FMGE Biochemistry Sample Paper – 5

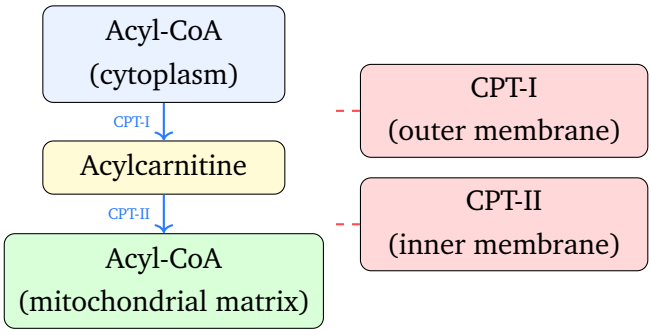
Duration: 60 Minutes **Maximum Marks: 40**

Instructions

- This paper contains **40 Multiple Choice Questions** modelled on the **Biochemistry** section of FMGE (Part A – Pre-clinical).
- Each correct answer carries **+1 mark**. There is **no negative marking** – attempt all questions.
- Questions follow the clinically integrated pattern of FMGE examination.
- Click a question number in the answer key to navigate to its solution.

FMGE Biochemistry – Q1 to Q40

Q1. A 45-year-old man is started on a carnitine-deficient diet as part of an experiment. His physician explains that long-chain fatty acids (LCFA) cannot enter the mitochondria for β-oxidation without a specific shuttle system. Which of the following correctly describes the carnitine shuttle?



(A) Short-chain fatty acids require carnitine to enter mitochondria

(B) CPT-I is located on the inner mitochondrial membrane and is activated by malonyl-CoA

(C) Carnitine palmitoyltransferase II (CPT-II) transfers acyl group back to CoA inside the matrix

(D) Malonyl-CoA activates CPT-I, promoting fatty acid oxidation during fed state

Q2. A researcher studying haemoglobin oxygen binding observes that the O_2 binding curve is sigmoidal rather than hyperbolic. This cooperative oxygen binding in haemoglobin is an example of which type of allosteric interaction?

(A) Heterotropic inhibition, where a different ligand decreases binding affinity

(B) Homotropic activation, where the same substrate (O_2) promotes further O_2 binding to adjacent subunits

(C) Heterotropic activation by 2,3-BPG promoting O_2 binding

(D) Non-cooperative binding following Michaelis-Menten kinetics

Q3. A 12-year-old boy passes recurrent kidney stones that appear hexagonal on microscopy and are radiolucent on plain X-ray. Urine amino acid chromatography reveals elevated cystine, ornithine, lysine, and arginine. The defect lies in which transporter?

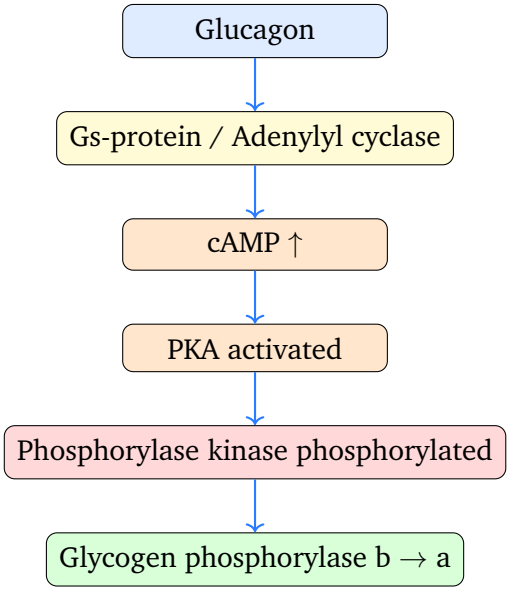
(A) SGLT1 (sodium-glucose linked transporter)

(B) Cationic amino acid transporter (SLC3A1/SLC7A9) in the renal tubule and intestine

(C) PEPT1 (peptide transporter 1) in the small intestine

(D) Neutral amino acid transporter (Hartnup disease transporter)

Q4. A 55-year-old man with Type 2 diabetes is given glucagon intravenously during a hypoglycaemic emergency. Glucagon stimulates hepatic glycogenolysis via a cAMP-PKA cascade. Which statement correctly describes the sequence of events?



(A) Glucagon → cAMP → PKA → phosphorylase kinase activated → glycogen phosphorylase b converted to a

(B) Glucagon directly activates glycogen phosphorylase without a second messenger

(C) cAMP activates protein phosphatase 1 to dephosphorylate glycogen phosphorylase

(D) PKA phosphorylates glycogen synthase (activating it) and inhibits glycogenolysis

Q5. A 25-year-old body builder consumes large amounts of raw eggs daily to increase protein intake. After 3 months he develops a scaly dermatitis, alopecia, and conjunctivitis. Serum biotin levels are undetectable. What is the mechanism of biotin deficiency in this patient?

(A) Raw egg white contains linamarase which degrades biotin in the intestine

(B) Avidin in raw egg white binds biotin with extremely high affinity (Kd $\sim 10^{-15}$ M) in the gut, preventing absorption

(C) Raw eggs contain an anti-biotin antibody that blocks biotin receptors

(D) Excessive protein intake competitively inhibits biotin absorption via shared transporter

Q6. A patient is found to have hyperammonaemia with elevated glutamine and low citrulline, but normal N-acetylglutamate (NAG) levels. Investigation reveals that carbamoyl phosphate synthetase I (CPS-I) is not activated. Which molecule is the essential allosteric activator of CPS-I?

(A) Carbamoyl phosphate

(B) Ornithine

(C) N-acetylglutamate (NAG)

(D) Arginine directly activates CPS-I

Q7. A researcher separates proteins from a tissue extract using a denaturing gel system. Proteins are boiled with sodium dodecyl sulphate (SDS) and β-mercaptoethanol before loading. On what basis does SDS-PAGE separate proteins?

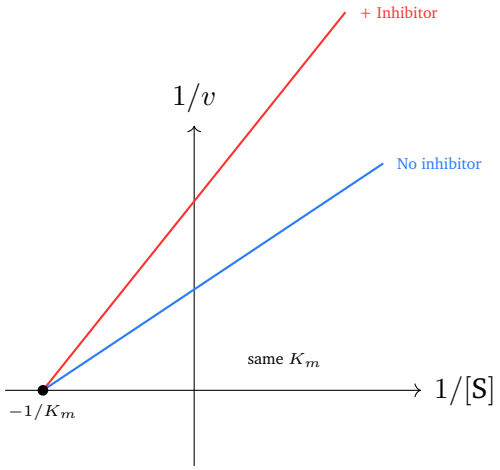
(A) Isoelectric point (charge at native pH)

(B) Three-dimensional shape (native conformation)

(C) Affinity for the gel matrix

(D) Molecular weight (size) alone, because SDS confers uniform negative charge

Q8. A pharmacology student draws a Lineweaver-Burk (double-reciprocal) plot and notes that when a drug is added, the x-intercept stays the same but the y-intercept increases. Identify the correct interpretation:



(A) Competitive inhibition: V_{max} unchanged, apparent K_m increased

(B) Uncompetitive inhibition: both V_{max} and K_m decreased

(C) Competitive inhibition: K_m unchanged, V_{max} decreased

(D) Non-competitive inhibition: K_m unchanged, V_{max} decreased

Q9. A 35-year-old man of Mediterranean origin develops haemolytic anaemia after being given primaquine for malaria prophylaxis. His red cells cannot regenerate reduced glutathione. The enzyme whose deficiency is responsible produces NADPH via which pathway?

(A) Pentose phosphate pathway (hexose monophosphate shunt) – glucose-6-phosphate dehydrogenase (G6PD)

(B) Glycolysis – phosphoglycerate kinase step

(C) TCA cycle – isocitrate dehydrogenase

(D) β-oxidation – acyl-CoA dehydrogenase

Q10. In a mitochondria research experiment, cells treated with a compound show increased NADH/NAD^+ ratio and a halt in ATP synthesis, but the proton gradient across the inner mitochondrial membrane increases rather than decreases. The compound is oligomycin. Which complex does oligomycin inhibit?

(A) Complex I (NADH dehydrogenase)

(B) Complex III (cytochrome bc1 complex)

(C) ATP synthase (Complex V, F_0 subunit proton channel)

(D) Complex IV (cytochrome c oxidase)

Q11. A 28-year-old woman from West Africa presents with chronic haemolytic anaemia, painful crises, splenomegaly, and a history of protection against falciparum malaria as a child. Haemoglobin electrophoresis shows HbS. What is the molecular basis of sickle cell disease?

(A) Deletion of two α-globin genes causing α-thalassaemia trait

(B) Point mutation in the β-globin gene (HBB): codon 6 GAG$\rightarrow$GTG, replacing glutamate with valine

(C) Frameshift mutation in the α-globin gene producing an unstable haemoglobin

(D) Methylation of the HBF promoter preventing foetal haemoglobin production

Q12. A 60-year-old man with a history of premature myocardial infarction at age 42 undergoes advanced lipid testing. His LDL-C is only mildly elevated but lipoprotein(a) [Lp(a)] is markedly elevated. Why is Lp(a) considered a prothrombotic independent cardiovascular risk factor?

(A) Lp(a) contains apolipoprotein E which promotes foam cell formation

(B) Lp(a) inhibits LDL receptor recycling, trapping LDL in the circulation

(C) Lp(a) increases platelet aggregation by activating thromboxane synthesis

(D) Apolipoprotein(a) in Lp(a) has structural homology to plasminogen, competitively inhibiting fibrinolysis

Q13. A 10-year-old child develops multiple squamous cell carcinomas on sun-exposed areas of skin. He has a history of extreme sensitivity to sunlight since infancy, with blistering after minimal UV exposure. Skin biopsy shows accumulation of pyrimidine dimers. Which DNA repair pathway is defective?

(A) Base excision repair (BER) – repairs small chemical modifications

(B) Mismatch repair (MMR) – corrects replication errors

(C) Nucleotide excision repair (NER) – removes UV-induced bulky adducts

(D) Non-homologous end joining (NHEJ) – repairs double-strand breaks

Q14. A patient is admitted after 24 hours of total starvation. Blood glucose is 68 mg/dL. A medical student asks why blood glucose has not fallen further. The correct explanation involves the time course of glycogen depletion. How long does liver glycogen typically sustain blood glucose in complete fasting?

(A) 3–4 days; muscle glycogen is the primary buffer for blood glucose

(B) 48–72 hours; liver glycogen is a large reserve that depletes slowly

(C) 12–18 hours; after which gluconeogenesis becomes the primary glucose source

(D) 6–8 hours; but muscle glycogenolysis compensates immediately

Q15. A 3-year-old child has hepatomegaly, mild fasting hypoglycaemia, and generalised muscle weakness. Liver biopsy shows abnormal glycogen with very short outer chains (limit dextrin). Unlike Von Gierke disease, there is some gluconeogenic capability. Which glycogen storage disease is this?

(A) Type I (Von Gierke) – glucose-6-phosphatase deficiency

(B) Type II (Pompe) – acid α-glucosidase (acid maltase) deficiency

(C) Type V (McArdle) – muscle glycogen phosphorylase deficiency

(D) Type III (Cori disease) – debranching enzyme (amylo-1,6-glucosidase) deficiency

Q16. A first-year medical student learns about insulin secretion from pancreatic β-cells. A rise in blood glucose leads to insulin release via a specific intracellular signalling sequence. Arrange the following events in the correct order: (1) K^{+}_{ATP} channel closes; (2) glucose enters β-cell via GLUT2; (3) voltage-gated Ca^{2+} channels open; (4) ATP/ADP ratio rises; (5) insulin granule exocytosis.

(A) $4 \rightarrow 2 \rightarrow 1 \rightarrow 3 \rightarrow 5$

(B) $2 \rightarrow 4 \rightarrow 1 \rightarrow 3 \rightarrow 5$

(C) $2 \rightarrow 1 \rightarrow 4 \rightarrow 5 \rightarrow 3$

(D) $1 \rightarrow 2 \rightarrow 4 \rightarrow 3 \rightarrow 5$

Q17. A nutritionist discusses the role of choline in cellular metabolism. Choline is an essential nutrient found in egg yolk and soybeans. Which of the following correctly describes a metabolic role of choline?

(A) Precursor of phosphatidylcholine (lecithin), sphingomyelin, and acetylcholine; involved in methyl group metabolism via SAM

(B) Choline is the rate-limiting substrate for de novo purine synthesis

(C) Choline is converted to dopamine by choline acetyltransferase

(D) Choline is a cofactor for pyruvate carboxylase requiring biotin

Q18. During one complete turn of the TCA cycle, at which step is substrate-level phosphorylation (GTP production) carried out?

(A) Succinyl-CoA synthetase: succinyl-CoA + GDP + P_i $\rightarrow$ succinate + GTP + CoA

(B) Isocitrate dehydrogenase: isocitrate $\rightarrow$ α-ketoglutarate + CO_2

(C) Malate dehydrogenase: malate $\rightarrow$ oxaloacetate + NADH

(D) Aconitase: citrate $\rightarrow$ isocitrate (via cis-aconitate)

Q19. A pathology slide from a patient with hereditary haemochromatosis shows Prussian blue-positive granular deposits in hepatocytes. These deposits are insoluble iron aggregates. Compare the two principal forms of iron storage in the body:

(A) Ferritin: insoluble iron aggregate; haemosiderin: soluble 24-subunit protein shell

(B) Both ferritin and haemosiderin are equally soluble; differ only in location

(C) Haemosiderin stores Fe^{2+} in the ferrous state; ferritin stores Fe^{3+} in the ferric state

(D) Ferritin: soluble protein with apoferritin shell (up to 4500 Fe^{3+}); haemosiderin: insoluble partially degraded ferritin aggregate seen in iron overload

Q20. A 6-year-old child presents with jaundice, splenomegaly, and chronic haemolytic anaemia. A peripheral smear shows echinocytes and spherocytes. A fluorescent spot test is abnormal. Enzyme assay confirms pyruvate kinase (PK) deficiency. Which metabolite accumulates and what is its physiological consequence?

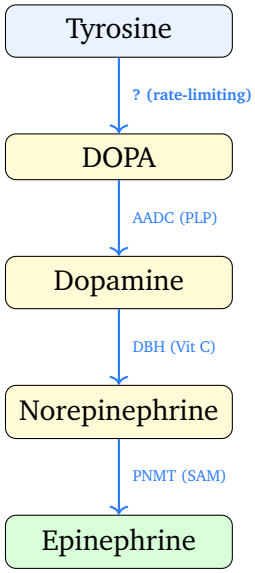
(A) 2,3-BPG accumulates; right-shifts O_2-Hb dissociation curve, improving O_2 delivery to tissues

(B) ATP accumulates; activates Na^+/K^+-ATPase, causing RBC dehydration

(C) Pyruvate accumulates; enters TCA cycle supporting ATP production

(D) Glucose-6-phosphate accumulates; protects against oxidative stress

Q21. A biochemistry lecture covers catecholamine biosynthesis. The pathway from tyrosine to epinephrine involves several enzymatic steps. Which enzyme catalyses the rate-limiting (first committed) step, and what cofactor does it require?



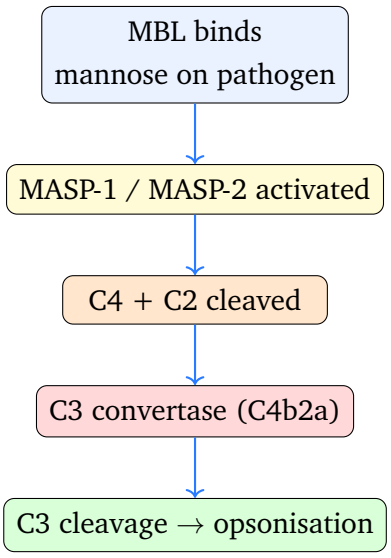
(A) Aromatic amino acid decarboxylase (AADC); cofactor pyridoxal phosphate (PLP)

(B) Tyrosine hydroxylase; cofactor tetrahydrobiopterin (BH_4)

(C) Dopamine β-hydroxylase (DBH); cofactor vitamin C (ascorbate)

(D) PNMT (phenylethanolamine N-methyltransferase); cofactor SAM

Q22. A patient with recurrent bacterial infections is found to have low serum levels of mannose-binding lectin (MBL). Immunological investigation shows failure of complement activation in the absence of antibodies. Which complement activation pathway is impaired?



(A) Classical pathway (requires IgM/IgG antibodies)

(B) Alternative pathway (requires Factor B, D, properdin)

(C) Lectin pathway (MBL + MASPs recognise microbial carbohydrates)

(D) Terminal complement pathway (C5b-9 membrane attack complex)

Q23. A neonate is born limp, with severe hypotonia, poor feeding, and refractory seizures. EEG shows burst suppression. CSF amino acid analysis shows glycine concentration disproportionately elevated compared to plasma (CSF:plasma glycine ratio >0.08). Plasma glycine is also elevated. Organic acids are normal. What is the most likely diagnosis and its enzymatic defect?

(A) Propionic acidaemia – propionyl-CoA carboxylase deficiency

(B) Non-ketotic hyperglycinaemia – defect in the glycine cleavage system (GCS), specifically the P, H, T, or L protein

(C) Glycine encephalopathy due to hyperprolinaemia type II

(D) Methylmalonic acidaemia – methylmalonyl-CoA mutase deficiency

Q24. A cardiologist considers starting a patient with severe hypertriglyceridaemia and low HDL on niacin (nicotinic acid) at 1.5 g/day. The patient asks about side effects. Which of the following correctly describes the pharmacological effects of high-dose niacin?

(A) Niacin activates PCSK9, reducing LDL receptor recycling, thereby modestly increasing LDL

(B) Niacin inhibits HMG-CoA reductase, primarily reducing LDL-cholesterol

(C) Niacin blocks bile acid reabsorption in the ileum, reducing total cholesterol

(D) Niacin inhibits hepatic VLDL secretion, reducing TG and LDL; raises HDL; causes prostaglandin-mediated flushing

Q25. A student reviewing connective tissue biochemistry notes that glycosaminoglycans (GAGs) are the major components of the extracellular matrix. Which statement about GAGs is correct?

(A) GAGs are linear polysaccharides of repeating disaccharide units; attached to core proteins they form proteoglycans; keratan sulphate and heparan sulphate are examples

(B) GAGs are branched polysaccharides similar in structure to glycogen

(C) GAGs are found exclusively in plasma membranes and serve as cell surface receptors

(D) GAGs are synthesised in the nucleus and exported to the cytoplasm for secretion

Q26. A patient with pernicious anaemia receives intramuscular cyanocobalamin injections. In the body, cyanocobalamin must be converted to active coenzyme forms. Which statement correctly pairs the active form of cobalamin with its enzyme-dependent reaction?

(A) Methylcobalamin is the cofactor for methylmalonyl-CoA mutase; adenosylcobalamin is the cofactor for methionine synthase

(B) Cyanocobalamin is itself the active cofactor used directly by methionine synthase

(C) Adenosylcobalamin is the cofactor for both methionine synthase and methylmalonyl-CoA mutase

(D) Methylcobalamin is the cofactor for methionine synthase; adenosylcobalamin is the cofactor for methylmalonyl-CoA mutase

Q27. A cell biology researcher studies how intracellular proteins are selectively degraded. She observes that short-lived regulatory proteins (e.g., cyclins) and misfolded proteins are tagged for destruction. Which pathway is responsible, and what is the energy requirement?

(A) Lysosomal autophagy – ATP-independent; non-selective bulk degradation

(B) Calpain-mediated degradation – calcium-dependent; degrades membrane proteins

(C) Ubiquitin-proteasome pathway – ATP-dependent; ubiquitin tags at lysine residues target protein to 26S proteasome

(D) Caspase cascade – requires cytochrome c release; responsible for all intracellular protein degradation

Q28. A physiology lecturer explains the mechanism by which thyroid hormone increases the basal metabolic rate (BMR). T3 acts on nuclear thyroid hormone receptors and upregulates several genes. Which biochemical mechanisms primarily account for the thermogenic effect of T3?

(A) Upregulation of Na^+/K^+-ATPase (increased futile ion cycling generating heat) and UCP-1 in brown adipose tissue (proton uncoupling)

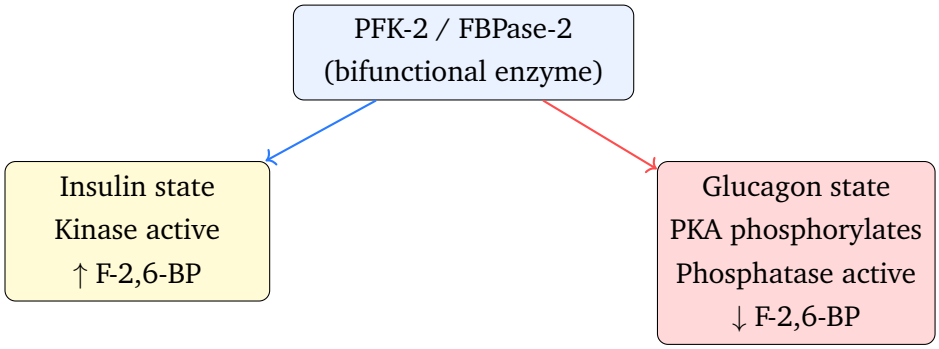
(B) Inhibition of glucokinase in the liver, reducing glucose phosphorylation

(C) Activation of fatty acid synthase, increasing lipogenesis and heat production

(D) Downregulation of mitochondrial biogenesis to reduce overall oxygen consumption

Q29. A molecular biology question describes a bifunctional enzyme with both kinase and phosphatase domains that regulates glycolysis and gluconeogenesis. When insulin is high, the kinase domain is active and produces fructose-2,6-bisphosphate (F-2,6-BP). When glucagon is high, PKA phosphorylates this enzyme, activating the phosphatase domain. Which enzyme is being described, and what is the net metabolic result of glucagon

stimulation?



(A) PFK-1/FBPase-1; glucagon increases F-2,6-BP promoting glycolysis

(B) PFK-2/FBPase-2; glucagon decreases F-2,6-BP, reducing PFK-1 activity and promoting gluconeogenesis

(C) Phosphoglucomutase; glucagon converts glucose-6-phosphate to glucose-1-phosphate

(D) Pyruvate kinase/pyruvate carboxylase; glucagon activates pyruvate kinase to increase glucose production

Q30. A toxicologist investigates a case of pesticide poisoning. The compound blocks electron transfer from iron-sulphur clusters to ubiquinone in the mitochondrial inner membrane, inhibiting Complex I. NADH cannot be oxidised and ATP synthesis halts. Which agent fits this description?

(A) Cyanide (CN^-) – inhibits Complex IV (cytochrome c oxidase)

(B) Antimycin A – inhibits Complex III at the Q_i site

(C) Oligomycin – inhibits ATP synthase (Complex V)

(D) Rotenone – inhibits Complex I (NADH-ubiquinone oxidoreductase)

Q31. During the folding of a newly synthesised polypeptide chain in the endoplasmic reticulum, a chaperone protein prevents premature or incorrect folding. A separate chaperonin complex in bacteria provides an enclosed hydrophilic chamber for proper folding of substrate proteins in an ATP-dependent manner. These molecular chaperones include:

(A) Ubiquitin and proteasome – tag and degrade all misfolded proteins without folding assistance

(B) Signal recognition particle (SRP) – facilitates protein folding in the cytoplasm

(C) Hsp70 (prevents premature folding during synthesis); GroEL/GroES (Hsp60 family, bacterial chaperonin folding chamber); BiP/GRP78 (ER chaperone)

(D) Ribosomes – directly fold proteins as they are translated, eliminating need for chaperones

Q32. Propionyl-CoA is generated from catabolism of odd-chain fatty acids and certain amino acids (valine, isoleucine, methionine, threonine). Propionyl-CoA is converted to succinyl-CoA in two steps. Which intermediate accumulates in vitamin B12 deficiency, and what is it used for diagnostically?

(A) Propionic acid accumulates; measured in plasma amino acid profile

(B) Methylmalonyl-CoA accumulates and is excreted as methylmalonic acid (MMA) in urine; elevated urinary MMA is a sensitive marker of B12 deficiency

(C) Succinyl-CoA accumulates and is detected by organic acid urine analysis

(D) Malonyl-CoA accumulates; detected by tandem mass spectrometry in newborn screening

Q33. A neuroscience lecture explains acetylcholine synthesis in presynaptic cholinergic terminals. Which enzyme directly synthesises acetylcholine, and what are the substrates?

(A) Acetylcholinesterase: acetylcholine + $H_2O \rightarrow$ choline + acetate (hydrolysis)

(B) Monoamine oxidase (MAO): degrades acetylcholine in the synaptic cleft

(C) Choline acetyltransferase (ChAT): choline + acetyl-CoA $\rightarrow$ acetylcholine + CoA

(D) Choline kinase: choline + ATP $\rightarrow$ phosphocholine + ADP

Q34. A biochemist studying insulin storage notes that insulin is stored as a hexameric complex in secretory granules of pancreatic β-cells. A specific divalent metal ion coordinates between insulin monomers to stabilise the hexameric form. Additionally, this same metal is found at the active site of carbonic anhydrase. Which metal is being described?

(A) Zinc (Zn^{2+}) – coordinates between insulin monomers in the hexameric storage form and is the active site metal of carbonic anhydrase

(B) Iron (Fe^{2+}) – carries oxygen in haemoglobin and is present in insulin granules

(C) Copper (Cu^{2+}) – found in ceruloplasmin and also stabilises insulin hexamers

(D) Magnesium (Mg^{2+}) – cofactor for ATP-dependent kinases including insulin receptor kinase

Q35. In de novo purine synthesis, the rate-limiting enzyme controls the first committed step by condensing a ribose derivative with glutamine. This enzyme is allosterically inhibited by the end products AMP and GMP. Identify the enzyme and its substrates:

(A) IMP cyclohydrolase: IMP $\rightarrow$ inosine $\rightarrow$ AMP/GMP

(B) ADSS (adenylosuccinate synthetase): IMP + aspartate $\rightarrow$ adenylosuccinate

(C) Amidophosphoribosyltransferase (PRPP amidotransferase): PRPP + glutamine $\rightarrow$ 5-phosphoribosylamine + PPi + glutamate

(D) Thymidylate synthase: dUMP $\rightarrow$ dTMP (pyrimidine, not purine, synthesis)

Q36. A hepatologist explains to a medical student why heavy drinkers develop tolerance to alcohol and increased liver injury. An enzyme system in the liver endoplasmic reticulum is induced by chronic alcohol use and contributes to oxidative stress via generation of free radicals. Which system is this?

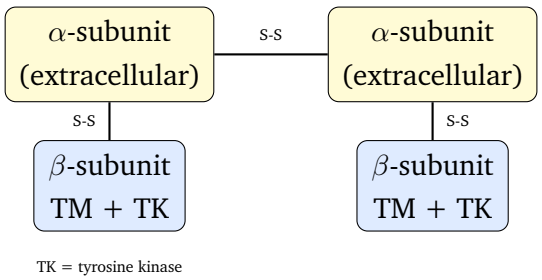
(A) Alcohol dehydrogenase (ADH) in the cytosol – induced by alcohol and is the main system even after induction

(B) Microsomal ethanol oxidizing system (MEOS) – CYP2E1, induced by chronic alcohol, uses NADPH and O_2, generates reactive oxygen species

(C) Catalase in peroxisomes – H_2O_2-dependent ethanol oxidation; becomes predominant in alcoholism

(D) Aldehyde dehydrogenase (ALDH) mitochondrial isoform – induced in alcoholics to remove acetaldehyde faster

Q37. Insulin binds to its receptor on target cells. The insulin receptor is unique compared to other hormone receptors. Which structural description correctly identifies the insulin receptor?



(A) Monomeric receptor with single transmembrane domain and serine/threonine kinase activity

(B) G-protein coupled receptor (GPCR) with seven transmembrane helices

(C) Nuclear receptor that directly binds DNA response elements after insulin binding

(D) Heterotetrameric receptor tyrosine kinase (RTK): $2\alpha + 2\beta$ subunits linked by disulphide bonds; β-subunits autophosphorylate on Tyr residues upon insulin binding

Q38. In the TCA cycle, isocitrate dehydrogenase catalyses the oxidative decarboxylation of isocitrate. This enzyme is considered one of the key regulatory enzymes of the cycle. Which of the following correctly describes its regulation and products?

(A) Isocitrate $\rightarrow$ α-ketoglutarate + CO_2 + NADH; activated by ADP and Ca^{2+}; inhibited by NADH and ATP

(B) Isocitrate $\rightarrow$ succinyl-CoA + CO_2 + $FADH_2$; activated by NAD^+

(C) Isocitrate $\rightarrow$ citrate (reverse reaction); activated by high ATP

(D) Isocitrate $\rightarrow$ oxaloacetate + CO_2 + NADPH; inhibited by AMP

Q39. Rigor mortis occurs in the hours following death. A forensic pathologist explains the biochemical basis. After death, ATP production ceases while myosin ATPase and other ATPases continue consuming residual ATP until depletion. How does ATP depletion cause rigor?

(A) Without ATP, myosin cannot detach from actin after the power stroke; the actin-myosin cross-bridges become locked (rigor state)

(B) ATP is needed to activate troponin; without ATP, troponin permanently blocks the myosin-binding sites on actin

(C) ATP depletion causes irreversible phosphorylation of myosin by ATP-independent kinases

(D) Loss of ATP causes K^+ efflux, permanently depolarising the sarcolemma and sustaining contraction

Q40. A 35-year-old woman with Wilson disease has low serum ceruloplasmin. A haematology textbook states that ceruloplasmin is a ferroxidase necessary for iron loading onto transferrin. Which statement correctly describes ceruloplasmin?

(A) Ceruloplasmin is a beta-globulin that stores copper in the liver and releases it to caeruloplasmin in plasma

(B) Ceruloplasmin is an iron storage protein equivalent to ferritin, found in erythrocytes

(C) Ceruloplasmin is an alpha-2 glycoprotein ferroxidase (contains 6–7 Cu atoms) that oxidises Fe^{2+} to Fe^{3+} for loading onto transferrin; low in Wilson disease, elevated in pregnancy

(D) Ceruloplasmin is produced in the spleen and transports haem iron from senescent erythrocytes to the liver

Detailed Solutions

Q1.

Solution

Concept – Carnitine shuttle (CPT-I / CPT-II): Long-chain fatty acids (LCFA, C>12) cannot cross the inner mitochondrial membrane as free acyl-CoA. Instead, the acyl group is transferred to carnitine by **CPT-I** on the **outer mitochondrial membrane**. Acylcarnitine is transported across by a translocase, and **CPT-II** on the inner membrane regenerates acyl-CoA inside the matrix for β-oxidation. **Malonyl-CoA inhibits CPT-I**, preventing futile cycling when fatty acid synthesis (which produces malonyl-CoA) is active. Short-chain and medium-chain FAs enter mitochondria independently of carnitine.

Distractors: (A) Short-chain FAs do *not* need carnitine – wrong. (B) CPT-I is on the *outer* membrane, and malonyl-CoA *inhibits* (not activates) it – wrong. (D) Malonyl-CoA *inhibits* CPT-I – wrong.

Final Answer: CPT-II transfers acyl group back to CoA inside the matrix. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – Cooperative (homotropic) allosteric binding in haemoglobin: Haemoglobin exhibits **homotropic** cooperativity – O_2 itself is both the substrate and the positive effector. Binding of O_2 to one α or β subunit induces a conformational change (T-state $\rightarrow$ R-state) that increases O_2 affinity of remaining subunits. This produces a **sigmoidal** O_2-binding curve described by the Hill equation (Hill coefficient $n \approx 2.8$ for Hb). 2,3-BPG is a *heterotropic* negative effector (different molecule, decreases affinity). Myoglobin shows hyperbolic (non-cooperative) binding.

Final Answer: Homotropic activation – O_2 promotes further O_2 binding cooperatively. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept – Cystinuria (SLC3A1/SLC7A9 defect): Cystinuria is an autosomal recessive defect in the **SLC3A1** (rBAT) / **SLC7A9** heterodimeric cationic amino

acid transporter expressed in the renal proximal tubule and intestinal epithelium. It fails to reabsorb the COLA group: **C**ystine, **O**rnithine, **L**ysine, **A**rginine. Only cystine is insoluble at normal urine pH, forming **hexagonal, radiolucent** kidney stones. Treatment: high fluid intake, urine alkalinisation (citrate), D-penicillamine (chelates cystine). Hartnup disease affects neutral amino acid transport.

Final Answer: Cationic amino acid transporter (SLC3A1/SLC7A9) in renal tubule and intestine. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept – Glucagon-stimulated glycogenolysis cascade: Glucagon $\rightarrow$ GPCR (Gs) $\rightarrow$ adenylyl cyclase $\rightarrow \uparrow$cAMP $\rightarrow$ PKA activated $\rightarrow$ PKA phosphorylates **phosphorylase kinase** (activating it) $\rightarrow$ phosphorylase kinase phosphorylates **glycogen phosphorylase b** converting it to active **phosphorylase a** $\rightarrow$ glycogen $\rightarrow$ glucose-1-phosphate $\rightarrow$ glucose-6-phosphate $\rightarrow$ (G6Pase in liver) $\rightarrow$ free glucose released into blood. Simultaneously, PKA phosphorylates and **inactivates** glycogen synthase (preventing futile cycling).

Final Answer: Glucagon $\rightarrow$ cAMP $\rightarrow$ PKA $\rightarrow$ phosphorylase kinase activated $\rightarrow$ glycogen phosphorylase b converted to a. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – Biotin deficiency from raw egg white (avidin): Raw egg white contains **avidin**, a glycoprotein that binds biotin with extraordinary affinity ($K_d \sim 10^{-15}$ M – among the tightest non-covalent interactions in biology). This prevents intestinal absorption of dietary biotin. **Cooking** denatures avidin, eliminating the binding. Biotin is the cofactor for carboxylases: pyruvate carboxylase, ACC (acetyl-CoA carboxylase), propionyl-CoA carboxylase, and β-methylcrotonyl-CoA carboxylase. Deficiency causes dermatitis, alopecia, conjunctivitis, and neurological symptoms.

Final Answer: Avidin in raw egg white binds biotin with extremely high affinity, preventing intestinal absorption. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q5

Q6.

Solution

Concept – N-acetylglutamate (NAG) as essential allosteric activator of CPS-I: Carbamoyl phosphate synthetase I (CPS-I) initiates the urea cycle by combining NH_3 + CO_2 + 2 ATP $\rightarrow$ carbamoyl phosphate. CPS-I is **absolutely dependent** on **N-acetylglutamate (NAG)** as an allosteric activator. NAG is synthesised by **NAG synthase** from acetyl-CoA + glutamate, and NAG synthase is itself activated by arginine. When arginine is high (protein catabolism), more NAG is made, activating CPS-I and accelerating the urea cycle. NAG synthase deficiency mimics CPS-I deficiency clinically.

Final Answer: N-acetylglutamate (NAG). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept – SDS-PAGE (denaturing gel electrophoresis): SDS (sodium dodecyl sulphate) is an anionic detergent that denatures proteins and binds to them in proportion to their mass, conferring a **uniform negative charge per unit length**. β-mercaptoethanol reduces disulphide bonds. Since all proteins have the same charge-to-mass ratio, separation is entirely by **molecular weight**: smaller proteins migrate faster through the polyacrylamide matrix. Proteins are visualised by Coomassie brilliant blue or silver stain. Native PAGE (no SDS) separates by size and charge; isoelectric focusing separates by pI.

Final Answer: Molecular weight (size) alone, because SDS confers uniform negative charge. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – Lineweaver-Burk plot interpretation (non-competitive inhibition): On a double-reciprocal plot (1/v vs 1/[S]): the **y-intercept = 1/V_{max}** and the **x-intercept = $-$1/K_m**. When the x-intercept is **unchanged** (same $-1/K_m$, same K_m) but the y-intercept **increases** (higher $1/V_{max}$, lower V_{max}), this is **non-**

competitive inhibition. The inhibitor binds a site other than the active site, does not compete with substrate (K_m unchanged), but reduces catalytic efficiency of every enzyme molecule (V_{max} falls). Competitive inhibitors: same y-intercept, x-intercept shifts; uncompetitive: both intercepts shift (parallel lines in L-B plot).

Final Answer: Non-competitive inhibition: K_m unchanged, V_{max} decreased. $\Rightarrow$ $\boxed{D}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept – G6PD deficiency and NADPH production via pentose phosphate pathway: Glucose-6-phosphate dehydrogenase (G6PD) is the first and rate-limiting enzyme of the **pentose phosphate pathway (PPP)** / hexose monophosphate shunt. It produces **NADPH**, which is essential for regenerating reduced glutathione (GSH) via glutathione reductase. GSH protects RBCs against oxidative damage. G6PD deficiency causes **haemolytic anaemia** triggered by oxidative stress (primaquine, dapsone, fava beans, infections). X-linked; most common enzyme deficiency in humans (>400 million affected worldwide).

Final Answer: Pentose phosphate pathway – G6PD produces NADPH. $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept – Oligomycin inhibits Complex V (F_0 subunit of ATP synthase): Oligomycin is a macrolide antibiotic that specifically blocks the **F_0 proton channel** of ATP synthase (Complex V). By preventing proton re-entry into the matrix through ATP synthase, it stops ATP synthesis. Because protons cannot flow through F_0, the proton gradient **builds up** (increases) and the electron transport chain (which pumps protons) slows due to back-pressure. This distinguishes oligomycin (ETC slows secondarily) from uncouplers like DNP (ETC speeds up because proton gradient collapses).

Final Answer: ATP synthase (Complex V, F_0 subunit proton channel). $\Rightarrow$ $\boxed{C}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – Sickle cell disease (HbS) – molecular basis: Sickle cell disease results from a **point mutation** in the **HBB** gene on chromosome 11: **codon 6 GAG → GTG**, substituting **glutamate (Glu)** with **valine (Val)** in the β-globin chain. Valine is hydrophobic and, when deoxygenated, HbS polymerises into long fibres that distort the RBC into a sickle shape. Heterozygotes (HbAS, sickle cell trait) are protected against P. falciparum malaria (evolutionary positive selection in endemic regions). α-Thalassaemia involves α-globin gene deletions.

Final Answer: Point mutation HBB codon 6 GAG→GTG; Glu → Val substitution in β-globin. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept – Lipoprotein(a) [Lp(a)] and fibrinolysis inhibition: Lp(a) consists of an LDL-like particle with **apolipoprotein(a) [apo(a)]** covalently linked to **ApoB-100** via a disulphide bond. Apo(a) contains multiple **kringle domains** with high structural homology to **plasminogen**. This structural mimicry allows Lp(a) to **competitively inhibit plasminogen binding** to fibrin and to endothelial plasminogen receptors, thereby reducing fibrinolysis and promoting thrombosis. Lp(a) is an independent cardiovascular risk factor; levels are >90% genetically determined and not reduced by statins.

Final Answer: Apo(a) homology to plasminogen competitively inhibits fibrinolysis. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept – Xeroderma pigmentosum (XP) and nucleotide excision repair (NER): XP is an autosomal recessive disorder caused by defects in the **nucleotide excision repair (NER)** pathway. NER is the principal mechanism for removing **bulky DNA adducts** including UV-induced **cyclobutane pyrimidine dimers (CPDs)** and 6-4 photoproducts. NER involves damage recognition, dual incision around the lesion (removing an oligonucleotide of ~27-30 bases), resynthesis, and ligation. At least 8 XP complementation groups (XPA–XPG + XPV). Clinical

features: extreme UV photosensitivity, early skin cancers, and neurological involvement in some groups. MMR fixes replication mismatches; BER fixes small base lesions.

Final Answer: Nucleotide excision repair (NER). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q13

Q14.

Solution

Concept – Time course of liver glycogen depletion in fasting: The liver contains $\sim$70–100 g of glycogen which is the primary buffer of blood glucose during the early post-absorptive period. Liver glycogen is typically **depleted within 12–18 hours** of complete fasting. After this point, the brain and other glucose-dependent tissues rely entirely on **gluconeogenesis** (primarily from amino acids – alanine/glutamine, lactate via Cori cycle, and glycerol). **Muscle glycogen** (300–400 g) cannot contribute to blood glucose because muscle **lacks glucose-6-phosphatase**; it serves only for local energy use.

Final Answer: 12–18 hours; after which gluconeogenesis becomes the primary glucose source. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – Cori disease (GSD Type III) – debranching enzyme deficiency: GSD Type III (Cori disease / Forbes disease) is caused by deficiency of the **debranching enzyme** (amylo-1,6-glucosidase + 4-α-glucanotransferase activity). Glycogen phosphorylase can degrade the outer branches of glycogen until it reaches within 4 residues of a branch point – producing a **limit dextrin** which cannot be further degraded without the debranching enzyme. Unlike Von Gierke (Type I), gluconeogenesis is intact, so hypoglycaemia is milder. Muscle may also be affected. Pompe (Type II) has acid maltase deficiency with cardiomyopathy.

Final Answer: Type III (Cori disease) – debranching enzyme deficiency. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – Insulin release from pancreatic β-cells: The correct sequence is: (2) Glucose enters β-cell via **GLUT2** (high-Km transporter; glucose entry proportional to blood glucose) $\rightarrow$ (4) glycolysis raises **ATP/ADP ratio** $\rightarrow$ (1) elevated ATP **closes K^+_{ATP} channels** $\rightarrow$ membrane depolarises $\rightarrow$ (3) voltage-gated **Ca^{2+} channels open** $\rightarrow$ Ca^{2+} influx $\rightarrow$ (5) **insulin granule exocytosis**. Sulphonylureas (glibenclamide) close K^+_{ATP} channels independently of glucose, stimulating insulin secretion.

Final Answer: Sequence 2 $\rightarrow$ 4 $\rightarrow$ 1 $\rightarrow$ 3 $\rightarrow$ 5. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept – Choline metabolism: Choline is an essential nutrient (conditionally essential; synthesised de novo from phosphatidylethanolamine via PEMT using **SAM** as methyl donor, but synthesis is insufficient to meet needs). Choline is the precursor of: (i) **phosphatidylcholine (lecithin)** – major phospholipid of cell membranes and lipoproteins; (ii) **sphingomyelin** (together with ceramide); (iii) **acetylcholine** (neurotransmitter) – choline + acetyl-CoA $\rightarrow$ ACh (via ChAT). It also donates methyl groups via betaine in the methionine cycle. Dietary sources: egg yolk, liver, soybeans, wheat germ.

Final Answer: Choline is a precursor of phosphatidylcholine, sphingomyelin, and acetylcholine; involved in methyl group metabolism via SAM. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – Substrate-level phosphorylation in TCA cycle (succinyl-CoA synthetase): In the TCA cycle, there is **one step of substrate-level phosphorylation**: **succinyl-CoA synthetase** (succinate thiokinase) catalyses: **Succinyl-CoA + GDP + P_i $\rightarrow$ Succinate + GTP + CoA**. In mammals, the mitochondrial enzyme uses GDP (producing GTP); in some tissues the ADP-linked isoform produces ATP directly. The GTP can be converted to ATP by nucleoside diphosphate kinase. The other NADH-generating steps (isocitrate DH, α-KG DH, malate DH) and the $FADH_2$-generating step (succinate DH) contribute to oxidative phosphorylation,

not substrate-level phosphorylation.

Final Answer: Succinyl-CoA synthetase: succinyl-CoA + GDP + P_i $\rightarrow$ succinate + GTP + CoA. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept – Ferritin vs haemosiderin (iron storage): Ferritin is the primary, **soluble** iron storage protein: a 24-subunit protein shell (apoferritin) that can accommodate up to 4500 atoms of **Fe^{3+}** in its core. Serum ferritin reflects total body iron stores. **Haemosiderin** is an **insoluble**, partly degraded aggregate of ferritin, seen in tissues with iron overload (haemochromatosis, haemosiderosis, transfusion-related iron overload). Prussian blue stain (potassium ferrocyanide) detects haemosiderin as blue granules in tissue sections. In severe iron overload, liver haemosiderin $\rightarrow$ fibrosis $\rightarrow$ cirrhosis.

Final Answer: Ferritin: soluble, apoferritin shell storing Fe^{3+}; haemosiderin: insoluble partially degraded ferritin aggregate in iron overload. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – Pyruvate kinase (PK) deficiency – 2,3-BPG accumulation: PK catalyses the last step of glycolysis (PEP $\rightarrow$ pyruvate + ATP). Its deficiency blocks glycolysis at this step, causing upstream accumulation of glycolytic intermediates including **2,3-bisphosphoglycerate (2,3-BPG)**. 2,3-BPG binds the central cavity of deoxyhaemoglobin and **right-shifts** the O_2-haemoglobin dissociation curve, reducing O_2 affinity and improving O_2 delivery to peripheral tissues. This partially compensates for the anaemia. ATP depletion reduces RBC deformability, causing extravascular haemolysis. Inheritance: autosomal recessive.

Final Answer: 2,3-BPG accumulates; right-shifts O_2-Hb dissociation curve, improving O_2 delivery. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept – Catecholamine biosynthesis – rate-limiting step: The biosynthetic pathway: Tyrosine $\xrightarrow{\text{Tyrosine hydroxylase (TH)}}$ DOPA $\xrightarrow{\text{AADC (PLP)}}$ Dopamine $\xrightarrow{\text{DBH (Vit C)}}$ Norepinephrine $\xrightarrow{\text{PNMT (SAM)}}$ Epinephrine. **Tyrosine hydroxylase (TH)** is the **rate-limiting enzyme**; its cofactor is **tetrahydrobiopterin (BH_4)**. TH is inhibited by end-product feedback (catecholamines compete with BH_4). AADC uses PLP; DBH requires ascorbate (Vitamin C) and copper; PNMT requires SAM as methyl donor and is induced by glucocorticoids from the adrenal cortex.

Final Answer: Tyrosine hydroxylase; cofactor tetrahydrobiopterin (BH_4). $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – Complement lectin pathway (MBL / MASPs): The **lectin pathway** is activated when **mannose-binding lectin (MBL)** recognises **terminal mannose/GlcNAc** residues on microbial surfaces. MBL is associated with **MASP-1 and MASP-2** (MBL-associated serine proteases). MASP-2 cleaves **C4** and **C2** to form the C3 convertase **C4b2a** – identical to the classical pathway C3 convertase. This is antibody-independent innate immunity. MBL deficiency causes recurrent bacterial infections in young children. The alternative pathway uses C3, Factor B, D, and properdin (spontaneous C3 hydrolysis on foreign surfaces).

Final Answer: Lectin pathway – MBL + MASPs recognise microbial carbohydrates. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q22

Q23.

Solution

Concept – Non-ketotic hyperglycinaemia (NKH) – glycine cleavage system defect: NKH (glycine encephalopathy) is caused by deficiency of one of the four components of the **glycine cleavage system (GCS)**: **P-protein** (pyridoxal-phosphate-dependent glycine decarboxylase), **H-protein** (lipoic acid-containing carrier), **T-protein** (THF-dependent aminomethyltransferase), or **L-protein** (dihydrolipoamide dehydrogenase). Glycine accumulates and crosses the blood-brain barrier; elevated CSF glycine acts as a **co-agonist at NMDA receptors** causing excitotoxicity. Neonatal presentation with hypotonia, seizures, and apnoea. No

ketosis (differentiates from organic acidaemias). Organic acids normal (differentiates from MMA and propionic acidaemia).

Final Answer: Non-ketotic hyperglycinaemia – glycine cleavage system (GCS) defect. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept – Niacin (nicotinic acid) pharmacological effects at high doses: At pharmacological doses (1–2 g/day), niacin: (i) **inhibits hepatic VLDL secretion** (by inhibiting diacylglycerol acyltransferase-2 and reducing lipolysis in adipose tissue via GPR109A), reducing TG and subsequently LDL; (ii) **raises HDL** by reducing catabolism of ApoA-I; (iii) reduces Lp(a). Side effect: **cutaneous flushing** due to prostaglandin D_2 and E_2 release from Langerhans cells (reduced by aspirin premedication or extended-release formulations). Hepatotoxicity with extended-release formulations. It does not work via statin (HMG-CoA reductase), ezetimibe (cholesterol absorption), or bile acid sequestrant mechanisms.

Final Answer: Niacin inhibits hepatic VLDL secretion, reduces TG and LDL, raises HDL; prostaglandin-mediated flushing. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – Glycosaminoglycans (GAGs) and proteoglycans: GAGs are **unbranched (linear)** polysaccharides of repeating **disaccharide units** (one amino sugar + one uronic acid or galactose). Types include: heparan sulphate (GlcA/IdoA + GlcNAc/GlcNS), chondroitin sulphate, dermatan sulphate, keratan sulphate (galactose + GlcNAc-SO_4), and hyaluronan. GAGs are covalently attached to **core proteins** forming **proteoglycans**. They are highly negatively charged (sulphate and carboxylate groups), attract water, and are abundant in extracellular matrix (cartilage, basement membranes, cornea). Mucopolysaccharidoses arise from defects in lysosomal GAG-degrading enzymes.

Final Answer: Linear polysaccharide disaccharide repeats; attached to core proteins $\rightarrow$ proteoglycans; examples: keratan sulphate, heparan sulphate. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept – Active cobalamin coenzyme forms (methylcobalamin vs adenosylcobalamin): Cyanocobalamin (pharmacological) is converted in the body to two active coenzyme forms: (i) **Methylcobalamin** – cofactor for **methionine synthase**: 5-methylTHF + homocysteine → THF + methionine (remethylation); (ii) **Adenosylcobalamin** – cofactor for **methylmalonyl-CoA mutase**: methylmalonyl-CoA → succinyl-CoA. B12 deficiency impairs *both* reactions: ↑homocysteine + ↑methylmalonic acid. Folate trap results from methylcobalamin deficiency (5-methylTHF accumulates, cannot be demethylated to THF without B12).

Final Answer: Methylcobalamin → methionine synthase; adenosylcobalamin → methylmalonyl-CoA mutase. ⇒ $\boxed{D}$

Answer: (D) Go Back to Q26

Q27.

Solution

Concept – Ubiquitin-proteasome pathway (UPP): The UPP is the principal cytoplasmic proteolysis system for **short-lived, regulatory, and misfolded proteins**. Process: (i) **Ubiquitin** (76-aa) is activated by E1 (ubiquitin-activating enzyme) using ATP → transferred to E2 (conjugating enzyme) → E3 ligase transfers ubiquitin to a Lys residue on the substrate; (ii) polyubiquitin chain (Lys48-linked) is recognised by the **26S proteasome**; (iii) the 26S proteasome (20S catalytic barrel + 19S regulatory caps) unfolds and degrades the protein into peptides. Examples: cyclins, p53, IkB, misfolded CFTR. **ATP-dependent** process.

Final Answer: Ubiquitin-proteasome pathway – ATP-dependent; polyubiquitin tag → 26S proteasome degradation. ⇒ $\boxed{C}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept – Thyroid hormone thermogenesis mechanisms: T3 (the active form, derived from T4 deiodination) acts on **nuclear thyroid hormone receptors (TRα/TRβ)** and transcriptionally upregulates: (i) **Na^+/K^+-ATPase** – the major energy-consuming enzyme in most cells; increased expression means more ATP is consumed just for ion pumping, generating heat; (ii) **UCP-1 (uncoupling protein-1)** in brown adipose tissue – allows proton re-entry into the matrix bypassing ATP

synthase, dissipating the proton gradient as heat (non-shivering thermogenesis); (iii) mitochondrial biogenesis and oxidative enzymes. Net: increased BMR and heat production.

Final Answer: Upregulation of Na^+/K^+-ATPase and UCP-1 (thermogenesis). $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – PFK-2/FBPase-2 bifunctional enzyme and fructose-2,6-bisphosphate regulation: A single bifunctional enzyme has (i) **PFK-2 kinase** domain: phosphorylates fructose-6-phosphate $\rightarrow$ **fructose-2,6-bisphosphate (F-2,6-BP)**; (ii) **FBPase-2 phosphatase** domain: hydrolyses F-2,6-BP back to fructose-6-phosphate. **Insulin** $\rightarrow$ protein phosphatase activated $\rightarrow$ dephosphorylates the enzyme $\rightarrow$ **kinase domain active** $\rightarrow \uparrow$F-2,6-BP $\rightarrow \uparrow$PFK-1 activity $\rightarrow$ glycolysis. **Glucagon** $\rightarrow$ cAMP $\rightarrow$ PKA $\rightarrow$ phosphorylates enzyme $\rightarrow$ **phosphatase domain active** $\rightarrow \downarrow$F-2,6-BP $\rightarrow \downarrow$PFK-1, $\uparrow$FBPase-1 $\rightarrow$ gluconeogenesis favoured.

Final Answer: PFK-2/FBPase-2; glucagon decreases F-2,6-BP, reducing PFK-1 and promoting gluconeogenesis. $\Rightarrow$ $\boxed{B}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – Rotenone (Complex I inhibitor): Rotenone is a plant-derived compound (used as a pesticide and piscicide) that **inhibits Complex I** (NADH-ubiquinone oxidoreductase) by blocking the transfer of electrons from the terminal **iron-sulphur (Fe-S) cluster** (N-2) to **ubiquinone (CoQ)**. NADH cannot be re-oxidised; ATP synthesis halts. Rotenone is associated with Parkinson-like neurodegeneration in rodents (selective dopaminergic neuron loss). Compare: **cyanide/CO** $\rightarrow$ Complex IV; **antimycin A** $\rightarrow$ Complex III (Q_i site); **oligomycin** $\rightarrow$ Complex V.

Final Answer: Rotenone – inhibits Complex I (NADH-ubiquinone oxidoreductase). $\Rightarrow$ $\boxed{D}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – Molecular chaperones and chaperonins: Hsp70 (cytoplasm) binds hydrophobic segments of nascent polypeptides, preventing premature aggregation during synthesis. **GroEL/GroES** (bacterial Hsp60 family): GroEL is a 14-mer (two 7-mer rings); GroES caps one end; the substrate protein is enclosed in the **hydrophilic chamber** and given multiple ATP-dependent folding attempts. Eukaryotic equivalent: TRiC/CCT. **BiP (GRP78)** is the Hsp70 homologue in the ER lumen, recognising misfolded glycoproteins and triggering the unfolded protein response (UPR). **Hsp90** stabilises steroid receptors and signalling kinases. Chaperones do not add information but provide an isolated environment.

Final Answer: Hsp70 (premature folding prevention); GroEL/GroES (bacterial folding chamber); BiP/GRP78 (ER chaperone). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – Methylmalonyl-CoA and B12 deficiency (methylmalonic acid): Propionyl-CoA is carboxylated to **(D)-methylmalonyl-CoA** by propionyl-CoA carboxylase (biotin-dependent). A racemase converts D- to **(L)-methylmalonyl-CoA**. **Methylmalonyl-CoA mutase** (adenosylcobalamin-dependent) converts L-methylmalonyl-CoA $\rightarrow$ **succinyl-CoA** (TCA cycle entry). In **B12 deficiency**, the mutase is non-functional: methylmalonyl-CoA accumulates and is hydrolysed to **methylmalonic acid (MMA)**, excreted in urine. Elevated urinary MMA is the most sensitive marker of cellular B12 deficiency, distinguishing it from folate deficiency (which raises homocysteine but not MMA).

Final Answer: Methylmalonyl-CoA accumulates; excreted as methylmalonic acid in urine – sensitive B12 deficiency marker. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q32

Q33.

Solution

Concept – Acetylcholine synthesis (ChAT): Acetylcholine (ACh) is synthesised in the presynaptic terminal by **choline acetyltransferase (ChAT)**: **Choline + Acetyl-CoA $\rightarrow$ Acetylcholine + CoA**. Choline is transported into the terminal by the **high-affinity choline transporter (ChT1, SLC5A7)** – this uptake step is rate-limiting

under conditions of high cholinergic activity. ACh is then packaged into vesicles via VAChT (vesicular ACh transporter). After exocytosis, ACh is rapidly hydrolysed by **acetylcholinesterase (AChE)** in the synapse to choline + acetate. Choline is recycled back into the terminal.

Final Answer: Choline acetyltransferase (ChAT): choline + acetyl-CoA $\rightarrow$ acetylcholine + CoA. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q33

Q34.

Solution

Concept – Zinc in insulin storage and carbonic anhydrase: In pancreatic β-cell secretory granules, insulin is stored as a **Zn^{2+}-hexameric complex**: two **Zn^{2+} ions** coordinate the imidazole groups of **His-B10** from three insulin dimers, creating a stable hexamer. Upon secretion into the portal blood, the hexamers dissociate into monomers (the biologically active form) as zinc concentration falls. Additionally, **zinc** is the catalytic metal in **carbonic anhydrase** (Zn^{2+} at the active site activates water for CO_2 hydration: $CO_2 + H_2O \rightleftharpoons H_2CO_3$). Zinc is also in alcohol dehydrogenase, DNA polymerase, and many transcription factor zinc fingers.

Final Answer: Zinc (Zn^{2+}) – stabilises insulin hexamers; active site metal of carbonic anhydrase. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q34

Q35.

Solution

Concept – PRPP amidotransferase (rate-limiting step of purine de novo synthesis): De novo purine synthesis builds the purine ring on PRPP (phosphoribosyl pyrophosphate – an activated ribose). The **rate-limiting, committed step** is catalysed by **amidophosphoribosyltransferase (PRPP amidotransferase / glutamine PRPP amidotransferase)**: **PRPP + glutamine $\rightarrow$ 5-phosphoribosylamine (PRA) + PPi + glutamate**. This enzyme is **allosterically inhibited** by AMP and GMP (end-product feedback). PRPP itself (elevated in gout, HGPRT deficiency) drives increased de novo synthesis. The subsequent 10 steps build IMP, from which AMP and GMP branch.

Final Answer: Amidophosphoribosyltransferase (PRPP amidotransferase): PRPP + glutamine $\rightarrow$ 5-phosphoribosylamine + PPi + glutamate. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q35

Q36.

Solution

Concept – MEOS (CYP2E1) induction by chronic alcohol: At low-to-moderate alcohol intake, **cytosolic alcohol dehydrogenase (ADH)** is the primary enzyme. At high/chronic intake, the **microsomal ethanol oxidising system (MEOS)** is induced: the key enzyme is **CYP2E1** (a cytochrome P450 isoform in the smooth ER). MEOS: Ethanol + NADPH + $O_2 \rightarrow$ acetaldehyde + $NADP^+$ + H_2O. CYP2E1 induction explains alcohol tolerance (greater alcohol metabolism). Critically, CYP2E1 also generates **reactive oxygen species (ROS)** including superoxide, hydroxyl radical, and lipid peroxidation products, contributing to alcoholic hepatitis, fibrosis, and cirrhosis.

Final Answer: MEOS (CYP2E1) – induced by chronic alcohol; generates ROS causing oxidative liver injury. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q36

Q37.

Solution

Concept – Insulin receptor structure (heterotetrameric RTK): The insulin receptor is a **receptor tyrosine kinase (RTK)** with a unique heterotetrameric structure: **2** α**-subunits** (extracellular; contain the insulin binding site) + **2** β**-subunits** (transmembrane + intracellular tyrosine kinase domain), all linked by **disulphide bonds** (α-α and α-β). Insulin binding causes **autophosphorylation** of Tyr residues on the β subunits $\rightarrow$ recruits IRS-1/IRS-2 $\rightarrow$ PI3K $\rightarrow$ Akt/PKB $\rightarrow$ GLUT4 translocation, glycogen synthesis, protein synthesis. Distinct from GPCRs (glucagon, adrenaline), nuclear receptors (thyroid, steroid hormones), and cytokine receptors (JAK-STAT).

Final Answer: Heterotetrameric RTK: 2α (extracellular) + 2β (TM + tyrosine kinase); disulphide-linked; autophosphorylates on Tyr. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q37

Q38.

Solution

Concept – Isocitrate dehydrogenase (ICDH) regulation in TCA cycle: Isocitrate dehydrogenase (mitochondrial, NAD^+-linked) catalyses: **Isocitrate + NAD^+ $\rightarrow$ α-ketoglutarate + CO_2 + NADH**. This is an **oxidative decarboxylation** producing one NADH and one CO_2 per turn. Regulation: **Activated** by ADP (low energy) and **Ca^{2+}** (links muscle contraction to metabolism); **inhibited** by NADH (product inhibition) and ATP (high energy). It is widely considered a key rate-limiting step of the TCA cycle. There is also a cytoplasmic $NADP^+$-linked isoform (IDH1, mutated in glioma/AML) that produces NADPH.

Final Answer: Isocitrate $\rightarrow$ α-ketoglutarate + CO_2 + NADH; activated by ADP and Ca^{2+}; inhibited by NADH and ATP. $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q38

Q39.

Solution

Concept – Rigor mortis and the actin-myosin cross-bridge cycle: During normal muscle contraction, the cross-bridge cycle requires ATP at each step: ATP binding to myosin $\rightarrow$ myosin detaches from actin $\rightarrow$ ATP hydrolysis cocks the myosin head $\rightarrow$ Pi release triggers the power stroke $\rightarrow$ ADP release $\rightarrow$ **rigor complex** (unless new ATP binds). After death, ATP production ceases. Residual ATP is consumed rapidly. Without ATP, **myosin cannot detach from actin** after the power stroke – the cross-bridges remain permanently locked in the **rigor state**, causing muscle rigidity. Rigor mortis typically begins 2–6 hours post-mortem, peaks at 12 hours, and resolves by 48–72 hours as proteolysis degrades the cross-bridges.

Final Answer: Without ATP, myosin cannot detach from actin; cross-bridges locked in rigor state. $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q39

Q40.

Solution

Concept – Ceruloplasmin (copper-containing ferroxidase): Ceruloplasmin is an **alpha-2 glycoprotein** synthesised by **hepatocytes**. It contains **6–7 copper atoms** per molecule and functions as a **ferroxidase**: it oxidises **Fe^{2+} (ferrous)** $\rightarrow$ **Fe^{3+} (ferric)**, which is the form loaded onto **transferrin** for plasma transport. Low ceruloplasmin in **Wilson disease** (ATP7B copper transport defect) causes copper

accumulation in liver, brain, and cornea (Kayser-Fleischer rings). Low in **Menkes disease** (copper deficiency due to ATP7A defect). Increased in pregnancy (oestrogen stimulates synthesis), OCP use, and as an **acute phase protein** in inflammation.

Final Answer: Alpha-2 glycoprotein ferroxidase (6–7 Cu atoms); oxidises Fe^{2+} to Fe^{3+} for transferrin loading; low in Wilson disease. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q40

Answer Key – FMGE Biochemistry Sample Paper 5

1	C	2	B	3	B	4	A	5	B
6	C	7	D	8	D	9	A	10	C
11	B	12	D	13	C	14	C	15	D
16	B	17	A	18	A	19	D	20	A
21	B	22	C	23	B	24	D	25	A
26	D	27	C	28	A	29	B	30	D
31	C	32	B	33	C	34	A	35	C
36	B	37	D	38	A	39	A	40	C