume serves as an essential oxygen reservoir, preventing alveolar collapse during expiration and minimizing fluctuations in arterial blood gas compositions.
- (d) The volume of air remaining in the lungs after a maximum expiratory effort defines the Residual Volume, which represents the non-collapsible portion of the lung.
- (e) The volume inspired or expired with each normal breath defines the Tidal Volume, whereas the maximum volume inspired from the end-expiratory level reflects the Inspiratory Capacity.

Final Answer: The volume of air remaining in the lungs at the end of a normal passive expiration.

Answer: (C)

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Q17.

Solution

Concept: The coordination of voluntary motor activity requires continuous integration of proprioceptive feedback and real-time kinetic adjustments. The cerebellum plays a key role as a comparator, evaluating the intended motor command from the cerebral cortex against the actual physical execution of the movement.

Solution:

- (a) This patient presents with signs of cerebellar ataxia, including a wide-based gait, dysmetria, dysdiadochokinesia, and a characteristic coarse intention tremor.
- (b) An intention tremor is absent at rest but appears during deliberate, targeted voluntary movements, worsening in amplitude as the limb approaches its destination.
- (c) This specific motor deficit implicates a lesion localized within the lateral cerebellar hemispheres (cerebrocerebellum) and the intermediate zones (spinocerebellum), which plan and execute fine motor sequences.
- (d) Damage to these pathways disrupts the predictive dampening of movement, causing the limb to overshoot and undershoot the target continuously.
- (e) Lesions within the substantia nigra or basal ganglia pathways present with resting tremors, bradykinesia, and rigidity (Parkinsonism), rather than intention tremors or scanning speech.

Final Answer: Cerebellar cerebrocerebellum (lateral hemispheres) and spinocerebellum.

Answer: (B)

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Answer Key

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

