Physiology

Sample Paper – 6

Questions:	25	**Duration:**	45 min
Total Marks:	100	**Marking:**	+4 / −1

Topics: Cardiovascular · Pharmacology · Neurology · Endocrine · Immune · Renal · Respiratory

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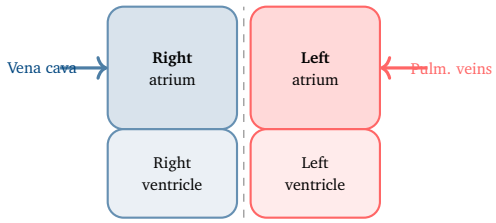
Quick Reference

Instructions

- This paper has **25 questions** carrying **100 marks**.
- Each correct answer: **+4 marks**. Each wrong answer: **−1 mark**. Unattempted: **0**.
- Suggested time: **45 minutes**. All questions are single-correct MCQs.
- Covers: Cardiovascular, Pharmacology/metabolism, Neurology, Endocrine, Immune, Renal, Respiratory systems.
- Click a question number in the answer key to jump to its solution.

Q1. The diagram below shows the four chambers of the heart. The two chambers that **receive** incoming blood (from the body or from the lungs) are collectively called the:



(A) Atria (right atrium and left atrium)
(B) Ventricles (right and left ventricle)
(C) Atrioventricular valves
(D) Pulmonary circulation chambers

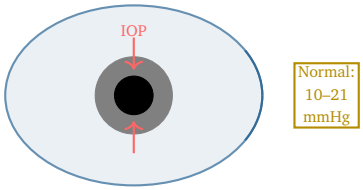
Q2. The primary site of drug metabolism (biotransformation), where most orally administered drugs are chemically modified by cytochrome P450 enzymes before entering systemic circulation, is the:

(A) Kidney (renal tubular secretion)
(B) Small intestine (enterocyte metabolism)
(C) Lung (pulmonary first-pass)
(D) Liver (hepatic first-pass effect)

Q3. Huntington's disease is an autosomal dominant neurodegenerative disorder caused by a mutation in the *HTT* gene. The underlying genetic defect is a:

(A) Single nucleotide substitution (missense mutation) creating a stop codon
(B) Large chromosomal deletion of the short arm of chromosome 4
(C) CAG trinucleotide repeat expansion in the huntingtin gene, producing a toxic polyglutamine protein
(D) Frameshift insertion leading to non-functional huntingtin protein

Q4. The diagram below depicts a tonometer measuring intraocular pressure (IOP) in the eye. Elevated IOP is the main risk factor for glaucoma. The normal range of IOP is:



(A) 0–5 mmHg (extremely low, vacuum-like)
(B) 5–10 mmHg (low normal range)
(C) 10–21 mmHg (normal physiological range)
(D) 25–35 mmHg (already hypertensive range)

Q5. Adrenaline (epinephrine), the primary hormone released during acute stress, is classified biochemically as a:

(A) Catecholamine derived from tyrosine, secreted by the adrenal medulla chromaffin cells
(B) Steroid hormone derived from cholesterol, secreted by the adrenal cortex
(C) Peptide hormone secreted by the anterior pituitary corticotroph cells
(D) Indoleamine derived from tryptophan, secreted by the pineal gland

Q6. During auscultation of the heart, the first heart sound (S1, "lubb") is produced by the closure of the atrioventricular valves at the onset of ventricular systole. S1 is produced by closure of the:

(A) Aortic valve and pulmonary valve (semilunar valves)
(B) Aortic valve only, at the end of systole
(C) Pulmonary valve only, at the end of systole
(D) Mitral valve and tricuspid valve (AV valves), at the start of systole

Q7. Haemolytic disease of the newborn (HDN / erythroblastosis foetalis) is a serious condition that occurs due to:

(A) ABO incompatibility causing maternal IgM to cross the placenta
(B) Maternal iron deficiency leading to inadequate foetal haemoglobin synthesis
(C) Foetal G6PD deficiency causing premature RBC destruction at birth
(D) Rh incompatibility: an Rh-negative mother sensitised by a previous Rh-positive foetus produces IgG anti-D antibodies that cross the placenta and destroy foetal RBCs

Q8. The organ that regulates the circadian (24-hour biological) rhythm by secreting melatonin in response to darkness is the:

(A) Pineal gland (epiphysis cerebri)
(B) Pituitary gland (hypophysis)
(C) Suprachiasmatic nucleus of the hypothalamus
(D) Adrenal cortex (zona reticularis)

Q9. Voluntary motor signals from the primary motor cortex (precentral gyrus) descend to control skeletal muscle via a two-neuron pathway. The neurons that carry signals from the cortex down through the brainstem and spinal cord (corticospinal tract) are called:

(A) Upper motor neurons (UMNs) of the corticospinal (pyramidal) tract
(B) Lower motor neurons (LMNs) of the anterior horn
(C) Interneurons of the dorsal horn (sensory relay neurons)
(D) Gamma motor neurons controlling muscle spindle tension

Q10. Peripheral vascular resistance — the main determinant of diastolic blood pressure — depends primarily on:

(A) Cardiac output (heart rate $\times$ stroke volume)
(B) Arteriolar diameter (radius^4 relationship via Poiseuille's law)
(C) Blood viscosity (haematocrit and plasma protein concentration)
(D) Venous capacitance and preload

Q11. The erythrocyte sedimentation rate (ESR) measures how quickly red blood cells settle in a tube of blood over one hour. ESR is significantly elevated in:

(A) Polycythaemia vera (excess red blood cells causing sludging)
(B) Inflammatory conditions, infections, and autoimmune diseases (due to raised fibrinogen and globulins)
(C) Sickle-cell anaemia (rigid cells fall slowly)
(D) Dehydration (haemoconcentration speeds up settling)

Q12. The adrenal cortex is divided into three concentric zones, each with distinct hormone products. The outermost zone (zona glomerulosa) secretes the main mineralocorticoid hormone, which is:

(A) Aldosterone (acts on kidney to retain Na^+ and excrete K^+)
(B) Cortisol (glucocorticoid; regulates stress and metabolism)
(C) Dehydroepiandrosterone (DHEA; adrenal androgen)
(D) Adrenaline (epinephrine; secreted by the adrenal medulla)

Q13. Peyer's patches are large aggregates of lymphoid follicles found in the wall of the small intestine (mainly ileum). They are part of:

(A) MALT — mucosa-associated lymphoid tissue (part of the innate and adaptive immune defence of the gut)
(B) The enteric nervous system (ENS) ganglia
(C) The exocrine digestive gland network (along with the pancreas)
(D) The portal circulation (gut-liver immune axis)

Q14. Hypocalcaemia (abnormally low blood calcium) causes characteristic neuromuscular symptoms because calcium normally inhibits neuronal excitability. The hallmark sign of hypocalcaemia is:

(A) Flaccid paralysis and absent deep tendon reflexes
(B) Bradycardia and prolonged QT interval only
(C) Increased neuromuscular excitability, muscle cramps, and tetany (Chvostek's and Trousseau's signs)
(D) Hyporeflexia and bone pain only

Q15. Cardiac muscle cells (cardiomyocytes) are electrically coupled and mechanically linked by specialised junctions at the ends of cells. These junctions, which allow action potentials to spread rapidly from cell to cell, are called:

(A) Neuromuscular junctions (motor end-plates)
(B) Intercalated discs (containing gap junctions and desmosomes)
(C) Tight junctions (zonula occludens) sealing the extracellular space
(D) Hemidesmosomes anchoring cardiomyocytes to the basement membrane

Q16. Stroke volume (the volume of blood ejected per heartbeat) is determined by three intrinsic factors. These are:

(A) Heart rate, blood viscosity, and arterial compliance
(B) Preload (end-diastolic volume), afterload (arterial resistance), and myocardial contractility
(C) Cardiac output, systemic vascular resistance, and mean arterial pressure
(D) Sympathetic tone, parasympathetic tone, and circulating catecholamines

Q17. Growth hormone (GH / somatotropin), which stimulates linear bone growth and protein anabolism, is produced by which cells of the pituitary gland?

(A) Corticotroph cells of the anterior pituitary (also produce ACTH)
(B) Thyrotroph cells of the anterior pituitary (also produce TSH)
(C) Somatotroph cells of the anterior pituitary
(D) Gonadotroph cells of the anterior pituitary (also produce LH and FSH)

Q18. Red blood cells (erythrocytes) perform one overriding physiological function above all others. That primary function is:

(A) Transport of oxygen from the lungs to tissues via haemoglobin
(B) Production of antibodies to fight systemic infections
(C) Phagocytosis of bacteria and cellular debris
(D) Secretion of clotting factors to initiate haemostasis

Q19. The coagulation cascade requires vitamin K as a cofactor for the hepatic synthesis of several procoagulant factors. Which vitamin is essential for the activation of clotting Factors II, VII, IX, and X?

(A) Vitamin A (retinol)
(B) Vitamin C (ascorbic acid)
(C) Vitamin E (tocopherol)
(D) Vitamin K (phylloquinone)

Q20. Myasthenia gravis is an autoimmune neuromuscular disease characterised by fluctuating muscle weakness that worsens with activity. It is caused by:

(A) Autoantibodies against voltage-gated calcium channels at the presynaptic terminal
(B) Autoantibodies against nicotinic acetylcholine receptors (nAChR) at the neuromuscular junction, reducing functional receptor density
(C) T-cell destruction of the myelin sheath of peripheral motor neurons
(D) Antibodies against the enzyme acetylcholinesterase, causing excess ACh accumulation

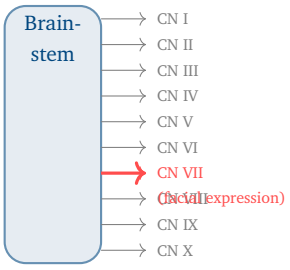
Q21. Hydrochloric acid (HCl) in the gastric juice creates the highly acidic environment (pH 1–2) needed for protein digestion and killing ingested pathogens. HCl is secreted by:

(A) Chief cells (peptic cells) that also secrete pepsinogen
(B) Mucous neck cells lining the gastric pits
(C) G-cells of the antrum that secrete gastrin
(D) Parietal cells (oxyntic cells) via the H^+/K^+-ATPase proton pump

Q22. Urine pH reflects the kidney's role in acid-base balance. The normal pH range of freshly voided urine in a healthy adult on a mixed diet is:

(A) 1.0–3.0 (strongly acidic, similar to stomach acid)
(B) 3.0–4.5 (moderately acidic)
(C) 4.5–8.0 (variable; typically acidic to neutral)
(D) 8.5–10.0 (strongly alkaline)

Q23. The diagram below shows the cranial nerves emerging from the brainstem. The cranial nerve that controls the muscles of facial expression (orbicularis oculi, orbicularis oris, frontalis, buccinator) is:



(A) Trigeminal nerve (CN V) — facial sensation
(B) Abducens nerve (CN VI) — lateral eye movement

(C) Glossopharyngeal nerve (CN IX) — taste posterior tongue
(D) Facial nerve (CN VII) — muscles of facial expression

Q24. Dead space in the respiratory system refers to regions ventilated by air that does not participate in gas exchange with the blood. Anatomical dead space comprises the:

(A) Alveoli that are over-ventilated relative to their blood perfusion (high V/Q ratio)
(B) Total lung capacity minus the functional residual capacity
(C) Conducting airways (nose, pharynx, larynx, trachea, bronchi, bronchioles) with a volume of $\approx$150 mL
(D) Residual volume of air that cannot be expelled even by forced expiration

Q25. Joints are classified by their structure and degree of movement. The most common and most mobile type of joint in the human body, characterised by a joint cavity filled with synovial fluid and lined by a synovial membrane, is the:

(A) Fibrous joint (suture or syndesmosis) — immovable or slightly movable
(B) Synovial (diarthrodial) joint — freely movable in multiple planes
(C) Cartilaginous joint (synchondrosis or symphysis) — slightly movable
(D) Gomphosis — the peg-in-socket joint of teeth in alveolar bone

Answer Key — Physiology Sample Paper 6

1	A	2	D	3	C	4	C	5	A
6	D	7	D	8	A	9	A	10	B
11	B	12	A	13	A	14	C	15	B
16	B	17	C	18	A	19	D	20	B
21	D	22	C	23	D	24	C	25	B

Detailed Solutions

Solution

Q1. (A) Atria (right atrium and left atrium)

The heart has two pairs of chambers: **atria** (receiving chambers) and **ventricles** (pumping chambers). The **right atrium** receives deoxygenated blood from the body via the superior vena cava, inferior vena cava, and coronary sinus. The **left atrium** receives oxygenated blood from the four pulmonary veins. Both atria contract simultaneously during atrial systole, pushing blood through AV valves into the ventricles. The atrial walls are thin-walled (low pressure) compared to the ventricles.

Solution

Q2. (D) Liver (hepatic first-pass effect)

After oral administration, drugs are absorbed by the small intestine $\rightarrow$ enter the portal vein $\rightarrow$ pass through the **liver** before reaching systemic circulation. This **first-pass metabolism** (hepatic biotransformation) significantly reduces the bioavailability of many drugs. Phase I reactions (cytochrome P450 oxidation/reduction/hydrolysis) and Phase II reactions (conjugation: glucuronidation, sulfation) occur in the liver. Drugs with high first-pass effect (e.g., morphine, propranolol, nitroglycerin) may require alternative routes (sublingual, IV).

Solution

Q3. (C) CAG trinucleotide repeat expansion in the huntingtin gene

Huntington's disease is caused by an abnormal expansion of the CAG repeat ($>$36 repeats, normal $\leq$35) in exon 1 of the *HTT* gene on chromosome 4p16.3. This encodes an elongated polyglutamine tract in the huntingtin protein, which misfolds and aggregates, preferentially destroying *striatal* neurons (caudate nucleus + putamen). Clinical features: choreiform movements, psychiatric disturbance, cognitive decline (onset typically 30–50 yrs). Autosomal dominant; anticipation occurs (earlier onset in successive generations, especially paternal transmission).

Solution

Q4. (C) 10–21 mmHg

Normal intraocular pressure (IOP) is **10–21 mmHg** (mean $\approx$ 15–16 mmHg). IOP is maintained by the balance between aqueous humour production (by ciliary body epithelium) and drainage (via the trabecular meshwork into Schlemm's canal). *Primary open-angle glaucoma* (POAG), the most common form, is characterised by IOP $>$ 21 mmHg with a patent but dysfunctional drainage angle. Elevated IOP damages the optic nerve (optic neuropathy), causing progressive visual field loss. Treatment: prostaglandin analogue eye drops, beta-blockers, carbonic anhydrase inhibitors, or surgery.

Solution

Q5. (A) Catecholamine derived from tyrosine, secreted by the adrenal medulla

Adrenaline (epinephrine) is a *catecholamine* synthesised from tyrosine via the pathway: Tyrosine $\rightarrow$ DOPA $\rightarrow$ Dopamine $\rightarrow$ Noradrenaline $\rightarrow$ Adrenaline (PNMT enzyme). It is secreted by **chromaffin cells of the adrenal medulla** (which are modified sympathetic postganglionic neurons). Adrenaline binds α and β adrenoceptors: increases HR, BP, bronchodilation, glycogenolysis. It is used clinically in anaphylaxis, cardiac arrest (IV), and as a local anaesthetic adjunct.

Solution

Q6. (D) Mitral and tricuspid (AV) valves, at the start of systole

S1 ("lubb") coincides with the *closure* of the **mitral (bicuspid)** and **tricuspid** valves at the onset of ventricular systole (isovolumetric contraction). This prevents backflow from ventricles into atria. **S2 ("dubb")** coincides with closure of the *aortic* and *pulmonary* (semilunar) valves at the end of systole. Splitting of S2 (A2 before P2) is physiological on inspiration. A pansystolic murmur suggests AV valve regurgitation; an ejection systolic murmur suggests semilunar valve stenosis.

Solution

Q7. (D) Rh incompatibility (Rh-negative mother, Rh-positive foetus)

HDN most severely occurs with *Rh (D) incompatibility*: an Rh^- mother carrying an Rh^+ foetus becomes sensitised during delivery (foeto-maternal haemorrhage). In a subsequent Rh^+ pregnancy, maternal **IgG anti-D antibodies** (unlike IgM, IgG crosses the placenta) attack foetal RBCs $\rightarrow$ haemolysis $\rightarrow$ foetal anaemia, hydrops, jaundice (kernicterus). Prevention: anti-D immunoglobulin (Rh immune globulin) given to Rh^- mothers at 28 weeks and within 72 h of delivery. ABO incompatibility (Option A) usually causes milder disease because ABO IgM antibodies do NOT cross the placenta.

Solution

Q8. (A) Pineal gland (epiphysis cerebri)

The **pineal gland** (a small endocrine gland in the epithalamus) secretes **melatonin** from tryptophan (via serotonin). Melatonin secretion is suppressed by light (via retinohypothalamic tract → suprachiasmatic nucleus → superior cervical ganglion → pineal) and rises in darkness. It regulates the sleep-wake **circadian rhythm**. The *suprachiasmatic nucleus* (SCN) of the hypothalamus acts as the master clock, but it is the pineal that translates this clock signal into hormonal output (melatonin). Melatonin supplements are used for jet lag and insomnia.

Solution

Q9. (A) Upper motor neurons (UMNs) of the corticospinal tract

Upper motor neurons (UMNs) originate in the primary motor cortex (precentral gyrus, Brodmann area 4) and descend via the *corticospinal (pyramidal) tract*: internal capsule → cerebral peduncles → medullary pyramids (where 85% decussate = lateral corticospinal tract) → synapse on *lower motor neurons* (LMNs) in the anterior horn of the spinal cord. LMNs then innervate skeletal muscle. UMN lesion signs: spasticity, hyperreflexia, Babinski sign. LMN lesion signs: flaccidity, hyporeflexia, fasciculations, muscle wasting.

Solution

Q10. (B) Arteriolar diameter (Poiseuille's law)

According to **Poiseuille's law**, blood flow resistance is inversely proportional to the *fourth power* of vessel radius ($R \propto 1/r^4$). Therefore, **arteriolar diameter** is the dominant determinant of peripheral vascular resistance (PVR). Small changes in arteriolar radius produce enormous changes in resistance. Arteriolar tone is regulated by: sympathetic vasoconstriction, local metabolites (CO_2, H^+, adenosine), myogenic autoregulation, and vasoactive hormones (angiotensin II, endothelin, NO). PVR mainly determines diastolic BP; cardiac output mainly determines systolic BP.

Solution

Q11. (B) Inflammatory conditions, infections, and autoimmune diseases

ESR measures the rate at which RBCs fall through plasma. In *inflammation*, acute-phase proteins (especially **fibrinogen**, and also α-globulins) coat RBCs, causing them to form *rouleaux* (stacked coin-like aggregates) that sediment faster. ESR is elevated in: bacterial infections, autoimmune diseases (rheumatoid arthritis, SLE), malignancies, and pregnancy. Normal ESR: $<$15 mm/h (men), $<$20 mm/h (women) (Westergren method). ESR is a non-specific marker; CRP is more specific and rises faster. In polycythaemia (Option A), ESR is actually *decreased*.

Solution

Q12. (A) Aldosterone (mineralocorticoid)

The adrenal cortex zones: **Zona Glomerulosa** (outermost) → aldosterone (mineralocorticoid); Zona Fasciculata (middle) → cortisol (glucocorticoid); Zona Reticularis (inner) → androgens (DHEA, androstenedione). Mnemonic: "GFR" = Glomerulosa/Fasciculata/Reticularis; and "Salt/Sugar/Sex" for their products. **Aldosterone** acts on the principal cells of the distal nephron via nuclear mineralocorticoid receptors (MR) to increase ENaC and Na^+/K^+-ATPase expression. The adrenal *medulla* (not cortex) secretes adrenaline.

Solution

Q13. (A) MALT (mucosa-associated lymphoid tissue)

Peyer's patches are organised lymphoid follicles in the *submucosal* and mucosal layer of the ileum. They are the largest component of gut-associated lymphoid tissue (GALT), which is itself the largest subdivision of **MALT**. Specialised M-cells (microfold cells) overlying Peyer's patches sample luminal antigens and present them to underlying lymphocytes. Peyer's patches contain predominantly B-cell follicles with germinal centres for IgA class-switching. Secretory IgA (sIgA) is the main antibody of mucosal immunity, produced in vast quantities (≈3–5 g/day in the gut).

Solution

Q14. (C) Increased neuromuscular excitability, muscle cramps, and tetany

Normal serum calcium: 8.5–10.5 mg/dL (2.1–2.6 mmol/L). Ionised Ca^{2+} stabilises voltage-gated Na^+ channels, raising the threshold for depolarisation. In **hypocalcaemia**, Na^+ channels activate more easily → neurons and muscles are *hyperexcitable*. Clinical signs: *Chvostek's sign* (facial muscle twitch on tapping CN VII); *Trousseau's sign* (carpopedal spasm with BP cuff inflation); tetany; seizures; prolonged QT interval (cardiac). Causes: hypoparathyroidism, vitamin D deficiency, hypomagnesaemia, massive blood transfusion (citrate chelates Ca^{2+}).

Solution

Q15. (B) Intercalated discs (gap junctions and desmosomes)

Cardiac muscle is a functional *syncytium*: all cardiomyocytes contract as one unit. This is achieved by **intercalated discs** at the ends of cardiomyocytes, which contain: (1) **Gap junctions** (connexons made of connexin-43) — allow direct electrical coupling and ion flow, propagating action potentials at high speed; (2) **Desmosomes** and *fascia adherens* — mechanical anchors that resist the tensile forces of contraction. This coupling ensures the atria and ventricles contract synchronously. Disruption of gap junctions (e.g., in ischaemia) leads to arrhythmias.

Solution

Q16. (B) Preload, afterload, and myocardial contractility

Stroke volume (SV) is determined by three intrinsic factors:

Preload: end-diastolic ventricular volume (EDV) = the stretch on ventricular walls before contraction. ↑ preload → ↑ SV (Frank-Starling law).

Afterload: the resistance the ventricle must overcome to eject blood (mainly aortic pressure/SVR). ↑ afterload → ↓ SV.

Contractility (inotropy): the intrinsic force of contraction at a given preload. Adrenaline ↑ contractility via β_1 receptors. Normal SV ≈ 70 mL; CO = HR × SV ≈ 5 L/min at rest.

Solution

Q17. (C) Somatotroph cells of the anterior pituitary

Growth hormone (GH) is a 191-amino-acid peptide secreted by **somatotroph cells** (also called somatotropes), which constitute ≈50% of anterior pituitary cells. GH secretion is stimulated by GHRH (growth-hormone-releasing hormone) from the hypothalamus and inhibited by somatostatin. GH acts directly on tissues (lipolysis, anti-insulin) and indirectly via IGF-1 (insulin-like growth factor-1) from the liver to stimulate linear bone growth. GH excess (somatotroph adenoma) before epiphyseal fusion → gigantism; after fusion → acromegaly.

Solution

Q18. (A) Transport of oxygen from the lungs to tissues via haemoglobin

The primary — and essentially sole — function of **erythrocytes** is **oxygen transport**: O_2 binds reversibly to haemoglobin (Hb) at the pulmonary capillaries (high pO_2, low temperature, low CO_2 → R-state/high affinity) and is released at tissues (low pO_2, high temperature, high CO_2, low pH → T-state/low affinity; Bohr effect). Each Hb carries 4 O_2 molecules (1.34 mL O_2/g Hb). RBCs also transport CO_2 (≈23% as carbaminohaemoglobin) and contribute to acid-base buffering, but oxygen transport is the primary function.

Solution

Q19. (D) Vitamin K

Vitamin K activates clotting factors by enabling γ-carboxylation of specific glutamate residues (by the enzyme γ-glutamyl carboxylase), which allows the factors to bind Ca^{2+} and phospholipid membranes. Vitamin K-dependent factors: **II** (prothrombin), **VII**, **IX**, **X**, and anticoagulants Protein C and Protein S. Warfarin inhibits vitamin K epoxide reductase, preventing vitamin K recycling and reducing synthesis of these factors. Vitamin K deficiency: neonates (no gut flora), malabsorption syndromes, or prolonged antibiotic use.

Solution

Q20. (B) Autoantibodies against nicotinic acetylcholine receptors at the NMJ
Myasthenia gravis (MG) is caused by IgG autoantibodies (anti-AChR in 85% of cases; anti-MuSK in ≈10%) directed against **nicotinic acetylcholine receptors** (nAChR) at the *postsynaptic* neuromuscular junction. Antibodies cause receptor destruction (complement-mediated) and cross-linking, reducing the number of functional receptors. The result is decremental response to repetitive nerve stimulation and fatigable weakness (ocular muscles first). Treatment: acetylcholinesterase inhibitors (pyridostigmine), immunosuppression, thymectomy (thymic hyperplasia or thymoma present in 75%).

Solution

Q21. (D) Parietal cells (oxyntic cells) via the H^+/K^+-ATPase proton pump
Parietal cells in the fundic gastric glands secrete HCl via the **H^+/K^+-ATPase** (proton pump) on their apical membrane, achieving a gastric pH of 1–2. Stimulated by acetylcholine (vagal), gastrin, and histamine (H_2 receptors). *Proton pump inhibitors* (PPIs: omeprazole, pantoprazole) irreversibly block H^+/K^+-ATPase and are the mainstay of peptic ulcer and GORD treatment. Chief cells secrete pepsinogen (activated to pepsin by HCl); G-cells secrete gastrin; mucous neck cells secrete protective mucus.

Solution

Q22. (C) 4.5–8.0 (variable; typically acidic to neutral)
Urine pH normally ranges from **4.5 to 8.0**, reflecting the kidney's ability to vary H^+ excretion to maintain blood pH. On a typical Western diet (high protein), urine is usually mildly acidic (pH ≈ 5–6). After a meal ("alkaline tide" as parietal cells secrete HCl and venous blood becomes temporarily alkaline), urine becomes transiently alkaline. The kidney excretes H^+ as ammonium (NH_4^+) and titratable acids ($H_2PO_4^-$). Alkaline urine (>7.5) may indicate UTI with urease-producing organisms (e.g., *Proteus*, *Klebsiella*).

Solution

Q23. (D) Facial nerve (CN VII)
The **facial nerve (CN VII)** is a mixed cranial nerve. Its **motor** division (from the facial nucleus in the pons) controls all muscles of *facial expression*: frontalis (forehead wrinkling), orbicularis oculi (eye closure), orbicularis oris (lip puckering), buccinator (cheek), and platysma. Other functions: taste from anterior 2/3 of tongue (chorda tympani), lacrimation, salivation, stapedius reflex. *Bell's palsy* is unilateral LMN facial nerve palsy causing ipsilateral complete facial weakness. CN V (trigeminal) provides facial *sensation*; CN IX (glossopharyngeal) carries taste from posterior 1/3 of tongue.

Solution

Q24. (C) Conducting airways, ≈150 mL

Anatomical dead space (≈150 mL in adults; ≈2.2 mL/kg) comprises the **conducting airways** — nose, pharynx, larynx, trachea, bronchi, and bronchioles (down to terminal bronchioles) — which conduct but do not exchange gas. *Alveolar dead space* = ventilated but under-perfused alveoli (V/Q $\to \infty$). Total dead space = anatomical + alveolar = *physiological dead space* (≈150 mL in health; increases in pulmonary embolism). Of each tidal volume (500 mL), ≈350 mL reaches alveoli for gas exchange (alveolar ventilation = (VT − VD) × RR).

Solution

Q25. (B) Synovial (diarthrodial) joints

Synovial joints are the most numerous and most freely movable joints in the body. Features: (1) a *joint cavity* containing synovial fluid (a viscous ultrafiltrate of plasma + hyaluronic acid from synoviocytes, providing lubrication); (2) a *synovial membrane* lining the joint capsule; (3) *articular cartilage* (hyaline) covering bone ends; (4) a fibrous joint capsule reinforced by ligaments. Subtypes: hinge (elbow), pivot (atlantoaxial), ball-and-socket (hip, shoulder), condyloid (wrist), saddle (thumb CMC), plane/gliding. Rheumatoid arthritis is an autoimmune synovitis.