S4 Biology Practice Paper: Digestion and Absorption, Circulation and the Heart, Gas Exchange and Breathing, Plant Water and Mineral Transport, Ecosystem Energy and Matter Cycling, Disease Transmission and Immunity (100 marks)

S4 Biology | 100 marks | 75 minutes

1. Digestion and absorption (17 marks)

Give energies and masses to 1 d.p. and percentages to 2 d.p.

(a) A person takes 100 g of protein, 60 g of fat and 300 g of carbohydrate each day. The energy values are 17 kJ/g for protein, 38 kJ/g for fat and 17 kJ/g for carbohydrate. Find the energy supplied by each nutrient, the total energy intake and the percentage of the total supplied by each nutrient. *(5 marks)*

(b) Salivary amylase has a relative activity of 100%% at 37 C, 5%% at 60 C and 8%% at 0 C. Find the fall in percentage points at 60 C compared with 37 C, and explain why the low activity at the two temperatures has different causes. *(4 marks)*

(c) Bile emulsifies fat globules from a mean diameter of 0.8 mm to 0.02 mm. Assuming the total volume of fat is unchanged, find the factor by which the diameter is reduced and the factor by which the total surface area increases. *(4 marks)*

(d) Compare the routes by which glucose and long-chain fatty acids enter the blood after absorption in the small intestine. *(4 marks)*

2. Circulation and the heart (17 marks)

Use mL and L; show the working for every rate.

(a) A person at rest has a heart rate of 75 beats per minute and a stroke volume of 70 mL. Find the cardiac output in mL/min and in L/min. *(4 marks)*

(b) The person has a blood volume of 5.0 L. Using the cardiac output in (a), how many seconds does one complete circulation of the blood take? *(4 marks)*

(c) The total cross-sectional area of the aorta is 3.0 cm2 with a blood velocity of 30 cm/s; the total cross-sectional area of the capillaries is 3,000 cm2. Find the blood flow rate in cm3/s and the mean velocity in the capillaries. *(5 marks)*

(d) Explain why the wall of the left ventricle is thicker than that of the right ventricle, and state how blood is returned to the heart in the veins. *(4 marks)*

3. Gas exchange and breathing (17 marks)

Give gas volumes in mL and percentages to 1 d.p.

(a) A person has a tidal volume of 500 mL, a breathing rate of 12 per minute and an anatomical dead space of 150 mL. Find the pulmonary ventilation and the alveolar ventilation per minute. *(5 marks)*

(b) The total alveolar surface area is normally about 70 m2. If emphysema reduces it by 40%, and other factors are unchanged, find the remaining area and the diffusion rate of oxygen as a percentage of normal. *(4 marks)*

(c) Each gram of haemoglobin can combine with 1.34 mL of oxygen. A person has a haemoglobin concentration of 150 g/L and a blood volume of 5 L. Find the total volume of oxygen the blood can carry. *(4 marks)*

(d) Explain why a smoker with carbon monoxide poisoning can still be short of oxygen even when inhaling plenty of oxygen. *(4 marks)*

4. Plant water and mineral transport (16 marks)

Work in g m-2 h-1; time in hours.

(a) A plant with a leaf area of 0.5 m2 loses 250 g of water in 5 hours. Find the mean transpiration rate in g m-2 h-1. *(4 marks)*

(b) The same plant absorbs 1.8 L of water a day, 95% of which is lost by transpiration. Find the daily transpiration loss and the water retained in the plant. *(4 marks)*

(c) Compare xylem and phloem in the substances carried, the direction of transport and the driving force. *(4 marks)*

(d) One plant is placed in distilled water and another in a solution containing potassium ions, both aerated. Predict and explain the difference in potassium uptake by the roots. *(4 marks)*

5. Ecosystem energy and matter cycling (17 marks)

Work in kJ m-2 yr-1; give efficiency to 1 d.p.

(a) Net production by the producers of an ecosystem is 40,000 kJ m-2 yr-1 and the efficiency of energy transfer between trophic levels is 10%. Find the energy available to the primary, secondary and tertiary consumers and the total energy of the three consumer levels. *(5 marks)*

(b) A field absorbs 1,200,000 kJ m-2 yr-1 of light energy and its net primary production is 48,000 kJ m-2 yr-1. Find the ecological efficiency. *(4 marks)*

(c) Describe how carbon passes from the atmosphere into living organisms and how it returns to the atmosphere. *(4 marks)*

(d) A mark-recapture estimate is made: 80 animals are caught and marked, then 100 are recaptured of which 16 are marked. Estimate the population size and state two assumptions of the method. *(4 marks)*

6. Disease transmission and immunity (16 marks)

Give counts as whole numbers and percentages as whole numbers.

(a) A disease has a basic reproduction number R0 of 4. Find the minimum vaccination coverage needed for herd immunity, and the coverage if R0 falls to 2. *(4 marks)*

(b) A bacterium divides every 20 minutes. Starting with 500 cells, how many are present after 2 hours under ideal conditions? *(4 marks)*

(c) Explain why stopping a course of antibiotics early encourages the appearance of resistant bacteria. *(4 marks)*

(d) State three measures that reduce the spread of respiratory infections in a school and explain the principle behind each. *(4 marks)*
