FMGE Biochemistry Sample Paper – 1

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 55-year-old strict vegan presents with fatigue, tingling in hands and feet, and unsteady gait. Blood film shows hypersegmented neutrophils and macrocytosis. Serum methylmalonic acid and homocysteine are both elevated. Which vitamin deficiency best explains this clinical picture?

(A) Folate (vitamin B9)

(B) Thiamine (vitamin B1)

(C) Pyridoxine (vitamin B6)

(D) Cobalamin (vitamin B12)

Q2. The Michaelis constant (K_m) of an enzyme is best defined as the substrate concentration at which:

(A) The reaction velocity is zero

(B) The reaction velocity equals half of V_{max}

(C) The reaction velocity equals V_{max}

(D) The enzyme is fully saturated with substrate

Q3. A 3-month-old infant brought for developmental assessment has fair skin, blond hair, and a musty body odour. Urine ferric chloride test is positive (olive green). Dietary restriction of which amino acid is the cornerstone of treatment?

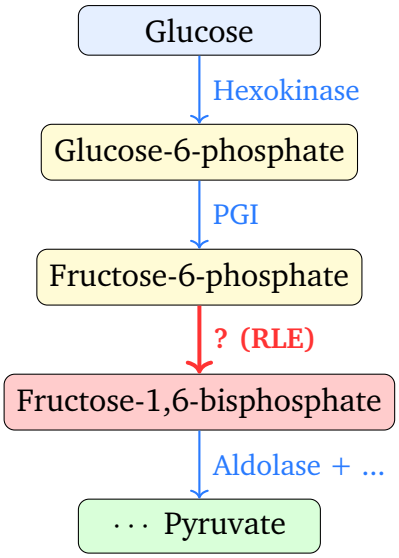
(A) Tyrosine

(B) Phenylalanine

(C) Leucine

(D) Methionine

Q4. In the glycolytic pathway shown below, the rate-limiting (committed) step is catalysed by which enzyme?



(A) Phosphofructokinase-1 (PFK-1)

(B) Hexokinase

(C) Phosphoglucose isomerase

(D) Pyruvate kinase

Q5. A 2-year-old child from a community with minimal sun exposure presents with bowing of legs and a rachitic rosary on chest examination. X-ray shows cupped and frayed metaphyses with a wide growth plate. Which vitamin deficiency is most responsible?

(A) Vitamin A

(B) Vitamin C

(C) Vitamin K

(D) Vitamin D

Q6. A chronic alcoholic presents with lactic acidosis and elevated pyruvate. The enzyme complex that irreversibly decarboxylates pyruvate to form acetyl-CoA and requires thiamine pyrophosphate (TPP), lipoic acid, CoA, FAD, and NAD^+ is:

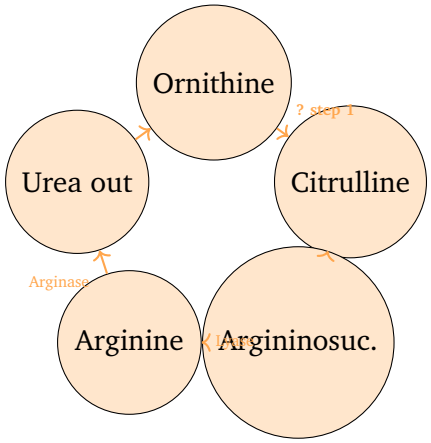
(A) Pyruvate carboxylase

(B) α-Ketoglutarate dehydrogenase

(C) Transketolase

(D) Pyruvate dehydrogenase complex (PDC)

Q7. In the urea cycle shown below, the enzyme responsible for the first committed step (condensation of carbamoyl phosphate with ornithine) that occurs in the mitochondrial matrix is:



(A) Carbamoyl phosphate synthetase I (CPS-I)

(B) Arginase

(C) Ornithine transcarbamylase (OTC)

(D) Argininosuccinate synthetase

Q8. A night-guard who works outdoors reports difficulty seeing in dim light. Examination reveals xerosis of the conjunctiva (Bitot's spots). This condition results from deficiency of a vitamin essential for the synthesis of rhodopsin, a light-sensitive pigment in rod cells. The deficient vitamin is:

(A) Vitamin A (retinol)

(B) Vitamin B2 (riboflavin)

(C) Vitamin E (α-tocopherol)

(D) Vitamin B12 (cobalamin)

Q9. A pharmaceutical company designs a drug that binds reversibly to the active site of an enzyme, competing with the substrate. The drug is a competitive inhibitor. What change in enzyme kinetics is expected when this inhibitor is added at increasing concentrations?

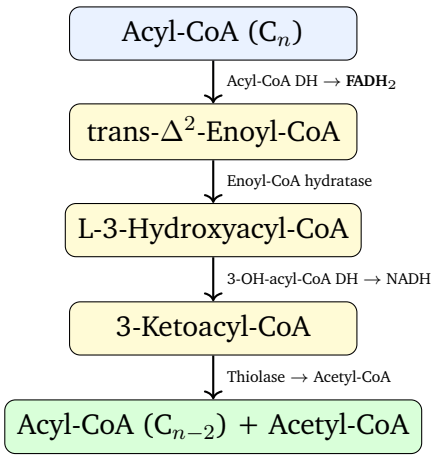
(A) Decreased V_{max}, unchanged K_m

(B) Unchanged V_{max}, increased K_m

(C) Decreased V_{max}, decreased K_m

(D) Unchanged V_{max}, decreased K_m

Q10. In one turn of the β-oxidation spiral for a saturated fatty acyl-CoA (as shown in the simplified cycle below), how many molecules of $FADH_2$ are generated?



(A) 2 $FADH_2$

(B) 3 $FADH_2$

(C) 1 $FADH_2$

(D) 0 $FADH_2$

Q11. A patient with severe pneumonia has a blood gas showing pH 7.30, pCO_2 55 mmHg. In this state of hypercapnia, the oxygen-haemoglobin dissociation curve shifts to the right. This is known as the Bohr effect. What does the rightward shift signify?

(A) Increased affinity of haemoglobin for oxygen

(B) Decreased affinity of haemoglobin for oxygen (facilitating O_2 unloading in tissues)

(C) Increased affinity for CO at the haem iron

(D) Conversion of oxyhaemoglobin to methaemoglobin

Q12. A 30-year-old man with poor dietary intake presents with perifollicular haemorrhages, swollen bleeding gums, and corkscrew hairs. A blood test shows anaemia. The vitamin deficiency responsible for impaired collagen synthesis (failure of hydroxylation of proline and lysine residues) is:

(A) Vitamin C (ascorbic acid)

(B) Vitamin K

(C) Vitamin B6 (pyridoxine)

(D) Vitamin E

Q13. The Meselson-Stahl experiment (1958) demonstrated that DNA replication is:

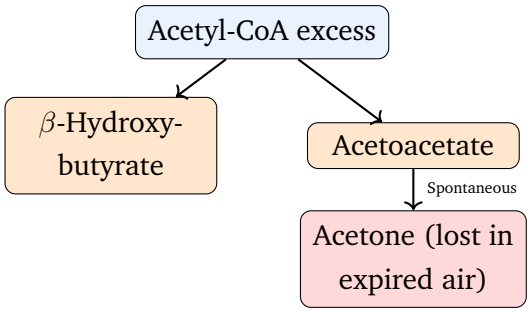
(A) Semi-conservative: each daughter duplex contains one parental and one new strand

(B) Conservative: both parental strands stay together; both new strands form a second duplex

(C) Dispersive: parental and new DNA are randomly mixed throughout all strands

(D) Bidirectional only from a single fixed point

Q14. A type 1 diabetic who stopped insulin presents with vomiting, Kussmaul breathing, and a blood glucose of 480 mg/dL. Urine shows 4+ ketones. The ketone body produced in the **largest quantity** in this patient's liver is:



(A) Acetone

(B) β-Hydroxybutyrate (3-hydroxybutyrate)

(C) Acetoacetate

(D) Propionyl-CoA

Q15. A 6-month-old infant presents with massive hepatosplenomegaly, hypoglycaemia that worsens with fasting, and lactic acidaemia. Liver biopsy shows markedly elevated glycogen content. Glucose-6-phosphatase activity is absent. Which glycogen storage disease is this?

(A) Type II (Pompe disease)

(B) Type III (Cori disease)

(C) Type V (McArdle disease)

(D) Type I (Von Gierke disease)

Q16. During intense exercise, skeletal muscle operates anaerobically. Pyruvate is converted to lactate by lactate dehydrogenase (LDH). What is the **primary role** of this reaction in anaerobic glycolysis?

(A) Regeneration of NAD^+ from NADH, allowing glycolysis to continue

(B) Production of additional ATP

(C) Transfer of lactate to the TCA cycle directly

(D) Synthesis of alanine for gluconeogenesis

Q17. A neonate develops encephalopathy on the 4th day of life. Urine has a distinctive sweet, maple syrup odour. Plasma amino acid analysis shows markedly elevated leucine, isoleucine, and valine. The enzyme deficient in this condition is:

(A) Phenylalanine hydroxylase

(B) Cystathionine beta-synthase

(C) Branched-chain α-keto acid dehydrogenase (BCKDH)

(D) Homogentisic acid oxidase

Q18. A patient with hypercholesterolaemia is started on a statin drug. Statins lower cholesterol by competitively inhibiting the rate-limiting enzyme of cholesterol biosynthesis. This enzyme is:

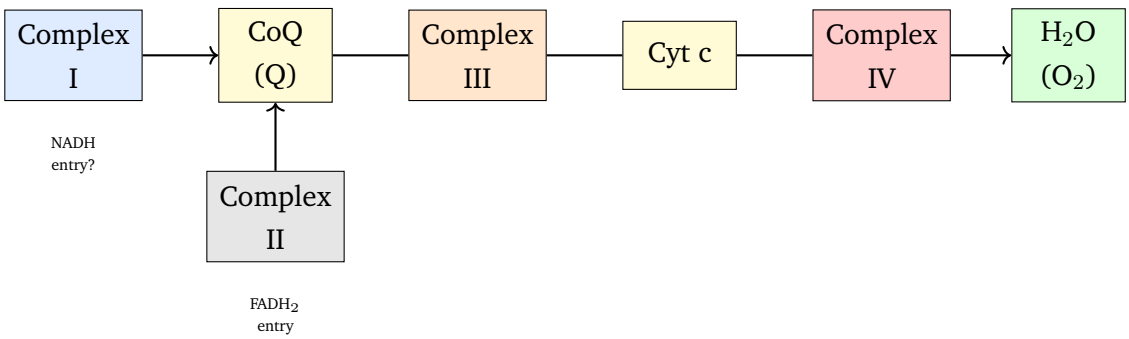
(A) HMG-CoA reductase

(B) HMG-CoA synthase

(C) Squalene synthase

(D) Lanosterol synthase

Q19. The mitochondrial electron transport chain (ETC) is shown schematically below. NADH generated in the TCA cycle donates its electrons at which point of entry?



(A) Complex II

(B) Complex III

(C) Coenzyme Q directly

(D) Complex I (NADH-ubiquinone oxidoreductase)

Q20. Serum albumin is the most abundant plasma protein and is synthesised exclusively by hepatocytes. Hypoalbuminaemia causes oedema by reducing oncotic pressure. Which of the following conditions would **NOT** be expected to cause hypoalbuminaemia?

(A) Nephrotic syndrome

(B) Polycythaemia vera

(C) Severe protein malnutrition (kwashiorkor)

(D) Advanced liver cirrhosis

Q21. A 3-year-old child with Marfanoid habitus, downward lens dislocation, intellectual disability, and elevated homocysteine in urine is found to have a deficiency of cystathionine beta-synthase. Homocystinuria is characterised by the accumulation of which amino acid?

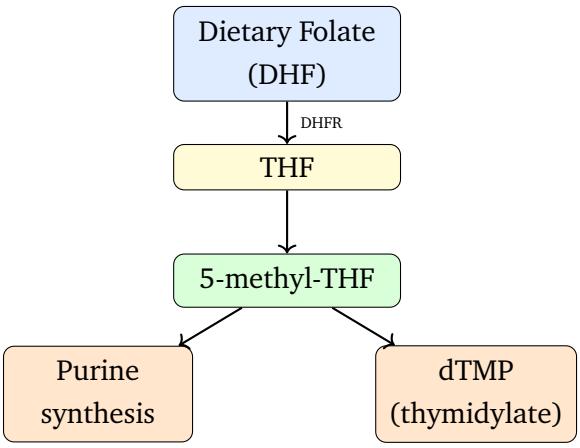
(A) Methionine only

(B) Cysteine

(C) Homocysteine (and methionine)

(D) Lysine

Q22. Periconceptional supplementation with which vitamin is recommended to prevent neural tube defects? This vitamin is required for one-carbon transfer reactions including the synthesis of purines and thymidylate as shown below.



(A) Vitamin B12

(B) Vitamin B6

(C) Vitamin C

(D) Folic acid (vitamin B9)

Q23. During a prolonged fast, gluconeogenesis supplies glucose to the brain and red blood cells. Which enzyme is **unique to gluconeogenesis** and catalyses the bypass of the irreversible PFK-1 reaction?

(A) Fructose-1,6-bisphosphatase

(B) Pyruvate kinase

(C) Phosphoglucose isomerase

(D) Aldolase

Q24. A 3-week-old neonate delivered at home develops intracranial haemorrhage. Prothrombin time (PT) is markedly prolonged. Factors II, VII, IX, and X are deficient because their γ-carboxylation requires a fat-soluble vitamin. Deficiency of which vitamin explains this?

(A) Vitamin A

(B) Vitamin D

(C) Vitamin K

(D) Vitamin E

Q25. Thyroid hormones (T3/T4) increase the basal metabolic rate. At the biochemical level, this is primarily because they upregulate:

(A) Glycogen synthase activity

(B) Na^+/K^+-ATPase expression and mitochondrial uncoupling proteins (thermogenesis)

(C) HMG-CoA reductase activity

(D) Glucokinase activity in the liver

Q26. A middle-aged man notices that his urine turns dark brown-black on standing exposed to air. Examination reveals bluish-black pigmentation of ear cartilage and sclerae (ochronosis) and early-onset lumbar arthritis. Urine chromatography reveals elevated homogentisic acid. The deficient enzyme is:

(A) Phenylalanine hydroxylase

(B) Homogentisic acid oxidase

(C) Maleylacetoacetate isomerase

(D) Cystathionine beta-synthase

Q27. Hereditary nonpolyposis colorectal cancer (HNPCC / Lynch syndrome) is caused by mutations in genes of the DNA repair system that corrects base-pair mismatches introduced during replication. This repair pathway is:

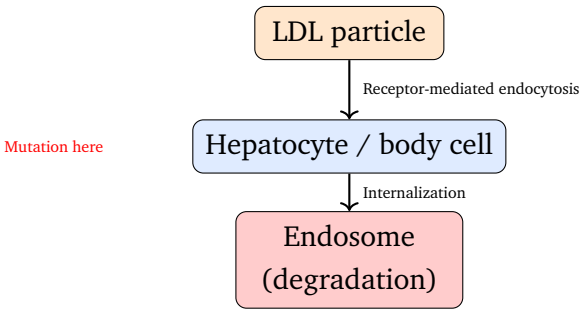
(A) Base excision repair (BER)

(B) Nucleotide excision repair (NER)

(C) Mismatch repair (MMR)

(D) Homologous recombination (HR)

Q28. A 35-year-old man has serum LDL-cholesterol of 380 mg/dL despite a low-fat diet. He has xanthomas over the Achilles tendons and corneal arcus. His father died of myocardial infarction at age 40. Genetic testing reveals a loss-of-function mutation in the gene that codes for:



(A) Apolipoprotein B-100

(B) PCSK9

(C) Apolipoprotein E

(D) LDL receptor (LDLR)

Q29. Succinate dehydrogenase (Complex II of the ETC) is unique among TCA cycle enzymes because it is embedded in the inner mitochondrial membrane. Its prosthetic group FAD accepts electrons from succinate to form fumarate. This classifies succinate dehydrogenase as:

(A) An FAD-linked oxidoreductase (flavoprotein)

(B) An NAD^+-linked dehydrogenase

(C) A kinase

(D) A thiolase

Q30. An inhibitor binds to an allosteric site on an enzyme, distinct from the active site, without affecting substrate binding (K_m unchanged). However, the catalytic efficiency is reduced. This pattern of inhibition is:

(A) Competitive inhibition

(B) Non-competitive (allosteric) inhibition

(C) Uncompetitive inhibition

(D) Irreversible covalent inhibition

Q31. After a meal, rising blood glucose stimulates insulin release. Insulin promotes glucose uptake by skeletal muscle and adipocytes. The mechanism is:

(A) Upregulation of GLUT1 gene transcription

(B) Opening of ATP-sensitive K^+ channels in muscle

(C) Translocation of GLUT4 vesicles from intracellular stores to the plasma membrane

(D) Inhibition of glucagon receptors

Q32. A chronic alcoholic is admitted with confusion, nystagmus, and ataxia (Wernicke's encephalopathy). He also has peripheral neuropathy. An important enzyme in the pentose phosphate pathway, transketolase, is deficient. The vitamin whose deficiency causes this presentation is:

(A) Thiamine (vitamin B1)

(B) Niacin (vitamin B3)

(C) Pyridoxine (vitamin B6)

(D) Riboflavin (vitamin B2)

Q33. A newborn girl is found on newborn screening to have elevated galactose in blood. She presents with jaundice, hepatomegaly, cataracts, and E. coli sepsis. Urine reducing substances are positive but glucose negative. The most common enzymatic defect causing classic galactosaemia is deficiency of:

(A) Galactokinase

(B) Galactose-1-phosphate uridylyltransferase (GALT)

(C) UDP-galactose-4-epimerase

(D) Lactase

Q34. The total ATP yield from complete oxidation of one molecule of glucose (aerobic, standard P/O ratios per the current consensus) is best approximated as:

(A) 36–38 ATP (classical textbook estimate)

(B) 24 ATP

(C) 30–32 ATP (current consensus, accounting for membrane leakage and transport costs)

(D) 42 ATP

Q35. A patient with acute viral hepatitis has markedly elevated serum aminotransferases. The enzyme that catalyses the transfer of an amino group from aspartate to α-ketoglutarate, producing oxaloacetate and glutamate, and that is raised **most specifically** in liver disease compared to cardiac disease is:

(A) Alanine aminotransferase (ALT)

(B) Aspartate aminotransferase (AST)

(C) γ-Glutamyl transferase (GGT)

(D) Lactate dehydrogenase (LDH)

Q36. A patient presents with the "3Ds": **D**iarrhea, **D**ermatitis (Casal's necklace – symmetric photosensitive skin lesions), and **D**ementia. He is a maize-dependent farm labourer. Which vitamin deficiency is responsible?

(A) Thiamine (vitamin B1)

(B) Pyridoxine (vitamin B6)

(C) Riboflavin (vitamin B2)

(D) Niacin (vitamin B3)

Q37. Adrenaline binds to β-adrenergic receptors on the hepatocyte surface. This activates adenylyl cyclase via a G_s protein, generating a second messenger that activates protein kinase A (PKA). The second messenger is:

(A) Inositol-1,4,5-trisphosphate (IP_3)

(B) Diacylglycerol (DAG)

(C) Cyclic AMP (cAMP)

(D) Cyclic GMP (cGMP)

Q38. A chronic alcoholic presents with a fatty liver (hepatic steatosis). The biochemical mechanism is mainly due to the high NADH/NAD^+ ratio resulting from ethanol metabolism by alcohol dehydrogenase and aldehyde dehydrogenase. This high NADH/NAD^+ ratio leads to:

(A) Increased fatty acid oxidation in hepatocytes

(B) Increased gluconeogenesis

(C) Increased TCA cycle activity

(D) Inhibition of fatty acid oxidation and increased fatty acid synthesis/esterification

Q39. A 45-year-old Ashkenazi Jewish woman presents with progressive hepatosplenomegaly, anaemia, thrombocytopaenia, and bone pain. Bone marrow biopsy reveals "wrinkled tissue paper" macrophages (Gaucher cells) engorged with glucocerebroside. The enzyme deficient in Type 1 Gaucher's disease is:

(A) Sphingomyelinase

(B) Hexosaminidase A

(C) Arylsulphatase A

(D) Glucocerebrosidase (β-glucosidase)

Q40. During translation, the ribosome reads the mRNA codon AUG as the start signal and incorporates methionine. The ribosome subunits used in bacteria (prokaryotes) are:

(A) 40S and 60S, assembling to give 80S

(B) 30S and 50S, assembling to give 90S

(C) 30S and 50S, assembling to give 70S

(D) 40S and 60S, assembling to give 100S

Detailed Solutions

Q1.

Solution

Concept – Vitamin B12 (Cobalamin) deficiency: Both elevated methylmalonic acid AND elevated homocysteine point to vitamin B12 deficiency. Folate deficiency raises homocysteine but NOT methylmalonic acid. B12 is required for (i) methionine synthase (converts homocysteine→methionine, needs 5-methylTHF) and (ii) methylmalonyl-CoA mutase (converts methylmalonyl-CoA→succinyl-CoA). Neurological features (subacute combined degeneration of spinal cord – affecting posterior and lateral columns) are unique to B12 deficiency. Source: strict veganism (B12 is found only in animal products).

Final Answer: Cobalamin (Vitamin B12). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q1

Q2.

Solution

Concept – Michaelis Constant (K_m): K_m is defined operationally as the substrate concentration at which the reaction velocity (v) equals exactly half of the maximum velocity (V_{max}). A low K_m indicates high affinity of the enzyme for its substrate; a high K_m indicates low affinity. K_m is a property of the enzyme-substrate pair at a given temperature and pH.

Final Answer: The reaction velocity equals half of V_{max}. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept – Phenylketonuria (PKU): PKU is caused by deficiency of **phenylalanine hydroxylase** (PAH), which converts phenylalanine to tyrosine. Accumulated phenylalanine is converted to phenylpyruvate (phenylketones), producing the musty urine odour and a positive ferric chloride test. Dietary restriction of **phenylalanine** (while ensuring adequate tyrosine – now an essential amino acid) is the mainstay of treatment. Hypopigmentation occurs because tyrosine is the melanin precursor.

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

Answer: (B) Go Back to Q3

Q4.

Solution

Concept – Rate-Limiting Enzyme of Glycolysis: Phosphofructokinase-1 (PFK-1) catalyses the phosphorylation of fructose-6-phosphate to fructose-1,6-bisphosphate and is the committed, rate-limiting step of glycolysis. It is inhibited by ATP, citrate, and H^+ (low pH) and activated by AMP, ADP, and fructose-2,6-bisphosphate. Hexokinase is regulated but not the committed step. Pyruvate kinase is important but irreversibility of PFK-1 makes it the canonical rate-limiting step.

Final Answer: Phosphofructokinase-1 (PFK-1). $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept – Vitamin D deficiency (Rickets): Vitamin D (cholecalciferol) is essential for intestinal calcium and phosphate absorption. Deficiency leads to hypocalcaemia and hypophosphataemia, impairing mineralisation of the growing bone matrix (osteoid). In children this causes **rickets**: bowing of legs, rachitic rosary (costochondral junction beading), and the characteristic X-ray findings of cupped and frayed metaphyses with a widened growth plate.

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

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – Pyruvate Dehydrogenase Complex (PDC): PDC is a multienzyme complex that irreversibly converts pyruvate to acetyl-CoA + CO_2. Cofactors: **TPP** (E1/pyruvate decarboxylase), **lipoic acid** (E2/dihydrolipoamide acetyltransferase), **CoA** (E2), **FAD** (E3/dihydrolipoamide dehydrogenase), **NAD^+** (E3). In alcoholism, thiamine deficiency impairs PDC. α-Ketoglutarate dehydrogenase is a TCA cycle enzyme with the same cofactors but acts on a different substrate.

Final Answer: Pyruvate dehydrogenase complex (PDC). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – First committed step of the urea cycle (OTC): Carbamoyl phosphate synthetase I (CPS-I) makes carbamoyl phosphate from NH_3 + CO_2 (committed to urea synthesis). However, the first step of the urea *cycle proper* is **ornithine transcarbamylase (OTC)**, which condenses ornithine with carbamoyl phosphate to form **citrulline** in the mitochondria. OTC deficiency is the most common urea cycle disorder (X-linked). CPS-I is technically the preceding step outside the cycle.

Final Answer: Ornithine transcarbamylase (OTC). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept – Vitamin A and rhodopsin: Vitamin A (all-trans-retinol) is converted to 11-cis-retinal, which combines with the protein opsin to form **rhodopsin** in rod cells. Light isomerises 11-cis-retinal to all-trans-retinal, triggering the phototransduction cascade. Deficiency leads to night blindness, then xerophthalmia (Bitot's spots, corneal ulceration, keratomalacia). Vitamin A also maintains epithelial integrity and is essential for immune function.

Final Answer: Vitamin A (retinol). $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept – Competitive inhibition kinetics: A competitive inhibitor binds the active site and competes directly with substrate. Increasing substrate concentration can displace the inhibitor, so V_{max} **is unchanged** with excess substrate. However, a higher substrate concentration is needed to reach half-V_{max}, so **apparent** K_m **is increased**. On a Lineweaver-Burk (double reciprocal) plot, competitive inhibition gives lines with the same y-intercept (V_{max} unchanged) but a higher x-intercept (apparent K_m increased).

Final Answer: Unchanged V_{max}, increased K_m. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q9

Q10.

Solution

Concept – $FADH_2$ yield per turn of β-oxidation: Each turn of the β-oxidation spiral produces exactly **1 $FADH_2$** (at the first step: acyl-CoA dehydrogenase), **1 NADH** (at the third step: 3-hydroxyacyl-CoA dehydrogenase), and **1 acetyl-CoA** (at the thiolysis step). For palmitic acid (C16), there are 7 turns producing 7 $FADH_2$, 7 NADH, and 8 acetyl-CoA.

Final Answer: 1 $FADH_2$ per turn. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – Bohr effect (rightward shift of O_2-Hb curve): The Bohr effect describes decreased haemoglobin O_2 affinity at low pH, high CO_2, and high 2,3-BPG – conditions found in metabolically active tissues. A **rightward shift** means haemoglobin releases O_2 more readily to tissues (decreased affinity). The P_{50} (O_2 tension at 50% saturation) increases. This is physiologically adaptive: tissues producing CO_2 need more O_2 delivery.

Final Answer: Decreased affinity for O_2 (facilitating O_2 unloading). $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept – Vitamin C (Ascorbic acid) and collagen: Vitamin C is essential as a cofactor for **prolyl hydroxylase** and **lysyl hydroxylase**, which hydroxylate proline and lysine in procollagen. Without hydroxylation, collagen triple-helix formation is unstable and poorly cross-linked. The result is **scurvy**: bleeding gums, perifollicular haemorrhages, corkscrew hairs, impaired wound healing, and anaemia (iron absorption is also reduced because ascorbate normally reduces Fe^{3+} to Fe^{2+} for absorption).

Final Answer: Vitamin C (ascorbic acid). $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept – Semi-conservative DNA replication (Meselson-Stahl): Using ^{15}N and ^{14}N labelling and CsCl density-gradient centrifugation, Meselson and Stahl showed that after one generation all DNA had intermediate density (hybrid), after two generations 50% was hybrid and 50% light. This proves **semi-conservative** replication: each daughter duplex contains one original (template) strand plus one newly synthesised strand. Conservative replication (both parental strands together) was disproved by the appearance of hybrid DNA after one round.

Final Answer: Semi-conservative. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept – Ketone bodies (DKA): In DKA, insulin deficiency causes massive fat mobilisation and hepatic ketogenesis. Three ketone bodies are produced: acetoacetate (from HMG-CoA), β**-hydroxybutyrate** (from reduction of acetoacetate by β-OHBAD; produced in the largest quantity, ratio β-OHB : AcAc = 3:1 or higher in severe DKA), and acetone (from spontaneous decarboxylation of acetoacetate – gives fruity breath but is produced least). In measuring serum ketones, β-hydroxybutyrate assays are preferred.

Final Answer: β-Hydroxybutyrate (3-hydroxybutyrate). $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept – Von Gierke disease (GSD Type I): Absence of **glucose-6-phosphatase** prevents the liver from releasing free glucose from glucose-6-phosphate (derived from both glycogenolysis and gluconeogenesis). This causes severe fasting hypoglycaemia, lactic acidaemia, hyperlipidaemia, and hepatomegaly. Pompe (Type II) affects muscle with acid maltase deficiency; McArdle (Type V) affects muscle phosphorylase; Cori (Type III) is a debranching enzyme defect.

Final Answer: Type I (Von Gierke disease). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – NAD^+ regeneration in anaerobic glycolysis: Glycolysis requires NAD^+ to continue (GAPDH step oxidises glyceraldehyde-3-P to 1,3-BPG). In the absence of O_2, the mitochondrial ETC cannot re-oxidise NADH. LDH converts pyruvate to lactate while **oxidising NADH back to NAD^+**, regenerating the coenzyme needed for glycolysis to proceed. This produces no additional ATP – its sole role is NAD^+ recycling.

Final Answer: Regeneration of NAD^+ from NADH, allowing glycolysis to continue. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q16

Q17.

Solution

Concept – Maple Syrup Urine Disease (MSUD): Deficiency of **branched-chain α-keto acid dehydrogenase (BCKDH)** impairs the oxidative decarboxylation of the α-keto acids derived from leucine, isoleucine, and valine. These accumulate and are excreted in urine, imparting the characteristic maple syrup/caramel odour. Leucine is particularly neurotoxic. Without early treatment (restricted BCAA intake + thiamine supplementation), encephalopathy and death follow rapidly.

Final Answer: Branched-chain α-keto acid dehydrogenase (BCKDH). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q17

Q18.

Solution

Concept – Rate-limiting enzyme of cholesterol synthesis (HMG-CoA reductase): HMG-CoA reductase catalyses the conversion of HMG-CoA to mevalonate – the committed, rate-limiting step of de novo cholesterol biosynthesis. This is the target of statins (competitive inhibitors). Activity is suppressed by high intracellular cholesterol (SREBP pathway) and by glucagon/insulin-glucagon ratio. HMG-CoA synthase catalyses the preceding step (also involved in ketone body synthesis).

Final Answer: HMG-CoA reductase. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept – NADH entry into ETC: Complex I (NADH-ubiquinone oxidoreductase) is the entry point for electrons from NADH. It oxidises NADH to NAD^+ and transfers electrons to ubiquinone (CoQ). Complex II (succinate dehydrogenase) receives electrons from $FADH_2$ (not NADH) and feeds them directly into CoQ. Complex I pumps 4 H^+ across the inner mitochondrial membrane per NADH, contributing to the proton gradient driving ATP synthesis.

Final Answer: Complex I. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept – Conditions causing hypoalbuminaemia: Hypoalbuminaemia results from: (i) decreased synthesis (liver failure, malnutrition), (ii) increased loss (nephrotic syndrome – albumin lost in urine; protein-losing enteropathy), or (iii) increased catabolism (severe illness). **Polycythaemia vera** is a myeloproliferative disorder (excess red cell production) with no primary mechanism for reducing albumin. Liver function and protein intake are typically normal in PV.

Final Answer: Polycythaemia vera. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept – Homocystinuria (CBS deficiency): Cystathionine beta-synthase (CBS) converts **homocysteine + serine** $\rightarrow$ **cystathionine** (requires pyridoxal phosphate / B6). Deficiency causes accumulation of both **homocysteine and methionine** (the precursor). Clinical features: Marfanoid habitus, *downward* ectopia lentis (upward in Marfan syndrome), intellectual disability, thromboembolic events, and osteoporosis. Urine nitroprusside test is positive.

Final Answer: Homocysteine (and methionine). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q21

Q22.

Solution

Concept – Folic acid and neural tube defects: Folic acid (B9) is required as THF for one-carbon transfer reactions: synthesis of purines (C2 and C8), dTMP (via thymidylate synthase – 5,10-methylene-THF), and methionine regeneration. Periconceptional supplementation (400–800 μg/day) significantly reduces the incidence of neural tube defects (spina bifida, anencephaly) by ensuring adequate nucleotide synthesis for rapid cell division in the closing neural tube.

Final Answer: Folic acid (vitamin B9). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept – Fructose-1,6-bisphosphatase (FBPase-1) – unique to gluconeogenesis: Gluconeogenesis must bypass three irreversible glycolytic steps. FBPase-1 bypasses the PFK-1 step, converting fructose-1,6-bisphosphate back to fructose-6-phosphate. It is **unique to gluconeogenesis** (not present in glycolysis) and is the key regulatory enzyme of gluconeogenesis, inhibited by AMP and fructose-2,6-bisphosphate. Pyruvate kinase, phosphoglucose isomerase, and aldolase are shared between glycolysis and gluconeogenesis.

Final Answer: Fructose-1,6-bisphosphatase. $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept – Vitamin K and coagulation factor γ-carboxylation: Vitamin K (fat-soluble) is required as a cofactor for γ-glutamyl carboxylase, which carboxylates glutamate residues on clotting factors II (prothrombin), VII, IX, X, and proteins C and S. γ-Carboxylation is essential for these factors to bind calcium and phospholipid surfaces. Neonates have low vitamin K stores (sterile gut, limited placental transfer, low breast milk content), predisposing to haemorrhagic disease of the newborn.

Final Answer: Vitamin K. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept – Thyroid hormones and metabolic rate: T3 (the active form) acts on nuclear receptors to upregulate genes encoding **Na^+/K^+-ATPase** (increasing energy consumption) and **uncoupling proteins (UCPs)** in mitochondria (increasing heat production by allowing proton leak across the inner membrane). The net effect is increased BMR. T3 also increases glucose absorption, glycogenolysis, lipid mobilisation, and protein catabolism.

Final Answer: Na^+/K^+-ATPase and mitochondrial uncoupling proteins. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q25

Q26.

Solution

Concept – Alkaptonuria (ochronosis): Alkaptonuria is an autosomal recessive disorder due to deficiency of **homogentisic acid oxidase** (homogentisate 1,2-dioxygenase). Homogentisic acid accumulates in tyrosine catabolism. It is excreted in urine (darkens on oxidation/alkalinisation) and deposits in connective tissues (cartilage, sclerae, tendons) as a dark polymer (ochronosis), causing early-onset degenerative arthritis. Phenylalanine hydroxylase deficiency causes PKU.

Final Answer: Homogentisic acid oxidase. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept – DNA Mismatch Repair (MMR): MMR recognises and corrects base-base mismatches and small insertion-deletion loops introduced during DNA replication. Key proteins: **MSH2, MSH6** (recognise mismatches), **MLH1, PMS2** (coordinate repair). Germline mutations in these genes cause Lynch syndrome (HNPCC). MMR deficiency is detected clinically by microsatellite instability (MSI-H). Nucleotide excision repair (NER) corrects bulky DNA adducts (e.g., UV-induced thymine dimers). Base excision repair (BER) corrects small base lesions.

Final Answer: Mismatch repair (MMR). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept – Familial Hypercholesterolaemia (FH): FH is caused by loss-of-function mutations in the **LDL receptor (LDLR)** gene. Without functional LDLR, LDL particles cannot be internalised by liver and peripheral cells, leading to markedly elevated serum LDL. Heterozygous FH (prevalence 1:500) causes LDL>190 mg/dL; homozygous FH causes LDL>500 mg/dL. Xanthomas and premature atherosclerosis are hallmarks. Mutations in ApoB-100 (prevents LDL binding to receptor) cause a similar phenotype (familial defective ApoB).

Final Answer: LDL receptor (LDLR). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept – Succinate dehydrogenase (Complex II): Succinate dehydrogenase oxidises succinate to fumarate in the TCA cycle, with electrons transferred to a covalently bound **FAD** prosthetic group, forming $FADH_2$. It is the only TCA enzyme embedded in the inner mitochondrial membrane and doubles as Complex II of the ETC. Because electrons from $FADH_2$ enter the ETC at CoQ (bypassing Complex I), $FADH_2$ yields approximately 1.5 ATP per molecule compared with 2.5 ATP per NADH.

Final Answer: An FAD-linked oxidoreductase (flavoprotein). $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept – Non-competitive inhibition: A non-competitive (or allosteric) inhibitor binds a site other than the active site and does not interfere with substrate binding, so K_m **is unchanged**. However, it reduces the catalytic efficiency of every enzyme molecule, so V_{max} **is decreased**. On a Lineweaver-Burk plot, lines intersect the x-axis at the same point (same K_m) but have different y-intercepts (different V_{max}). Competitive inhibitors increase K_m without changing V_{max}; uncompetitive inhibitors decrease both.

Final Answer: Non-competitive (allosteric) inhibition. $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q30

Q31.

Solution

Concept – Insulin and GLUT4 translocation: Insulin binds the insulin receptor (tyrosine kinase), initiating a PI3K-Akt signalling cascade that causes **GLUT4-containing storage vesicles** to translocate from the cytoplasm to the plasma membrane. GLUT4 is expressed in skeletal muscle and adipose tissue. Once inserted into the membrane, GLUT4 facilitates glucose uptake by facilitated diffusion. Brain and red blood cells use GLUT1 (insulin-independent).

Final Answer: Translocation of GLUT4 vesicles to the plasma membrane. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q31

Q32.

Solution

Concept – Thiamine (Vitamin B1) and Wernicke's encephalopathy: Thiamine (B1) serves as the coenzyme thiamine pyrophosphate (TPP) for three key enzymes: (i) pyruvate dehydrogenase, (ii) α-ketoglutarate dehydrogenase (TCA), and (iii) **transketolase** (pentose phosphate pathway). Deficiency in alcoholics impairs these enzymes, especially in high-energy-demand tissues (brain). The clinical triad of Wernicke's encephalopathy: **confusion, ophthalmoplegia, and ataxia**. Untreated, it progresses to Korsakoff's syndrome (amnestic disorder).

Final Answer: Thiamine (Vitamin B1). $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q32

Q33.

Solution

Concept – Classic Galactosaemia (GALT deficiency): Classic galactosaemia is caused by deficiency of **galactose-1-phosphate uridylyltransferase (GALT)**, causing accumulation of galactose-1-phosphate (toxic to liver, kidney, brain, lens). Newborns present with jaundice, hepatomegaly, cataracts, and are susceptible to E. coli neonatal sepsis. Galactokinase deficiency causes only cataracts (from galactitol accumulation) and is milder. Urine reducing substances are positive; glucose oxidase strips are negative (galactose, not glucose).

Final Answer: Galactose-1-phosphate uridylyltransferase (GALT). $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q33

Q34.

Solution

Concept – Total ATP yield from aerobic glucose oxidation: The classical estimate (36–38 ATP) was based on P/O ratios of 3 for NADH and 2 for $FADH_2$ and no accounting for transport costs. The current consensus, using updated P/O ratios (2.5 for NADH, 1.5 for $FADH_2$) and deducting ATP equivalents for malate-aspartate shuttle and phosphate/pyruvate transport, gives **30–32 ATP** per glucose. This is the value used in modern biochemistry curricula (Nelson & Cox, Stryer).

Final Answer: 30–32 ATP (current consensus). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q34

Q35.

Solution

Concept – ALT specificity for liver disease: Both ALT and AST are aminotransferases elevated in hepatocellular injury. **ALT (alanine aminotransferase)** is more liver-specific: it is found predominantly in the liver cytosol. AST is found in the liver (both cytosol and mitochondria), heart muscle, skeletal muscle, kidney, and brain. In viral hepatitis, ALT is proportionally higher than AST (ALT>AST). In alcoholic liver disease and myocardial infarction, AST>ALT. Thus ALT is the preferred marker of hepatocellular damage.

Final Answer: ALT (alanine aminotransferase). $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q35

Q36.

Solution

Concept – Pellagra (Niacin/Vitamin B3 deficiency): Niacin (B3) is the precursor of NAD^+ and $NADP^+$. Deficiency impairs oxidative metabolism throughout the body. Classical pellagra presents with the "4Ds": **Diarrhoea, Dermatitis** (bilateral photosensitive skin lesions – Casal's necklace on the neck), **Dementia** (or dysphoria), and (in severe cases) **Death**. It occurs in maize-dependent populations because maize (corn) is low in tryptophan (the precursor for de novo niacin synthesis) and has bound niacin (niacytin) not bioavailable without alkali treatment (nixtamalisation).

Final Answer: Niacin (Vitamin B3). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q36

Q37.

Solution

Concept – cAMP as second messenger: Adrenaline binds β-adrenergic receptors $\rightarrow$ Gs protein activated $\rightarrow$ adenylyl cyclase converts ATP $\rightarrow$ **cyclic AMP (cAMP)** $\rightarrow$ cAMP activates PKA $\rightarrow$ PKA phosphorylates phosphorylase kinase and other targets $\rightarrow$ glycogenolysis and lipolysis. cAMP is hydrolysed to AMP by phosphodiesterase (PDE – inhibited by caffeine and theophylline, prolonging cAMP action).

Final Answer: Cyclic AMP (cAMP). $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q37

Q38.

Solution

Concept – Alcoholic fatty liver and NADH/NAD$^+$ ratio: Ethanol is oxidised by alcohol dehydrogenase (ADH) to acetaldehyde and then by aldehyde dehydrogenase (ALDH) to acetate. Both reactions generate NADH, raising the NADH/NAD$^+$ ratio in hepatocytes. High NADH: (i) **inhibits β-oxidation of fatty acids** (NADH is a product of β-oxidation, so high NADH inhibits it by product feedback); (ii) inhibits gluconeogenesis (pyruvate and OAA are diverted to lactate/malate); (iii) promotes fatty acid synthesis and esterification. The result is **hepatic steatosis (fatty liver)**.

Final Answer: Inhibition of fatty acid oxidation and increased fatty acid synthesis/esterification. $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q38

Q39.

Solution

Concept – Gaucher's disease (Type I): Gaucher's disease is the most common lysosomal storage disease. Type I (non-neuronopathic) is caused by deficiency of **glucocerebrosidase (β-glucosidase)**, which cleaves glucocerebroside into glucose and ceramide. Glucocerebroside accumulates in macrophages (Kupffer cells, splenic macrophages, bone marrow). Clinical features: hepatosplenomegaly, anaemia, thrombocytopaenia, Erlenmeyer flask deformity of femur, bone crises. Enzyme replacement therapy (imiglucerase) is available. Sphingomyelinase deficiency causes Niemann-Pick; Hexosaminidase A deficiency causes Tay-Sachs.

Final Answer: Glucocerebrosidase (β-glucosidase). $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q39

Q40.

Solution

Concept – Prokaryotic ribosome subunits: Bacterial (prokaryotic) ribosomes are **70S** in total, composed of a **30S** small subunit (containing 16S rRNA) and a **50S** large subunit (containing 5S + 23S rRNA). Eukaryotic ribosomes are 80S (40S + 60S). This difference is clinically exploited by antibiotics: aminoglycosides and tetracyclines target the 30S subunit; macrolides, chloramphenicol, and clindamycin target the 50S subunit.

Final Answer: 30S and 50S, assembling to give 70S. $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q40

Answer Key – FMGE Biochemistry Sample Paper 1

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