S4 Biology Practice Paper: Cell Structure and Function, Enzymes and Metabolism, Cell Division and Genetics, Nutrition and Digestion, Gas Exchange and Transport, Ecosystems and Energy Flow

S4 | Biology | Time: 75 minutes | Total: 100 marks | 24 questions

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Section A Cell Structure and Function

Part A: 4 to 5 marks each, 17 marks in total.

1. State three structures present in plant cells but absent in animal cells. [4]

Answer: Cell wall, chloroplast and a large central vacuole (all three are unique to plant cells).

2. A microscope has a x10 eyepiece and a x40 objective. A cell image measures 8 mm. Find the actual length in micrometres. [4]

Answer: Total magnification = 10 x 40 = 400; actual length = 8 mm / 400 = 0.02 mm = 20 micrometres.

3. Compare cube-shaped cells of side 2 cm and 4 cm. Find the surface area to volume ratio of each and state which diffuses more efficiently. [5]

Answer: Side 2 cm: surface area 24 cm2, volume 8 cm3, ratio 3.0; side 4 cm: surface area 96 cm2, volume 64 cm3, ratio 1.5. The ratio falls 2 times, so the smaller cell has the larger surface area to volume ratio and diffuses more efficiently.

4. State one main function each of the mitochondrion, ribosome, chloroplast and cell membrane. [4]

Answer: Mitochondrion: aerobic respiration to produce ATP; ribosome: protein synthesis; chloroplast: photosynthesis; cell membrane: selectively permeable control of movement of substances.

Section B Enzymes and Metabolism

Part B: 4 to 5 marks each, 17 marks in total.

5. What is an enzyme? Use the lock and key model to explain how an enzyme acts on its substrate. [4]

Answer: An enzyme is a biological catalyst (a protein) produced by living cells that lowers the activation energy. In the lock and key model the active site shape is complementary to one specific substrate, forming an enzyme-substrate complex, and the enzyme is reused.

6. An enzyme acts at 2.0 units at 20 C and 4.0 units at 30 C. Find Q10 and explain why the rate falls sharply at 60 C. [5]

Answer: Q10 = 4.0 / 2.0 = 2.0. At 60 C the enzyme (a protein) is denatured above its optimum, the active site changes shape so substrate cannot bind, and the rate falls sharply.

7. Pepsin works best at pH 2 and trypsin at pH 8. How much do the optima differ, and where does each act? [4]

Answer: They differ by 6 pH units. Pepsin acts in the stomach (strongly acidic); trypsin acts in the small intestine (slightly alkaline).

8. Compare competitive and non-competitive inhibitors, and state which type is relieved by raising substrate concentration. [4]

Answer: A competitive inhibitor competes with the substrate for the same active site, so raising substrate concentration relieves it; a non-competitive inhibitor binds elsewhere and changes the active site shape, so more substrate does not help.

Section C Cell Division and Genetics

Part C: 4 to 5 marks each, 18 marks in total.

9. A human body cell has 46 chromosomes. After DNA replication how many chromatids does one chromosome contain, and how many chromosomes does each daughter cell have after mitosis? [5]

Answer: After replication each chromosome has 2 chromatids, 92 in the whole cell; after mitosis each daughter cell still has 46 chromosomes, identical to the parent cell.

10. How many gametes arise by meiosis from a cell with 2n = 46, how many chromosomes does each gamete carry, and what is the zygote chromosome number? [4]

Answer: 4 gametes are formed, each with n = 23 chromosomes; after fertilisation the zygote is restored to 2n = 46.

11. In the cross Aa x Aa, what is the ratio of dominant to recessive phenotypes, and how many of each are expected among 400 offspring? [4]

Answer: Genotypes are 1 AA : 2 Aa : 1 aa, a phenotype ratio of 3 : 1; among 400 offspring about 300 are dominant and 100 recessive.

12. For XX x XY parents, what is the ratio of males to females, and how many males among 300 offspring? [5]

Answer: Half the offspring are XX (female) and half XY (male), a 1 : 1 ratio; about 150 of 300 offspring are male, i.e. 50%.

Section D Nutrition and Digestion

Part D: 4 to 5 marks each, 17 marks in total.

13. Give one food test and its positive result for starch, reducing sugar, protein and fat. [4]

Answer: Starch: iodine solution turns blue-black; reducing sugar: Benedict solution heated gives a brick-red precipitate; protein: biuret reagent turns purple; fat: a translucent grease spot on filter paper (or an emulsion forms).

14. A person needs 8400 kJ per day, 30% of it from fat. Fat supplies 39 kJ per gram. Find the daily fat intake. [4]

Answer: Energy from fat = 8400 x 30% = 2520 kJ; fat mass = 2520 / 39 = 64.6 g.

15. At which pH are salivary amylase, pepsin and pancreatic enzymes most active, and state two features of villi that aid absorption. [5]

Answer: Salivary amylase about pH 7 (neutral); pepsin about pH 2 (strongly acidic); pancreatic enzymes about pH 8 (slightly alkaline). Villi: finger-like projections increase surface area, and a one-cell-thick wall with blood capillaries and a lacteal shortens the diffusion path.

16. A person is 1.5 m tall and weighs 45 kg. Find the BMI using mass in kg divided by the square of height in metres. [4]

Answer: BMI = 45 / 1.5 squared = 45 / 2.25 = 20.0, which is within the normal range (18.5 to 24.9).

Section E Gas Exchange and Transport

Part E: 4 to 5 marks each, 17 marks in total.

17. State three structural features of alveoli that suit gas exchange. [4]

Answer: The alveolar and capillary walls are very thin (about one cell thick, short diffusion path), the alveoli are extremely numerous giving a large surface area, and the moist lining lets gases dissolve before diffusing.

18. Describe the changes in the intercostal muscles, ribs, diaphragm and thoracic volume during inhalation. [4]

Answer: The intercostal muscles contract moving the ribs up and out; the diaphragm contracts and flattens (moves down). Thoracic volume increases, intrapulmonary pressure falls and air is drawn in.

19. Stroke volume is 70 mL and heart rate is 72 beats per minute. Find the cardiac output in litres per minute. [4]

Answer: Cardiac output = 70 mL x 72 = 5040 mL per minute = 5.04 litres per minute.

20. State one function of each of the four components of blood, and explain why heart rate rises during exercise. [5]

Answer: Red blood cells: haemoglobin transports oxygen; white blood cells: phagocytosis and immune defence; platelets: blood clotting; plasma: transport of nutrients, hormones and wastes. During exercise muscles respire faster, needing more oxygen and producing more carbon dioxide, so heart and breathing rates rise.

Section F Ecosystems and Energy Flow

Part F: 3 to 4 marks each, 14 marks in total.

21. Producers fix 10000 kJ. Using the ten per cent law, find the energy at the primary, secondary and tertiary consumer levels, and their total. [4]

Answer: Primary consumer 1000 kJ, secondary 100 kJ, tertiary 10 kJ, total 1110 kJ, the rest being lost in respiration, excretion and undigested material.

22. State two processes that remove carbon dioxide from the atmosphere and two that release it in the carbon cycle. [3]

Answer: Removal: photosynthesis and dissolving in sea water. Release: respiration and burning fossil fuels (decomposition also releases carbon dioxide).

23. Why is the pesticide DDT most concentrated in top consumers of a food chain? [3]

Answer: DDT is not easily broken down or excreted and accumulates in fat, so at each trophic level biomass falls while the toxin retained is passed on, raising its concentration (bioaccumulation).

24. Why is an ecological pyramid usually upright, and what is the role of decomposers? [4]

Answer: About ninety per cent of energy and biomass is lost at each transfer, so lower levels are larger and the pyramid is upright. Decomposers break down dead organisms and wastes, releasing minerals to the soil for reuse by producers and so recycling nutrients.
