S4 Biology Practice Paper I Magnification, enzyme activity, osmosis, gas exchange, cardiac output, energy transfer

S4 Biology I Time allowed: 60 minutes I Total: 100 marks I 24 questions

Question 1 Cells and magnification (17 marks)

Answer ALL parts. Show your working and include units.

1. A student photographs a human cheek cell. The cell image is 60 mm across and the actual diameter of the cell is 75 micrometres. Calculate the magnification of the micrograph. (4 marks)

> **Answer:** Magnification = image size / actual size = (60 x 1000 micrometres) / 75 micrometres = 800 times

2. In an electron micrograph an organelle has an image length of 4.5 mm and an actual length of 0.9 micrometres. Find the magnification. (4 marks)

> **Answer:** 4.5 x 1000 / 0.9 = 5000 times

3. A cell is 20 micrometres long. A student draws it 5 cm long. Calculate the magnification of the drawing. (4 marks)

> **Answer:** 5 cm = 50 000 micrometres; 50 000 / 20 = 2500 times

4. Explain why the magnification of a light microscope cannot be increased without limit. (5 marks)

> **Answer:** Resolution is limited by the wavelength of light: two points closer than about 200 nm cannot be distinguished, so further magnification only gives a blurred image.

Question 2 Enzyme activity and temperature (17 marks)

Answer ALL parts. Show your working and include units.

5. An enzyme catalyses a reaction that produces 24 cm3 of gas in 10 minutes. Calculate the average rate of reaction in cm3 per minute. (4 marks)

> **Answer:** 24 / 10 = 2.4 cm3 per minute

6. In the same experiment the rate is 2.5 cm3 per minute at 30 degrees C and 5.0 cm3 per minute at 40 degrees C. Calculate Q10 for this enzyme between 30 and 40 degrees C. (4 marks)

> **Answer:** Q10 = rate at 40 C / rate at 30 C = 5.0 / 2.5 = 2.0

7. At 60 degrees C the rate falls to 0.2 cm3 per minute. Explain why. (4 marks)

> **Answer:** The high temperature denatures the enzyme protein, so the active site changes shape and the substrate can no longer bind, greatly reducing enzyme-substrate complexes.

8. If substrate is plentiful and the temperature is optimum, predict the effect on the initial rate of doubling the enzyme concentration. Explain. (5 marks)

> **Answer:** The initial rate roughly doubles and is directly proportional to enzyme concentration, because the number of active sites is the limiting factor when substrate is plentiful.

Question 3 Osmosis and change in mass (17 marks)

Answer ALL parts. Show your working and include units.

9. A potato strip of mass 2.40 g is placed in 0.2 M sucrose solution. After 30 minutes its mass is 2.16 g. Calculate the percentage change in mass. (4 marks)

> **Answer:** (2.16 - 2.40) / 2.40 x 100 = -10.0 percent, a decrease of 10.0 percent

10. A potato strip of the same initial mass is placed in distilled water. After 30 minutes its mass is 2.76 g. Calculate the percentage change in mass. (4 marks)

> **Answer:** (2.76 - 2.40) / 2.40 x 100 = +15.0 percent

11. Explain the difference between the two results. (4 marks)

> **Answer:** Distilled water has a higher water potential than the cell sap, so water enters the cells by osmosis and they become turgid and heavier; 0.2 M sucrose has a lower water potential, so water leaves the cells and they lose mass.

12. How could this experiment be used to find the isotonic concentration for the potato tissue? (5 marks)

> **Answer:** Repeat with a series of sucrose concentrations, plot percentage change in mass against concentration, and read off the concentration where the line crosses zero percent, i.e. no change in mass.

Question 4 Gas exchange and pulmonary ventilation (17 marks)

Answer ALL parts. Show your working and include units.

13. At rest a person has a tidal volume of 500 cm3 and a breathing rate of 15 breaths per minute. Calculate the pulmonary ventilation rate. (4 marks)

> **Answer:** 500 x 15 = 7500 cm3 per minute

14. During exercise the tidal volume rises to 700 cm3 and the breathing rate to 30 breaths per minute. Calculate the ventilation rate and how many times the resting value it is. (4 marks)

> **Answer:** 700 x 30 = 21000 cm3 per minute; 21000 / 7500 = 2.8 times the resting value

15. Inhaled air contains 21 percent oxygen and exhaled air contains 16 percent oxygen. Using the ventilation rate in part (a), estimate the oxygen uptake per minute. (4 marks)

> **Answer:** (21 - 16) / 100 x 7500 = 375 cm3 per minute

16. Explain why breathing becomes deeper and faster during exercise. (5 marks)

> **Answer:** Muscles use more oxygen and produce more carbon dioxide, so the carbon dioxide concentration of the blood rises and stimulates the breathing centre, making breathing deeper and faster to remove carbon dioxide and take in more oxygen.

Question 5 Cardiac output and blood flow (16 marks)

Answer ALL parts. Show your working and include units.

17. At rest a person has a stroke volume of 70 cm3 and a heart rate of 72 beats per minute. Calculate the cardiac output in dm3 per minute. (4 marks)

> **Answer:** 70 x 72 = 5040 cm3 per minute = 5.04 dm3 per minute

18. During exercise the stroke volume is 110 cm3 and the heart rate is 150 beats per minute. Calculate the cardiac output and how many times the resting value it is. (4 marks)

> **Answer:** 110 x 150 = 16500 cm3 per minute = 16.5 dm3 per minute; 16500 / 5040 = about 3.27 times

19. At rest about 20 percent of the cardiac output flows to skeletal muscle. Calculate the blood flow to skeletal muscle per minute in cm3 and in dm3. (4 marks)

> **Answer:** 0.20 x 5040 = 1008 cm3 per minute, about 1.01 dm3 per minute

20. Explain why cardiac output increases during exercise. (4 marks)

> **Answer:** Sympathetic stimulation raises the heart rate, while increased venous return and stronger ventricular contraction raise the stroke volume; heart rate and stroke volume rise together, so cardiac output increases greatly.

Question 6 Photosynthesis and energy transfer (16 marks)

Answer ALL parts. Show your working and include units.

21. Grass contains 50 000 kJ of energy and a cow assimilates 8 000 kJ. Calculate the efficiency of energy transfer from grass to cow. (4 marks)

> **Answer:** 8 000 / 50 000 x 100 = 16 percent

22. The cow assimilates 8 000 kJ of energy and 1 600 kJ becomes human biomass. Calculate the efficiency of energy transfer from cow to human. (4 marks)

> **Answer:** 1 600 / 8 000 x 100 = 20 percent

23. Explain why a shorter food chain provides more energy for human use. (4 marks)

> **Answer:** At each trophic level only part of the energy is passed on; the rest is lost through respiration, excretion and heat. A shorter chain means fewer such losses.

24. When other factors are adequate, the rate of photosynthesis stops rising at high light intensity. Explain why. (4 marks)

> **Answer:** Light is no longer the limiting factor; the rate is limited by another factor such as carbon dioxide concentration or temperature, so further increases in light intensity have no effect.