intersect@finish

FMGE Biochemistry Sample Paper – 7

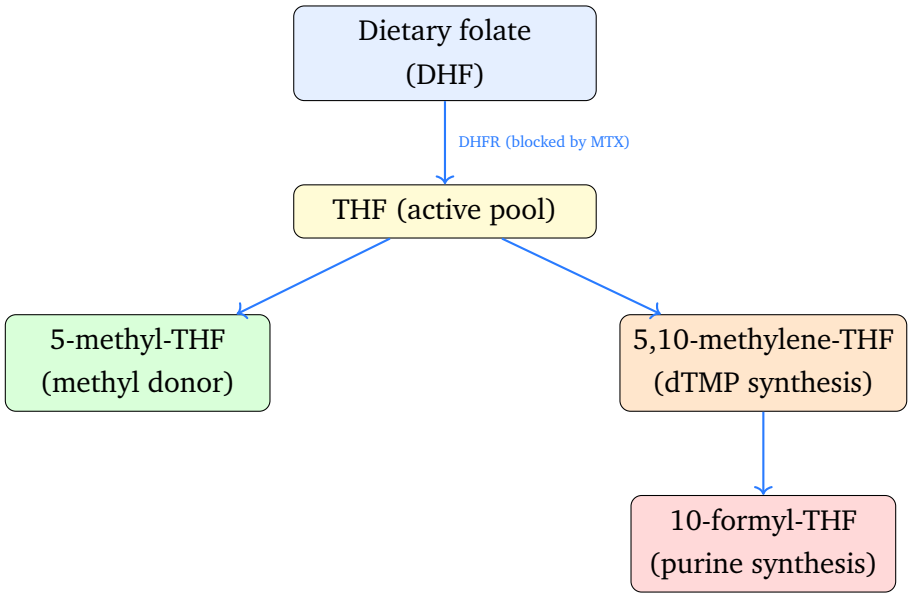
Duration: 60 Minutes **Maximum Marks: 40**

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 28-year-old woman undergoing treatment for acute lymphoblastic leukaemia develops megaloblastic anaemia and oral mucositis after two weeks of methotrexate therapy. Her physician explains that the drug blocks folate activation. The **active coenzyme form** of folate that directly donates a methyl group to homocysteine via methionine synthase is:



(A) 10-Formyl-THF

(B) 5,10-Methylene-THF

(C) 5-Methyl-THF

(D) Dihydrofolate (DHF)

Q2. An enzyme preparation is tested in a kinetic experiment at saturating substrate concentrations. A total enzyme concentration of 2×10^{-8} mol/L converts 4×10^{-4} mol/L of substrate per second. The turnover number (k_{cat}) of this enzyme is:

(A) 2×10^{4} s^{-1}

(B) 2×10^{-4} s^{-1}

(C) 8×10^{-12} s^{-1}

(D) 4×10^{4} s^{-1}

Q3. A 4-year-old boy presents with coarse facial features, corneal clouding, hepatosplenomegaly, cardiac valvular disease, and developmental regression. X-ray shows dysostosis multiplex. Urine shows elevated dermatan and heparan sulfate. Enzyme assay reveals absent α-L-iduronidase activity. Which of the following best describes this disorder?

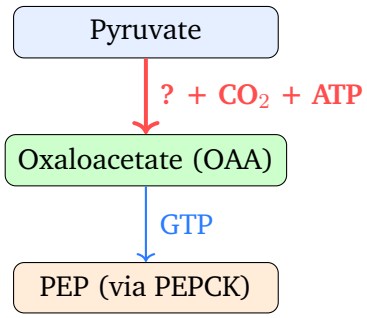
(A) Hunter syndrome (MPS II)

(B) Morquio syndrome (MPS IV)

(C) Hurler syndrome (MPS I-H)

(D) Sanfilippo syndrome (MPS III)

Q4. During prolonged fasting, a 55-year-old man begins gluconeogenesis in the liver. Pyruvate must first be converted to oxaloacetate (OAA) before entering the gluconeogenic pathway. The enzyme catalysing this reaction requires biotin as a cofactor and is activated by acetyl-CoA. Which enzyme is this?



(A) Pyruvate carboxylase

(B) Pyruvate dehydrogenase

(C) PEPCK

(D) Malic enzyme

Q5. A premature neonate develops haemorrhagic disease on day 2 of life. The paediatrician notes that the infant was not given an injection at birth. Investigation reveals prolonged PT and APTT but normal platelet count. Vitamin K is synthesised by gut bacteria. Which bacterial source of vitamin K2 (menaquinone) is correct, and why is prophylaxis required in neonates?

(A) Lactobacillus – neonates lack breast milk

(B) Staphylococcus aureus – intestinal colonisation fails at birth

(C) Bacteroides / E. coli – neonates have sterile gut and low placental/breast milk K2 transfer

(D) Clostridium – neonates cannot absorb fat-soluble vitamins

Q6. A 32-year-old man presents with progressive visual loss beginning in his twenties, night blindness, constricted visual fields (ring scotoma), and eventual blindness. Ophthalmoscopy shows chorioretinal atrophy. Plasma ornithine is markedly elevated. Dietary restriction of arginine is recommended. The enzymatic defect is:

(A) Arginase

(B) Ornithine decarboxylase

(C) Carbamyl phosphate synthetase I

(D) Ornithine aminotransferase (OAT)

Q7. A forensic laboratory receives a blood sample from a patient suspected of carrying the sickle-cell mutation in the HBB gene. The laboratory digests DNA with a restriction enzyme, separates fragments by gel electrophoresis, transfers to a membrane, and hybridises with a labelled probe specific for the β-globin gene. Which molecular technique is being described?

(A) Western blot

(B) Northern blot

(C) ELISA

(D) Southern blot

Q8. A patient with familial hypercholesterolaemia homozygous for LDL receptor mutations has dramatically elevated LDL cholesterol. Each LDL particle contains one molecule of a structural apolipoprotein that acts as a ligand for the LDL receptor in liver cells. This apolipoprotein, synthesised exclusively in the liver (not intestine) is:

(A) ApoB-100

(B) ApoB-48

(C) ApoE

(D) ApoC-II

Q9. A marathon runner collapses near the finish line. Serum lactate is 14 mmol/L (normal <2). Muscles have been operating anaerobically. What is the **net ATP yield per molecule of glucose** in anaerobic glycolysis?

(A) 4 ATP

(B) 36 ATP

(C) 8 ATP

(D) 2 ATP

Q10. A 45-year-old chronic alcoholic is admitted with lactic acidosis (pH 7.2, serum lactate 8 mmol/L) and hypoglycaemia. Ethanol metabolism by alcohol dehydrogenase and aldehyde dehydrogenase generates excess NADH. Which of the following is a direct consequence of the elevated $NADH/NAD^+$ ratio in hepatocytes?

(A) Inhibition of gluconeogenesis and beta-oxidation, driving pyruvate to lactate via LDH

(B) Activation of the TCA cycle via isocitrate dehydrogenase

(C) Increased beta-oxidation of fatty acids

(D) Stimulation of gluconeogenesis from lactate

Q11. A 26-year-old woman on oral contraceptive pills has serum ceruloplasmin measured at 58 mg/dL (normal 20–40 mg/dL). Ceruloplasmin is a copper-carrying acute phase reactant synthesised by the liver. Which of the following conditions would **decrease** serum ceruloplasmin?

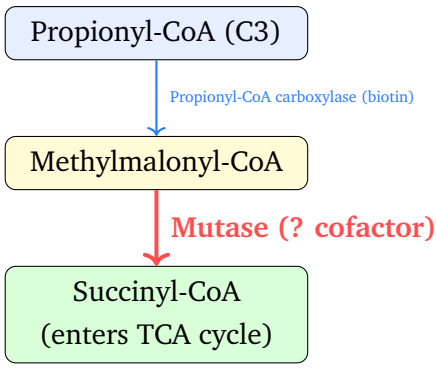
(A) Wilson disease (impaired hepatic copper incorporation into ceruloplasmin)

(B) Pregnancy

(C) Active rheumatoid arthritis

(D) Oral contraceptive pill use

Q12. A 52-year-old vegan woman develops a peripheral neuropathy with elevated serum methylmalonyl acid. The final steps of odd-chain fatty acid catabolism are shown below. Which cofactor is required for methylmalonyl-CoA mutase?



(A) Thiamine pyrophosphate (TPP)

(B) Adenosylcobalamin (vitamin B12)

(C) Pyridoxal phosphate (PLP)

(D) Biotin

Q13. A genetics student notes that the genetic code has 64 possible codons but only 20 standard amino acids are encoded. Two amino acids are unique in having only a single codon each. Which pair is correct?

(A) Leucine and Arginine (6 codons each)

(B) Methionine (AUG) and Tryptophan (UGG)

(C) Serine and Threonine

(D) Glycine and Alanine

Q14. A researcher studying gluconeogenesis identifies a key enzyme that converts oxaloacetate (OAA) to phosphoenolpyruvate (PEP) in a GTP-dependent reaction. Two isoforms exist: one cytosolic and one mitochondrial. The cytosolic isoform (encoded by PCK1) is the major gluconeogenic isoenzyme, induced by glucagon. This enzyme is:

(A) Pyruvate carboxylase

(B) Malic enzyme

(C) Phosphoenolpyruvate carboxykinase (PEPCK)

(D) Fructose-1,6-bisphosphatase

Q15. A 58-year-old man with premature coronary artery disease has low HDL cholesterol (18 mg/dL). Genetic testing identifies a mutation in the gene encoding a major structural protein of HDL that is also the activator of lecithin-cholesterol acyltransferase (LCAT), which esterifies cholesterol in HDL. The mutated protein is:

(A) ApoA-I

(B) ApoA-II

(C) ApoC-I

(D) ApoD

Q16. A cancer patient is started on methotrexate which inhibits dihydrofolate reductase (DHFR). An antibiotic used for urinary tract infections selectively inhibits bacterial DHFR with 50,000-fold greater affinity than human DHFR. This antibiotic is:

(A) Pyrimethamine

(B) Trimethoprim

(C) Sulfamethoxazole

(D) Fluorouracil

Q17. In a patient with sepsis and high fever, pyruvate dehydrogenase complex (PDC) activity is reduced despite adequate thiamine. Pyruvate accumulates. The mechanism of PDC inactivation under conditions of high NADH/NAD^+ and high acetyl-CoA/CoA ratios involves:

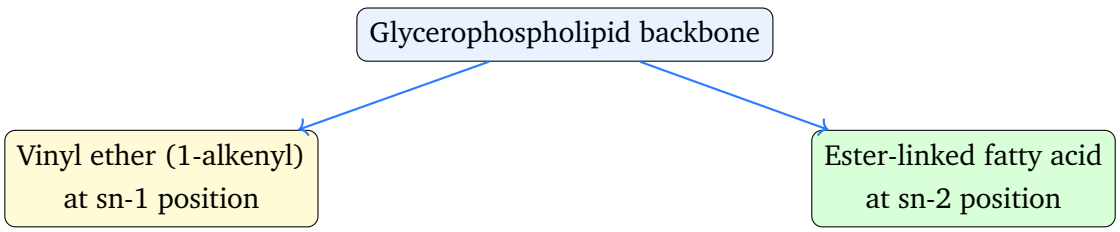
(A) Phosphorylation of the E1 subunit by pyruvate dehydrogenase kinase (PDK)

(B) Allosteric inhibition of the E2 subunit by lipoic acid

(C) Dephosphorylation by PDC phosphatase

(D) Competitive inhibition by oxaloacetate

Q18. A 3-year-old child with Zellweger syndrome (a peroxisomal biogenesis disorder) is found to have deficiency of a class of phospholipids that contain a vinyl ether linkage at the sn-1 position and are particularly abundant in myelin and cardiac muscle. These are:



(A) Sphingomyelins

(B) Phosphatidylcholines

(C) Lysophospholipids

(D) Plasmalogens (ether-linked phospholipids)

Q19. A biochemistry student studying vitamin C synthesis discovers that humans, unlike most mammals, cannot synthesise ascorbic acid. The enzyme missing in humans is L-gulonolactone oxidase (GULOP). Through which metabolic pathway does the conversion of glucose to ascorbic acid proceed in vitamin-C-synthesising mammals?

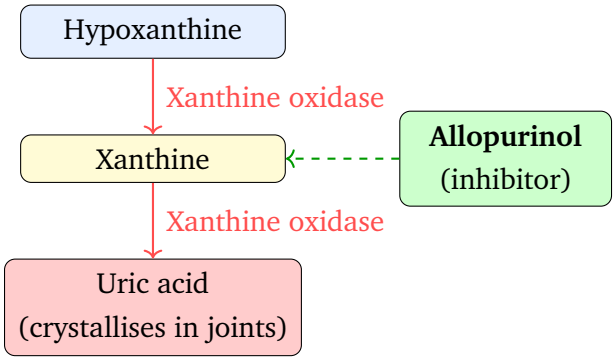
(A) Pentose phosphate pathway

(B) Glucuronate pathway (uronic acid pathway)

(C) Glycolysis

(D) Galactose metabolism

Q20. A 55-year-old man presents with a painful swollen first metatarsophalangeal joint (podagra). Joint aspirate shows negatively birefringent needle-shaped crystals under polarised light. He is started on allopurinol. What is the mechanism of action of allopurinol in this condition?



(A) Non-competitive inhibition of HGPRT

(B) Uricosuric agent – blocks renal tubular reabsorption of urate

(C) Competitive inhibition of xanthine oxidase (converted to oxypurinol, a non-competitive inhibitor)

(D) Activation of uricase to convert uric acid to allantoin

Q21. A 25-year-old woman with dry, scaly skin and poor wound healing is found to have a dietary deficiency of essential fatty acids. Linoleic acid (18:2 ω-6) is an essential fatty acid because:

(A) It is the precursor of cholesterol

(B) Humans lack the $\Delta 12$ and $\Delta 15$ desaturases needed to introduce double bonds beyond C9

(C) It cannot be catabolised by beta-oxidation

(D) It is only found in animal fat

Q22. A student reviewing amino acid biochemistry notes that at physiological pH (7.4) certain amino acid side chains carry a positive charge. Which of the following groups of amino acids are **positively charged** at pH 7.4?

(A) Aspartate, Glutamate, Cysteine

(B) Serine, Threonine, Asparagine

(C) Leucine, Isoleucine, Valine

(D) Arginine, Lysine, Histidine

Q23. A newborn infant with brown adipose tissue (BAT) generates heat during cold stress without shivering. A protein in the inner mitochondrial membrane allows protons to re-enter the mitochondrial matrix without passing through ATP synthase, dissipating the proton gradient as heat. This protein is:

(A) Thermogenin channel in sarcoplasmic reticulum

(B) VDAC (voltage-dependent anion channel)

(C) UCP1 (thermogenin) in brown adipose tissue mitochondria

(D) Cytochrome c oxidase (Complex IV)

A biochemistry viva examiner asks: "In the pyruvate dehydrogenase complex, which cofactor acts as a nucleophile via its thiazolium ring C2 carbon, attacking the carbonyl group of pyruvate to initiate decarboxylation?"

(A) Lipoic acid

(B) FAD

(C) NAD^+

(D) Thiamine pyrophosphate (TPP)

A 68-year-old man undergoing workup for early dementia is found to have the APOE $\varepsilon 4/\varepsilon 4$ genotype on genetic testing. Which of the following correctly describes the role of ApoE isoforms in Alzheimer's disease risk?

(A) ApoE4 is protective; ApoE2 increases Alzheimer's risk

(B) ApoE4 ($\varepsilon 4$) increases Alzheimer's disease risk $\sim$4-fold (heterozygous) and $\sim$12-fold (homozygous) by impairing amyloid clearance

(C) All three ApoE isoforms have identical Alzheimer's risk

(D) ApoE2 homozygosity causes familial hypercholesterolaemia

A 12-year-old boy presents with a pellagra-like photosensitive rash, episodic cerebellar ataxia, and psychiatric symptoms. His 24-hour urine shows markedly elevated neutral amino acids (alanine, serine, threonine, phenylalanine, tyrosine, tryptophan, histidine) but plasma levels of these amino acids are normal. The diagnosis is Hartnup disease. The transporter defective in this condition is:

(A) Cystinuria transporter (SLC3A1/SLC7A9)

(B) Dicarboxylic amino acid transporter

(C) Neutral amino acid transporter (SLC6A19 / B^0AT1) in intestine and kidney

(D) Dibasic amino acid transporter

A molecular biology textbook describes eukaryotic gene structure. Primary transcripts (pre-mRNA or hnRNA) undergo several processing steps before becoming mature, translatable mRNA. These steps include 5' capping, 3' polyadenylation, and splicing of introns. The concept that one gene can give

rise to multiple different proteins by including or excluding different exons is called:

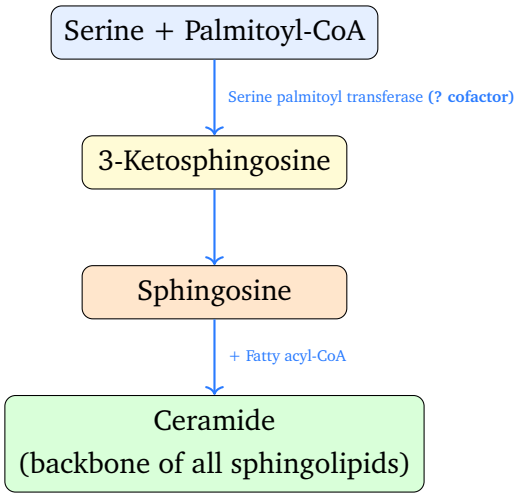
(A) Alternative splicing

(B) RNA editing

(C) Post-translational modification

(D) Translational frameshifting

The first step in sphingolipid biosynthesis involves condensation of serine and palmitoyl-CoA. The enzyme catalysing this step is serine palmitoyl transferase. This reaction requires which cofactor, and what is the immediate product?



(A) TPP; product = hydroxyethyl-TPP

(B) Biotin; product = carboxyl-serine

(C) FAD; product = flavin-serine

(D) Pyridoxal phosphate (PLP); product = 3-ketosphingosine

A 35-year-old woman with haemolytic anaemia has a pyruvate kinase deficiency confirmed by enzyme assay. The L-type pyruvate kinase isoform (in liver) differs from the M2-type (in muscle) in that it is regulated by insulin and glucagon. Which of the following is correct regarding hepatic pyruvate kinase regulation?

(A) Glucagon activates hepatic PK by dephosphorylation

(B) Glucagon (via PKA) phosphorylates and **inactivates** hepatic L-PK, while insulin activates it

(C) Insulin inhibits hepatic PK by phosphorylation

(D) Adrenaline activates hepatic PK via cAMP

A molecular biologist studies chromatin remodelling. She finds that trimethylation of histone H3 at lysine 9 (H3K9me3) is associated with gene silencing, while trimethylation at lysine 4 (H3K4me3) marks active genes. The enzymes adding methyl groups to lysine residues on histones are:

(A) Histone acetyltransferases (HATs)

(B) Histone deacetylases (HDACs)

(C) Histone demethylases (KDMs/LSD1)

(D) Histone methyltransferases (HMTs)

During a myocardial infarction, serum LDH-1 (H_4 isoform) is elevated early. Lactate dehydrogenase catalyses the interconversion of pyruvate and lactate. The cardiac LDH-1 isoform has **low affinity** for pyruvate (high K_m for pyruvate), meaning the aerobic heart preferentially uses pyruvate for oxidative phosphorylation rather than converting it to lactate. The LDH reaction is:

(A) Irreversible in the direction of lactate production

(B) Highly reversible: pyruvate + NADH $\rightleftharpoons$ lactate + NAD^+

(C) Unidirectional: lactate $\rightarrow$ pyruvate only

(D) Coupled to ATP synthesis directly

During PCR amplification of a DNA sample, the researcher uses a primer to bind the template strand. In the native DNA backbone, the linkage between adjacent nucleotides is a phosphodiester bond. This bond forms between:

(A) 2'-OH of one nucleotide and 5'-phosphate of the next

(B) 1'-OH and 3'-phosphate of adjacent nucleotides

(C) N-glycosidic bond and the phosphate

(D) 3'-OH of one nucleotide and 5'-phosphate of the next (3'$\rightarrow$5' phosphodiester bond)

A 6-month-old infant presents with peripheral neuropathy, bilateral foot drop, and cardiac involvement. His mother, who is breastfeeding him, is a recent immigrant with a poor diet. The infant was not given prophylactic vitamins at birth. Which of the following is the correct description of this form of vitamin B1 deficiency?

(A) Wernicke–Korsakoff syndrome

(B) Dry beriberi

(C) Pellagra

(D) Infantile (wet) beriberi

A 60-year-old woman with type 2 diabetes is admitted with severe hypoglycaemia after vigorous exercise and reduced caloric intake. Gluconeogenesis fails to compensate adequately. Amino acids can serve as gluconeogenic precursors by entering as TCA intermediates or as pyruvate/OAA. Which two amino acids are **purely ketogenic** and **cannot** contribute to gluconeogenesis?

(A) Alanine and glutamine

(B) Aspartate and asparagine

(C) Leucine and lysine

(D) Phenylalanine and tyrosine

A 48-year-old man with heterozygous familial hypercholesterolaemia (FH) fails to achieve adequate LDL reduction despite maximum-dose statin therapy. His cardiologist adds a subcutaneous injection given once monthly that blocks a serine protease secreted by the liver, which normally degrades LDL receptors. This drug class is:

(A) PCSK9 inhibitors (e.g., evolocumab, alirocumab)

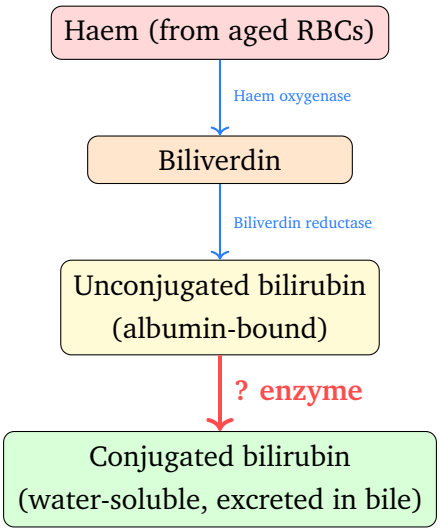
(B) Bile acid sequestrants

(C) Ezetimibe (NPC1L1 inhibitor)

(D) Fibrates (PPAR-α agonists)

A 3-day-old neonate presents with jaundice; serum total bilirubin is 18 mg/dL, predominantly unconjugated. Haemolysis is excluded. The bilirubin metabolism

pathway is shown. Which enzyme in the liver conjugates unconjugated bilirubin to make it water-soluble?



(A) Haem oxygenase

(B) Biliverdin reductase

(C) UDP-glucuronosyltransferase (UGT1A1)

(D) Alkaline phosphatase

A 52-year-old obese man with type 2 diabetes and metabolic syndrome undergoes liver biopsy showing macrovesicular steatosis with lobular inflammation (NASH). Unlike alcoholic fatty liver, NAFLD is driven by insulin resistance and metabolic syndrome. What is the shared final biochemical outcome between NAFLD and alcoholic fatty liver disease?

(A) Both exclusively proceed to cirrhosis within 5 years

(B) Both lead to hepatic steatosis, and potentially steatohepatitis and cirrhosis

(C) Alcoholic fatty liver never progresses to steatohepatitis

(D) NAFLD does not involve lipid accumulation in hepatocytes

A molecular biology student examines the structure of a transfer RNA (tRNA). The tRNA anticodon loop is responsible for recognising the codon on mRNA. The anticodon pairs with the codon in antiparallel fashion. Where is the anticodon located on the cloverleaf secondary structure of tRNA?

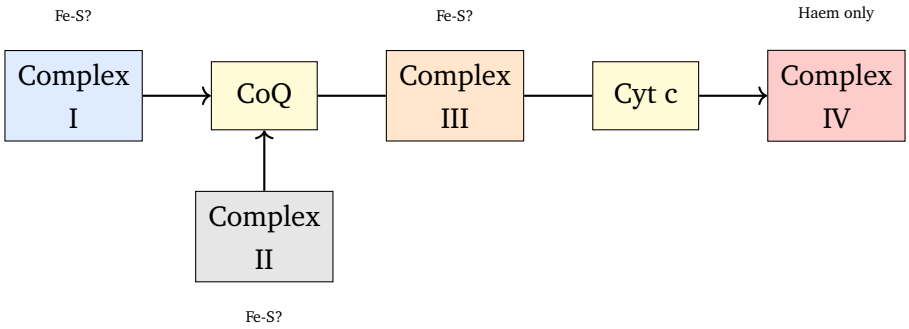
(A) In the TψC loop (loop 1)

(B) In the D-loop (loop 3)

(C) In loop 2 (anticodon loop, at the bottom of the cloverleaf)

(D) At the 3'-CCA acceptor stem

A researcher studying the mitochondrial electron transport chain characterises iron-sulfur (Fe-S) cluster proteins. Fe-S clusters participate in single-electron transfers by cycling between Fe^{2+} and Fe^{3+} states. In which complexes of the ETC are Fe-S clusters found?



(A) Only in Complex I

(B) In Complexes I, II, and III (but NOT in cytochrome c or Complex IV which uses haem copper centres)

(C) In all four complexes including cytochrome c

(D) Only in Complex II and Complex IV

A 30-year-old man with hereditary spherocytosis develops haemolytic anaemia during an infection. His red blood cells show increased oxidative stress. The tripeptide glutathione (GSH) protects cells from oxidative damage. Which of the following correctly describes the structure and function of glutathione?

(A) γ-Glu-Cys-Gly; the thiol of cysteine reduces H_2O_2; GSSG regenerated to GSH by glutathione reductase using NADPH

(B) Glu-Cys-Gly (normal peptide bond at Glu); functions as a substrate for thioredoxin reductase

(C) γ-Glu-Met-Gly; selenium-dependent glutathione peroxidase uses methionine as the active residue

(D) Glu-Cys-Ala; reduced by NADH-dependent glutathione reductase

Detailed Solutions

Q1.

Solution

Concept – THF one-carbon coenzyme forms: Tetrahydrofolate (THF) is the active coenzyme form of folate generated from DHF by DHFR (the target of methotrexate). THF carries one-carbon units in three oxidation states: (i) **5-methyl-THF** – the most reduced, carries the methyl group donated to homocysteine via methionine synthase (cobalamin-dependent); (ii) 5,10-methylene-THF – donates one carbon for dTMP synthesis by thymidylate synthase; (iii) 10-formyl-THF – donates formyl groups in purine ring synthesis. The "methyl trap" hypothesis: if B12 is deficient, 5-methyl-THF accumulates and cannot be recycled, depleting other THF forms.

Distractors: 10-formyl-THF (A) is for purines; 5,10-methylene-THF (B) is for thymidylate; DHF (D) is the oxidised inactive form.

Final Answer: 5-Methyl-THF. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – Turnover number (k_{cat}): The catalytic constant k_{cat} (turnover number) = number of substrate molecules converted per enzyme molecule per second at saturating substrate. $k_{cat} = V_{max}/[E]_T$. Here: $V_{max} = 4 \times 10^{-4}$ mol/L/s, $[E]_T = 2 \times 10^{-8}$ mol/L. Therefore $k_{cat} = \frac{4\times10^{-4}}{2\times10^{-8}} = 2 \times 10^4$ s^{-1}. The ratio k_{cat}/K_m is the specificity constant (catalytic efficiency). Carbonic anhydrase has one of the highest known k_{cat} ($\approx 10^6$ s^{-1}).

Distractors: B is incorrect (unit inversion); C is the product of numerator and denominator; D doubles the correct answer.

Final Answer: 2×10^4 s^{-1}. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q2

Q3.

Solution

Concept – Hurler syndrome (MPS I-H): Mucopolysaccharidosis type I-H (Hurler syndrome) is caused by autosomal recessive deficiency of α-**L-iduronidase**, leading to accumulation of dermatan sulfate and heparan sulfate in lysosomes. Clinical triad: **corneal clouding, hepatosplenomegaly, and intellectual disability**. Other features: coarse facial features (gargoyle facies), dysostosis multiplex, cardiac valvular disease, short stature, joint stiffness. Treatment: laronidase (enzyme replacement therapy) and haematopoietic stem cell transplantation (before age 2 for best neurological outcomes). Hunter syndrome (MPS II) is X-linked and lacks corneal clouding.

Distractors: Hunter (A) = iduronate-2-sulfatase, no corneal clouding, X-linked; Morquio (B) = galactosamine-6-sulfatase, no intellectual disability; Sanfilippo (D) = heparan sulfate only, severe intellectual disability.

Final Answer: Hurler syndrome (MPS I-H). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept – Pyruvate carboxylase: Pyruvate carboxylase is a mitochondrial enzyme that carboxylates pyruvate to oxaloacetate: pyruvate + CO_2 + ATP $\rightarrow$ OAA + ADP + P_i. It requires **biotin** as a prosthetic group (the biotin carboxyl carrier protein, BCCP) and is allosterically **activated by acetyl-CoA**. This ensures that when acetyl-CoA accumulates (e.g., during fasting), OAA is replenished to condense with acetyl-CoA in the TCA cycle (anaplerosis) and to provide the gluconeogenic substrate PEP (via PEPCK). Pyruvate carboxylase deficiency causes lactic acidaemia.

Distractors: Pyruvate dehydrogenase (B) decarboxylates pyruvate to acetyl-CoA, the opposite direction; PEPCK (C) acts on OAA, not pyruvate; malic enzyme (D) converts malate to pyruvate.

Final Answer: Pyruvate carboxylase. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – Vitamin K2 (menaquinone) and neonatal prophylaxis: Vitamin K2 (menaquinone) is synthesised by gut bacteria including **Bacteroides fragilis, E. coli, and other enteric organisms**. Neonates require intramuscular vitamin K at birth because: (i) the gut is **sterile** at birth (no bacterial K2 production); (ii) placental transfer of vitamin K is very limited; (iii) breast milk is poor in vitamin K. Without prophylaxis, neonates lack adequate vitamin K for γ-carboxylation of clotting factors II, VII, IX, X, causing haemorrhagic disease of the newborn (HDN), which can be intracranial.

Distractors: Lactobacillus (A) is not a major K2 producer; Staph aureus (B) is pathogenic; Clostridium (D) – absorption of fat-soluble vitamins is intact in term neonates.

Final Answer: Bacteroides / E. coli – neonates have sterile gut and low placental/breast milk K2 transfer. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept – Gyrate atrophy of choroid and retina: Gyrate atrophy is an autosomal recessive disorder caused by deficiency of **ornithine aminotransferase (OAT)**, a mitochondrial enzyme that normally converts ornithine + α-ketoglutarate $\rightarrow$ pyrroline-5-carboxylate (P5C) + glutamate. OAT deficiency causes **ornithine accumulation**, which is toxic to the retinal pigment epithelium, leading to: night blindness (early), ring scotoma, progressive chorioretinal atrophy, and eventual total blindness by age 40–60. Management includes a low-arginine diet (ornithine is derived from arginine) and pyridoxine (B6) supplementation in responsive patients.

Distractors: Arginase (A) deficiency causes hyperargininaemia with spastic diplegia; OD (B) decarboxylates ornithine to putrescine; CPS-I (C) causes urea cycle disorder.

Final Answer: Ornithine aminotransferase (OAT). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – Southern blot: The procedure described is the **Southern blot** (named after E.M. Southern, 1975): (i) Digest genomic DNA with restriction enzyme; (ii) separate fragments by agarose gel electrophoresis; (iii) denature and transfer (blot) to nitrocellulose or nylon membrane; (iv) hybridise with a labelled DNA probe; (v) visualise. Used for: RFLP analysis, detection of gene rearrangements, HBB genotyping (sickle cell). Memory aid: **S**outhern = D**NA**; **N**orthern = R**NA**; **W**estern = **P**rotein (antibody probe).

Distractors: Western (A) uses antibodies to detect proteins; Northern (B) detects RNA; ELISA (C) is a plate-based immunoassay for proteins/antigens.

Final Answer: Southern blot. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept – ApoB-100 structure and function: ApoB-100 is the major structural apolipoprotein of VLDL, IDL, and LDL particles, synthesised exclusively in the **liver**. It is a very large protein (4,536 amino acids), with one molecule per lipoprotein particle. ApoB-100 is the ligand recognised by the LDL receptor (LDLR) on hepatocytes and peripheral cells, mediating receptor-mediated endocytosis of LDL. ApoB-48 (truncated N-terminal 48% of ApoB) is produced in the **intestine** by mRNA editing (APOBEC1 converts codon 2153 CAA→UAA stop codon) and is the structural protein of chylomicrons.

Distractors: ApoB-48 (B) is intestinal; ApoE (C) is found on VLDL, IDL, chylomicrons – mediates receptor binding but is not the primary structural protein; ApoC-II (D) activates lipoprotein lipase.

Final Answer: ApoB-100. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – Net ATP yield of anaerobic glycolysis: In glycolysis, 2 ATP are consumed (hexokinase: glucose→G6P, and PFK-1: F6P→F-1,6-BP) and 4 ATP are produced (2 at phosphoglycerate kinase + 2 at pyruvate kinase). Net yield = 4 − 2 = **2 ATP** per glucose. Also 2 NADH are produced at GAPDH, but in anaerobic conditions LDH re-oxidises NADH to NAD^+ (no net NADH available for oxidative phosphorylation). The 2 ATP net yield sustains muscle function for short intense bursts.

Distractors: 4 ATP (A) is the gross yield before subtracting; 36 ATP (B) is the aerobic yield (classical estimate); 8 ATP (C) has no biochemical basis.

Final Answer: 2 ATP. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q9

Q10.

Solution

Concept – Elevated NADH/NAD^+ ratio effects in hepatocytes: When the NADH/NAD^+ ratio is high (as in alcoholism): (i) **TCA cycle is inhibited** (isocitrate DH and α-ketoglutarate DH are product-inhibited by NADH); (ii) **Gluconeogenesis is inhibited** (OAA is diverted to malate; pyruvate to lactate via LDH) – causes hypoglycaemia and **lactic acidosis**; (iii) **Beta-oxidation is inhibited** (high NADH/NAD^+ reverses the dehydrogenase steps); (iv) Acetyl-CoA redirected to ketone body and fatty acid synthesis → steatosis. The correct answer encompasses the lactic acidosis and hypoglycaemia scenario.

Distractors: B (TCA activation) is opposite; C (increased β-oxidation) is opposite; D (stimulation of gluconeogenesis) is the opposite of what occurs.

Final Answer: Inhibition of gluconeogenesis and beta-oxidation, driving pyruvate to lactate. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q10

Q11.

Solution

Concept – Ceruloplasmin as acute phase reactant: Ceruloplasmin is a copper-carrying α_2-glycoprotein synthesised by the liver. It is a **positive acute phase reactant**: levels rise in inflammation, pregnancy, OCP use, and infection. In contrast, ceruloplasmin is **decreased** in **Wilson disease** – the ATP7B gene product (copper-transporting ATPase) is defective, preventing hepatic incorporation of copper into apoceruloplasmin. Without copper, apoceruloplasmin is rapidly degraded, causing very low serum ceruloplasmin ($<$20 mg/dL). Also decreased in Menkes disease (ATP7A deficiency), protein malnutrition, and nephrotic syndrome (loss in urine).

Distractors: Pregnancy (B), rheumatoid arthritis (C), and OCP use (D) all *increase* ceruloplasmin.

Final Answer: Wilson disease. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept – Odd-chain fatty acid catabolism and vitamin B12: Odd-chain fatty acids (e.g., C15, C17) undergo β-oxidation like even-chain FAs, but the final thiolysis produces one molecule of **propionyl-CoA** (C3) rather than acetyl-CoA. Propionyl-CoA is converted by: (1) **Propionyl-CoA carboxylase** (biotin-dependent) $\rightarrow$ D-methylmalonyl-CoA $\rightarrow$ L-methylmalonyl-CoA; (2) **Methylmalonyl-CoA mutase** – requires **adenosylcobalamin (vitamin B12)** as cofactor – $\rightarrow$ succinyl-CoA $\rightarrow$ enters TCA cycle. Vitamin B12 deficiency causes elevated serum methylmalonic acid (a specific marker for B12 deficiency).

Distractors: TPP (A) is the cofactor for pyruvate/alpha-keto acid decarboxylases; PLP (C) is for transamination and decarboxylation; biotin (D) is for propionyl-CoA carboxylase, the preceding step.

Final Answer: Adenosylcobalamin (vitamin B12). $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept – Genetic code degeneracy – single-codon amino acids: Of the 64 codons, 61 encode amino acids and 3 are stop codons (UAA, UAG, UGA). The genetic code is **degenerate**: most amino acids have multiple synonymous codons. However, two amino acids have only **one codon** each: **Methionine (Met/M) = AUG** (also the start codon) and **Tryptophan (Trp/W) = UGG**. Leucine and arginine have 6 codons each (the maximum). Degeneracy is concentrated at the third (wobble) position of the codon.

Distractors: Leucine and Arginine (A) have 6 codons each; Serine (C) has 6 codons; Glycine and Alanine (D) have 4 codons each.

Final Answer: Methionine (AUG) and Tryptophan (UGG). $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q13

Q14.

Solution

Concept – PEPCK (Phosphoenolpyruvate carboxykinase): PEPCK catalyses the GTP-dependent decarboxylation-phosphorylation of OAA to PEP: OAA + GTP $\rightarrow$ PEP + CO_2 + GDP. This is the key gluconeogenic bypass of the irreversible pyruvate kinase reaction (PEP $\rightarrow$ pyruvate in glycolysis). Two isoforms: cytosolic PEPCK (PCK1, the major form, induced by glucagon via cAMP and by glucocorticoids; suppressed by insulin) and mitochondrial PEPCK (PCK2, constitutive). PEPCK activity is a critical determinant of gluconeogenic flux in the liver and kidney.

Distractors: Pyruvate carboxylase (A) makes OAA from pyruvate; malic enzyme (B) makes pyruvate from malate; FBPase-1 (D) bypasses PFK-1 at a later step.

Final Answer: PEPCK. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept – ApoA-I and HDL: ApoA-I is the major structural protein of HDL particles, accounting for about 70% of HDL protein mass. It is synthesised in the liver and intestine. ApoA-I is the primary **activator of LCAT** (lecithin-cholesterol

acyltransferase), which esterifies free cholesterol in HDL to cholesteryl esters (promoting reverse cholesterol transport). Loss-of-function mutations in ApoA-I cause **familial hypoalphalipoproteinaemia** (very low HDL). The Milano mutation (Arg173Cys) forms disulphide-linked homodimers but paradoxically appears cardioprotective. ApoA-II is the second most abundant HDL protein.

Distractors: ApoA-II (B) has roles in hepatic triglyceride metabolism but does not activate LCAT; ApoC-I (C) is on VLDL/chylomicrons; ApoD (D) is in HDL but is not the structural apolipoprotein and does not activate LCAT.

Final Answer: ApoA-I. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept – Trimethoprim and bacterial DHFR selectivity: Dihydrofolate reductase (DHFR) converts DHF $\rightarrow$ THF (the active coenzyme). It is the target of: (i) **Methotrexate** – tight-binding competitive inhibitor of human DHFR (anticancer, anti-inflammatory); (ii) **Trimethoprim (TMP)** – inhibits *bacterial* DHFR with approximately 50,000-fold greater affinity than human DHFR, making it selective as an antibiotic; (iii) **Pyrimethamine** – inhibits protozoal (Plasmodium, Toxoplasma) DHFR preferentially. TMP is used for UTIs, typically combined with sulfamethoxazole (co-trimoxazole). Fluorouracil (D) inhibits thymidylate synthase, not DHFR.

Distractors: Pyrimethamine (A) targets protozoal DHFR; sulfamethoxazole (C) inhibits dihydropteroate synthase (not DHFR); fluorouracil (D) is a thymidylate synthase inhibitor.

Final Answer: Trimethoprim. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept – PDC regulation by PDK (phosphorylation): The pyruvate dehydrogenase complex is regulated by a phosphorylation-dephosphorylation cycle. **Pyruvate dehydrogenase kinase (PDK)** phosphorylates serine residues on the E1 (pyruvate decarboxylase) subunit, causing **inactivation**. PDK is **activated** by: high NADH/NAD^+, high acetyl-CoA/CoA ratio, high ATP/ADP ratio. PDK is **inhibited** by pyruvate (product feedback keeps PDK off when pyruvate is plentiful).

PDC phosphatase (activated by Ca^{2+} and Mg^{2+}) dephosphorylates and *activates* PDC. In sepsis, inflammatory cytokines also upregulate PDK (via pyruvate dehydrogenase kinase 4 induction), diverting pyruvate away from the TCA cycle.

Distractors: Allosteric inhibition by lipoic acid (B) does not occur; dephosphorylation (C) would *activate* PDC; competitive inhibition by OAA (D) is not a known mechanism.

Final Answer: Phosphorylation of E1 by PDK. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – Plasmalogens and peroxisomal biogenesis disorders: Plasmalogens (also called ether phospholipids or 1-alkenyl-2-acyl phospholipids) are a class of glycerophospholipids with a **vinyl ether (1-alkenyl)** linkage at the *sn-1* position, in contrast to the typical ester linkage. They are synthesised in **peroxisomes** (the first two steps). Abundant in: myelin sheaths, cardiac muscle, platelets, and neuronal membranes. They protect against reactive oxygen species (the vinyl ether is preferentially oxidised as an antioxidant). Deficient in **Zellweger syndrome** and **rhizomelic chondrodysplasia punctata** (peroxisomal disorders).

Distractors: Sphingomyelins (A) are sphingolipids, not glycerophospholipids; phosphatidylcholines (B) have ester linkages at both *sn-1* and *sn-2*; lysophospholipids (C) have only one fatty acid chain.

Final Answer: Plasmalogens. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q18

Q19.

Solution

Concept – Glucuronate (uronic acid) pathway and vitamin C synthesis: The glucuronate pathway converts glucose-6-phosphate $\rightarrow$ glucose-1-phosphate $\rightarrow$ UDP-glucose $\rightarrow$ UDP-glucuronate. In most mammals, UDP-glucuronate is further metabolised via L-gulonate $\rightarrow$ L-gulonolactone $\rightarrow$ ascorbic acid (catalysed by **L-gulonolactone oxidase / GULOP**). In humans (and guinea pigs, most bats, some fish), *GULO* is a pseudogene due to multiple loss-of-function mutations, so vitamin C cannot be synthesised endogenously. The glucuronate pathway also provides

UDP-glucuronate for conjugation reactions (bilirubin, drug glucuronidation).

Distractors: Pentose phosphate pathway (A) generates NADPH and ribose-5-P, not ascorbic acid; glycolysis (C) leads to pyruvate; galactose metabolism (D) produces UDP-galactose/glucose but not ascorbate.

Final Answer: Glucuronate pathway. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q19

Q20.

Solution

Concept – Gout and allopurinol mechanism: Gout results from hyperuricaemia leading to deposition of monosodium urate crystals in joints (negatively birefringent, needle-shaped under polarised light). Xanthine oxidase (XO) converts hypoxanthine $\rightarrow$ xanthine $\rightarrow$ uric acid. **Allopurinol** (a hypoxanthine analogue) is a **competitive inhibitor** of XO, but its active metabolite **oxypurinol** (alloxanthine) is a **non-competitive/tight-binding inhibitor** of XO (binds the reduced form of the enzyme). This reduces uric acid production. Febuxostat is a non-purine selective XO inhibitor used when allopurinol is not tolerated.

Distractors: HGPRT inhibition (A) would increase uric acid (HGPRT salvages purines, reducing XO substrate); uricosuric agents (B) include probenecid and benzbromarone – different mechanism; uricase (D) is present in non-primate mammals, and pegloticase is a recombinant uricase used in refractory gout.

Final Answer: Competitive inhibitor of XO (converted to oxypurinol, non-competitive inhibitor). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q20

Q21.

Solution

Concept – Essential fatty acids and the Δ12/Δ15 desaturase requirement: Linoleic acid (18:2 ω-6) and **α-linolenic acid (18:3 ω-3)** are the two dietary essential fatty acids. Humans can introduce double bonds only up to the Δ9 position (using Δ9-desaturase), but cannot create double bonds at Δ12 or Δ15 because we lack **Δ12 and Δ15 desaturases**. Plants have these enzymes and thus synthesise linoleic and linolenic acids in their leaves (green vegetables, flaxseed, nuts). Deficiency causes: scaly skin (from impaired membrane phospholipid composition), poor wound healing, growth retardation, and arachidonic acid deficiency (linoleic

→ arachidonic via elongation and Δ6/Δ5 desaturases).

Distractors: Cholesterol precursor (A) is acetyl-CoA; EFAs can be beta-oxidised (C); EFAs are found in plant oils, not primarily animal fat (D).

Final Answer: Humans lack Δ12 and Δ15 desaturases. ⇒ $\boxed{B}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept – Positively charged amino acids at pH 7.4: At physiological pH 7.4, amino acid charge is determined by side chain pKa values. **Positively charged (basic) amino acids**: **Arginine** (pKa ≈12.5, guanidinium), **Lysine** (pKa ≈10.5, ε-amino), and **Histidine** (pKa ≈6.0 – partially positive at pH 7.4, about 9% protonated, which is biologically important for buffering and enzymatic catalysis). Aspartate and Glutamate are negatively charged (pKa ≈3.9 and 4.1). Serine, Threonine, Asparagine are polar but uncharged. Leucine, Isoleucine, Valine are non-polar.

Distractors: Aspartate and Glutamate (A) are *negatively* charged; Serine and Threonine (B) are neutral polar; Leucine, Ile, Val (C) are hydrophobic non-polar.

Final Answer: Arginine, Lysine, Histidine. ⇒ $\boxed{D}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept – UCP1 (thermogenin) and non-shivering thermogenesis: In brown adipose tissue (BAT), the inner mitochondrial membrane contains **uncoupling protein 1 (UCP1)**, also called thermogenin. UCP1 is a proton channel that allows H^+ to re-enter the mitochondrial matrix independently of ATP synthase, dissipating the proton-motive force as **heat** rather than ATP. Activation: cold stress → sympathetic norepinephrine → β_3-adrenoceptor → cAMP → PKA → lipolysis → free fatty acids activate UCP1 (and inhibit purine nucleotides that tonically suppress UCP1). Critical in neonates (large surface-to-volume ratio, limited shivering capacity) and hibernating mammals.

Distractors: "Thermogenin channel in sarcoplasmic reticulum" (A) is incorrect – UCP1 is in the IMM, not SR; VDAC (B) is in the outer mitochondrial membrane;

Complex IV (D) uses the proton gradient but drives O_2 reduction to water, not heat generation.

Final Answer: UCP1 (thermogenin) in brown adipose tissue mitochondria. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept – TPP mechanism in pyruvate decarboxylation: Thiamine pyrophosphate (TPP) is the cofactor for the E1 (pyruvate decarboxylase) subunit of PDC. The mechanism: (i) The **C2 carbon of the thiazolium ring** of TPP acts as a nucleophile (as a carbanion/ylide) – it attacks the carbonyl carbon of pyruvate; (ii) Pyruvate is decarboxylated ($-CO_2$), forming a **hydroxyethyl-TPP** intermediate ("active acetaldehyde"); (iii) The two-carbon hydroxyethyl group is transferred to the oxidised lipoamide of E2, generating acetyl-lipoamide + regenerated TPP. The same thiazolium C2 mechanism operates in α-ketoglutarate dehydrogenase and transketolase.

Distractors: Lipoic acid (A) accepts the acetyl group from hydroxyethyl-TPP but is not the nucleophile; FAD (B) is on E3 for NADH regeneration; NAD^+ (C) is also on E3 as the final electron acceptor.

Final Answer: Thiamine pyrophosphate (TPP). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – ApoE isoforms and Alzheimer's risk: ApoE exists as three major isoforms determined by polymorphisms at residues 112 and 158: **ApoE2** (Cys112, Cys158) – protective/neutral for Alzheimer's, but risk for type III hyperlipoproteinaemia; **ApoE3** (Cys112, Arg158) – the most common allele (≈78% of population), neutral for AD risk; **ApoE4** (Arg112, Arg158) – the $\varepsilon 4$ allele increases AD risk approximately **4-fold** in heterozygotes and **12-fold** in homozygotes. ApoE4 impairs clearance of amyloid-β from the brain and promotes neurofibrillary tangle formation. ApoE is also involved in lipoprotein metabolism (receptor-mediated clearance of VLDL and chylomicron remnants).

Distractors: A reverses the direction of risk; C is incorrect (the isoforms differ significantly); D – ApoE2 causes type III HLP (not familial hypercholesterolaemia,

which is due to LDLR mutation).

Final Answer: ApoE4 increases Alzheimer's risk ∼4-fold (heterozygous) and ∼12-fold (homozygous). ⇒ $\boxed{B}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – Hartnup disease and SLC6A19: Hartnup disease is an autosomal recessive disorder caused by defective **SLC6A19 (B^0AT1)**, a sodium-dependent neutral amino acid transporter expressed in the intestinal brush border and proximal renal tubule. It transports neutral amino acids (alanine, serine, threonine, phenylalanine, tyrosine, **tryptophan**, histidine, etc.). Deficiency causes: reduced intestinal absorption → bacterial colonic fermentation of tryptophan → reduced niacin and serotonin synthesis → pellagra-like rash; renal tubular loss of neutral amino acids → neutral aminoaciduria. Plasma amino acid levels are normal or low. Treatment: nicotinamide supplementation.

Distractors: Cystinuria transporter (A) affects dibasic amino acids (Cys, Lys, Arg, Orn); dicarboxylic AA transporter (B) transports aspartate and glutamate; dibasic AA transporter (D) is distinct from the neutral AA transporter.

Final Answer: Neutral amino acid transporter (SLC6A19 / B^0AT1). ⇒ $\boxed{C}$

Answer: (C) Go Back to Q26

Q27.

Solution

Concept – Alternative splicing of eukaryotic genes: Eukaryotic genes are **split genes**: coding sequences (exons) are interspersed with non-coding sequences (introns). After transcription, the primary transcript (pre-mRNA/hnRNA) undergoes: (i) 5' capping (m^7G cap); (ii) 3' polyadenylation (poly-A tail, added ∼200 bp downstream of AATAAA signal); (iii) **Splicing** – introns are removed by the spliceosome (snRNAs + proteins). **Alternative splicing** – the inclusion or exclusion of different exons – allows one gene to produce multiple protein isoforms. Classic example: tropomyosin gene produces >10 distinct mRNAs in different tissues.

Distractors: RNA editing (B) involves nucleotide modification (e.g., ApoB mRNA C→U editing by APOBEC1); post-translational modification (C) occurs after trans-

lation; translational frameshifting (D) is a ribosomal mechanism used by some viruses.

Final Answer: Alternative splicing. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept – First step of sphingolipid biosynthesis (serine palmitoyl transferase and PLP): The committed first step of de novo sphingolipid synthesis is the condensation of **L-serine + palmitoyl-CoA** to form **3-ketosphingosine** (3-dehydrosphinganine), catalysed by **serine palmitoyl transferase (SPT)**. This enzyme requires **pyridoxal phosphate (PLP)** as a cofactor (PLP forms a Schiff base with serine, facilitating decarboxylation and condensation). 3-Ketosphingosine is then reduced to sphinganine (dihydrosphingosine), desaturated to sphingosine, and N-acylated with a fatty acid by ceramide synthase to form **ceramide** – the backbone of all complex sphingolipids.

Distractors: TPP (A) is used in pyruvate decarboxylation, not sphingolipid synthesis; biotin (B) is for carboxylation reactions; FAD (C) is for oxidative reactions in the ETC.

Final Answer: Pyridoxal phosphate (PLP); product = 3-ketosphingosine. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept – Hepatic pyruvate kinase (L-type) regulation by glucagon: Liver pyruvate kinase (L-PK, encoded by PKLR gene) is regulated hormonally. **Glucagon** (via cAMP $\rightarrow$ PKA) **phosphorylates** L-PK $\rightarrow$ **inactivation** (prevents futile cycling during gluconeogenesis – phosphorylated PK cannot convert PEP back to pyruvate while PEPCK is generating PEP). **Insulin** activates L-PK (by promoting dephosphorylation via protein phosphatase). Also, L-PK is allosterically activated by fructose-1,6-bisphosphate (feedforward activation) and inhibited by ATP and alanine. Muscle M2-PK is constitutively active (not regulated by phosphorylation). PKD (pyruvate kinase deficiency) causes haemolytic anaemia as RBCs rely on glycolysis.

Distractors: Glucagon activating PK by dephosphorylation (A) is backwards; in-

sulin inhibiting PK (C) is the opposite; adrenaline (D) would mimic glucagon and inactivate L-PK.

Final Answer: Glucagon phosphorylates and inactivates hepatic L-PK; insulin activates it. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – Histone methyltransferases (HMTs): Chromatin remodelling involves covalent modification of histone tails. **Histone methyltransferases (HMTs)** add methyl groups ($-CH_3$) from S-adenosylmethionine (SAM) to lysine (K) or arginine (R) residues on histone tails. The biological outcome depends on which residue is methylated and the degree of methylation: **H3K4me3** = active transcription (euchromatin); **H3K9me3** and **H3K27me3** = gene silencing (heterochromatin, Polycomb repression). The methylation marks are reversed by histone demethylases (KDMs, including LSD1/KDM1A). These marks are central to genomic imprinting, X-chromosome inactivation, and cancer epigenetics.

Distractors: HATs (A) add acetyl groups (generally activate transcription); HDACs (B) remove acetyl groups (generally repress transcription); KDMs/LSD1 (C) are demethylases (remove methyl groups).

Final Answer: Histone methyltransferases (HMTs). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q30

Q31.

Solution

Concept – LDH reaction reversibility: Lactate dehydrogenase (LDH) catalyses a **highly reversible** reaction: pyruvate + NADH + H^+ $\rightleftharpoons$ lactate + NAD^+. In the direction of lactate production (in anaerobic muscle and RBCs), it regenerates NAD^+ for continued glycolysis. In the direction of pyruvate production (e.g., in the liver during the Cori cycle), it converts lactate back to pyruvate for gluconeogenesis. The cardiac (H_4, LDH-1) isoform has high affinity for lactate (low K_m for lactate) and high K_m for pyruvate, favouring lactate $\rightarrow$ pyruvate in the aerobic heart. LDH-5 (M_4, in liver and skeletal muscle) favours the opposite direction.

Distractors: Irreversibility in lactate production direction (A) is incorrect; unidirectionality (C) is incorrect; ATP coupling (D) is incorrect (LDH uses

$NADH/NAD^+$, not ATP).

Final Answer: Highly reversible: pyruvate + NADH $\rightleftharpoons$ lactate + NAD^+. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q31

Q32.

Solution

Concept – Phosphodiester bond in nucleic acid backbone: In DNA and RNA, adjacent nucleotides are covalently linked by a **phosphodiester bond**: the 3'-OH of one deoxyribose (or ribose) is esterified to the 5'-phosphate group of the next nucleotide. This creates a backbone with directionality (5'→3'). The bond is: 3'-O−P−O-5'. Both ester bonds are formed between the phosphate oxygens and the sugar hydroxyl groups. DNase I is a non-specific endonuclease that cleaves phosphodiester bonds. Restriction endonucleases cleave specifically at defined sequences. The backbone is negatively charged (phosphates) at physiological pH.

Distractors: 2'-OH (A) is in RNA ribose; in deoxyribose there is no 2'-OH; 1'-OH (B) is where the nitrogenous base is attached (N-glycosidic bond); N-glycosidic bond (C) connects base to sugar, not adjacent nucleotides.

Final Answer: 3'-OH of one nucleotide and 5'-phosphate of the next. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept – Infantile (wet) beriberi: Vitamin B1 (thiamine) deficiency causes beriberi in two main forms: **dry beriberi** (peripheral polyneuropathy predominantly) and **wet beriberi** (cardiac involvement: high-output cardiac failure, cardiomegaly, oedema). **Infantile beriberi** is a specific form occurring in breast-fed infants of thiamine-deficient mothers, typically at 2–6 months of age. It presents acutely with **cardiac failure, cyanosis, aphonia** ("silent" – no cry), peripheral neuropathy (foot drop), and can be rapidly fatal. It responds dramatically to parenteral thiamine. Wernicke–Korsakoff (A) is seen in adults, typically alcoholics.

Distractors: Wernicke–Korsakoff (A) is an adult neurological syndrome; dry beriberi (B) is predominantly neuropathic without cardiac involvement; pellagra (C) is niacin deficiency.

Final Answer: Infantile (wet) beriberi. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q33

Q34.

Solution

Concept – Purely ketogenic amino acids (Leucine and Lysine): Glucogenic amino acids can be converted to pyruvate or TCA cycle intermediates (OAA, fumarate, succinyl-CoA, α-ketoglutarate) and thus contribute to gluconeogenesis. Ketogenic amino acids yield acetyl-CoA or acetoacetyl-CoA only. **Leucine** and **Lysine** are the only two purely ketogenic amino acids – they cannot contribute to net glucose synthesis. All other amino acids are either purely glucogenic or both (glucogenic and ketogenic, e.g., phenylalanine, tyrosine, tryptophan, isoleucine, threonine). Memory: "**L**eucine and **L**ysine = **L**ost to gluconeogenesis."

Distractors: Alanine and glutamine (A) are purely glucogenic (major substrates for gluconeogenesis); aspartate and asparagine (B) are glucogenic; phenylalanine and tyrosine (D) are both glucogenic AND ketogenic (not purely ketogenic).

Final Answer: Leucine and Lysine. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q34

Q35.

Solution

Concept – PCSK9 inhibitors: PCSK9 (proprotein convertase subtilisin/kexin type 9) is a serine protease secreted by hepatocytes that binds to LDL receptors and targets them for lysosomal degradation. By blocking PCSK9, monoclonal antibodies (**evolocumab / Repatha** and **alirocumab / Praluent**) prevent LDLR degradation, allowing receptors to be recycled to the cell surface. This dramatically increases LDLR density $\rightarrow$ enhanced LDL clearance $\rightarrow$ $\sim$60% reduction in LDL. Used in familial hypercholesterolaemia (heterozygous and homozygous), statin-intolerant patients, and very high cardiovascular risk. Given as subcutaneous injections every 2–4 weeks.

Distractors: Bile acid sequestrants (B) bind bile acids in intestine (cholestyramine); ezetimibe (C) blocks NPC1L1 in intestinal brush border; fibrates (D) activate PPAR-α to increase LPL activity and reduce TG.

Final Answer: PCSK9 inhibitors (evolocumab, alirocumab). $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q35

Q36.

Solution

Concept – Bilirubin conjugation by UGT1A1: Bilirubin metabolism: Haem is catabolised by haem oxygenase to biliverdin → reduced by biliverdin reductase to **unconjugated (indirect) bilirubin**. Unconjugated bilirubin is **lipid-soluble**, binds albumin in blood, and is transported to the liver. Hepatocytes conjugate unconjugated bilirubin with glucuronic acid via **UDP-glucuronosyltransferase 1A1 (UGT1A1)** to form bilirubin diglucuronide (conjugated/direct bilirubin) – water-soluble, excreted in bile. UGT1A1 mutations cause Crigler-Najjar syndrome (type I – absent, type II – reduced) and Gilbert syndrome (mildly reduced). In neonates, UGT1A1 activity is low at birth, causing physiological jaundice.

Distractors: Haem oxygenase (A) converts haem to biliverdin; biliverdin reductase (B) converts biliverdin to unconjugated bilirubin; alkaline phosphatase (D) is a cholestatic marker, not a bilirubin-conjugating enzyme.

Final Answer: UDP-glucuronosyltransferase (UGT1A1). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q36

Q37.

Solution

Concept – NAFLD vs. alcoholic fatty liver (shared outcomes): Both NAFLD (driven by insulin resistance, metabolic syndrome, excess de novo lipogenesis, impaired beta-oxidation) and **alcoholic fatty liver** (driven by high NADH/NAD^+ inhibiting beta-oxidation, promoting fatty acid synthesis and esterification) share the same spectrum of histological progression: **steatosis** (fat accumulation, reversible) → **steatohepatitis** (steatosis + inflammation + ballooning) → **fibrosis** → **cirrhosis** → hepatocellular carcinoma. Neither exclusively progresses to cirrhosis within 5 years (A is wrong); alcoholic fatty liver absolutely can progress to steatohepatitis (C is wrong); NAFLD involves lipid accumulation (D is wrong).

Distractors: A – "exclusively within 5 years" is incorrect; C – alcoholic steatohepatitis (ASH) is well-recognised; D – steatosis is lipid accumulation by definition.

Final Answer: Both lead to steatosis, and potentially steatohepatitis and cirrhosis. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – tRNA anticodon loop location: The cloverleaf secondary structure of tRNA has four arms: (i) **Acceptor stem** (3'-CCA – where amino acid is attached); (ii) **D-loop** (contains dihydrouridine, involved in aminoacyl-tRNA synthetase recognition); (iii) **Anticodon loop (loop 2)** – located at the **bottom of the cloverleaf**, opposite the acceptor stem, contains the three-nucleotide anticodon that base-pairs with the mRNA codon in antiparallel fashion (5'→3' on mRNA pairs with 3'→5' on tRNA anticodon); (iv) **TψC loop** (contains pseudouridine and ribothymidine, involved in ribosome binding). Wobble pairing occurs at position 34 of the anticodon (5' end of anticodon / position 1 of the codon).

Distractors: TψC loop (A) is for ribosome interaction; D-loop (B) is for synthetase recognition (loop 3 is actually the variable loop); 3'-CCA acceptor stem (D) is where the amino acid is charged.

Final Answer: In loop 2 (anticodon loop). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q38

Q39.

Solution

Concept – Iron-sulfur clusters in ETC complexes: Fe-S (iron-sulfur) clusters are electron-transfer cofactors containing iron and inorganic sulfide (Fe_2S_2 or Fe_4S_4). They cycle between Fe^{2+} and Fe^{3+} for one-electron transfers. Distribution in ETC: **Complex I** (8 Fe-S clusters), **Complex II** (3 Fe-S clusters: 2Fe-2S, 4Fe-4S, 3Fe-4S), and **Complex III** (Rieske 2Fe-2S centre). **Cytochrome c** uses haem iron only (no Fe-S cluster). **Complex IV** uses haem a, haem a_3, and Cu_A/Cu_B centres – no Fe-S clusters. Inhibition of Fe-S cluster biosynthesis (e.g., frataxin mutation in Friedreich's ataxia) impairs all three complexes.

Distractors: Only Complex I (A) misses Complex II and III; all four complexes and cyt c (C) is incorrect; only Complex II and IV (D) misses Complexes I and III and incorrectly includes IV.

Final Answer: Complexes I, II, and III (not cytochrome c or Complex IV). $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – Glutathione (GSH) structure and function: Glutathione is a tripeptide: γ**-Glu-Cys-Gly** (note the *gamma* peptide bond at glutamate – the γ-carboxyl of glutamate is linked to the α-amino of cysteine). The **thiol (-SH) group of cysteine** is the active moiety. **Glutathione peroxidase** (GPx, selenium-dependent) uses 2 GSH to reduce H_2O_2 to H_2O (forming GSSG). **Glutathione reductase** uses **NADPH** (from the pentose phosphate pathway) to reduce GSSG back to 2 GSH. In RBCs with G6PD deficiency, NADPH generation is impaired $\rightarrow$ GSH depletion $\rightarrow$ oxidative haemolysis. GSH also detoxifies xenobiotics (glutathione-S-transferases) and maintains protein thiol groups in reduced state.

Distractors: Normal peptide bond at Glu (B) is incorrect (it is a gamma bond); methionine (C) is incorrect (cysteine is the active residue, and selenium is on GPx not GSH itself); NADH-dependent reductase (D) is incorrect (glutathione reductase uses NADPH).

Final Answer: γ-Glu-Cys-Gly; thiol of cysteine reduces H_2O_2; GSSG regenerated by glutathione reductase using NADPH. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q40

Answer Key – FMGE Biochemistry Sample Paper 7

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