1.2 Cells: Test Pack

AQA 7402 · Calculator allowed · about 55 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question tests core vocabulary used to describe the cell-surface membrane and cell recognition.

(a) Define the term antigen. **(1)**

(b) State what is meant by the term antibody. **(1)**

(c) State the term used to describe a cell that has engulfed and digested a pathogen by phagocytosis. **(1)**

(d) State what is meant by clonal selection in the immune response. **(1)**

(Total for Question 1 is 4 marks)

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2 A student investigated osmosis using cylinders of potato tissue. Cylinders of identical starting mass were placed into sucrose solutions of different concentration for 24 hours, then blotted dry and re-weighed. The percentage change in mass was calculated for each concentration.

Sucrose concentration (mol/dm3)	Percentage change in mass (%)
0.0	+12.0
0.2	+5.0
0.4	-2.0
0.6	-9.0
0.8	-15.0
1.0	-21.0

(a) State what is meant by water potential. **(1)**

(b) Using the data, estimate the sucrose concentration at which the potato tissue would show zero percentage change in mass, i.e. the concentration equal in water potential to the potato cells. Show your reasoning. **(3)**

(c) Explain, in terms of net water movement, why the potato cylinders gained mass in the 0.0 mol/dm3 solution. **(2)**

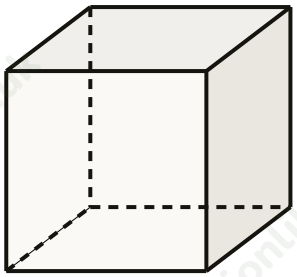
(d) Suggest why the potato cylinders were blotted dry before being re-weighed, and explain why using percentage change in mass, rather than absolute change in mass, improves the validity of comparisons between cylinders. **(3)**

(Total for Question 2 is 9 marks)

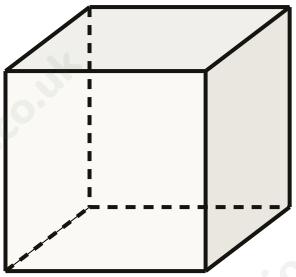
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3 A group of students used agar cubes containing phenolphthalein indicator (which turns from colourless to pink in alkaline conditions) to model diffusion into cells. Cubes with sides of 1 cm, 2 cm and 3 cm were prepared and placed into a beaker of sodium hydroxide solution. The time taken for each cube to turn completely pink (indicating the NaOH had diffused fully to the centre) was recorded.

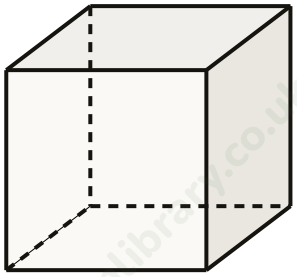
Diagram NOT accurately drawn



1 cm



2 cm



3 cm

(a) Predict, with a reason, which cube would turn completely pink in the shortest time. **(2)**

(b) The 1 cm cube took 4 minutes 30 seconds to turn completely pink. Assuming diffusion occurs from the outer surface towards the centre of the cube (a distance of 5 mm), calculate the mean rate of diffusion in mm per minute. **(3)**

(c) Evaluate the use of agar cubes as a model for diffusion into living cells in this investigation. **(3)**

(Total for Question 3 is 8 marks)

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4 A group of students carried out a required practical investigation into water potential using potato tissue. Cylinders of potato of equal mass were placed into sucrose solutions of different concentrations for 30 minutes, then blotted and reweighed. Table 3 shows the percentage change in mass of the potato cylinders at each sucrose concentration.

Table 3
Sucrose concentration (mol/dm3): 0.0, 0.2, 0.4, 0.6, 0.8, 1.0
Percentage change in mass: +8, +3, -2, -7, -12, -15

(a) Define water potential. **(1)**

(b) Using the data in Table 3, estimate the sucrose concentration of a solution that has the same water potential as the potato tissue (i.e. where there would be no change in mass). Show your working. **(3)**

(c) Explain, in terms of water potential, why the potato cylinders in 1.0 mol/dm3 sucrose solution decreased in mass. **(3)**

(d) Suggest one improvement to the method that would increase the validity of the results. Explain why this would improve validity. **(2)**

(Total for Question 4 is 9 marks)

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5 A cell biologist used cell fractionation followed by density-gradient (differential) centrifugation to isolate organelles from a liver cell homogenate. The homogenate was kept ice-cold, isotonic and buffered throughout. Successive centrifugation stages were used, each at higher speed than the last, and the pellet was retained after each spin.

Centrifugation speed	Organelle in pellet
Low speed (1000 x g)	Nuclei
Medium speed (10000 x g)	Mitochondria
High speed (100000 x g)	Ribosomes and small vesicles

(a) Explain why the homogenate is kept ice-cold, isotonic and buffered during cell fractionation. **(3)**

(b) Explain why nuclei sediment out at the lowest centrifugation speed, while ribosomes only sediment out at the highest speed. **(2)**

(c) A student wants to check that the mitochondrial pellet is not significantly contaminated with nuclei. Suggest a suitable method to test the purity of the mitochondrial fraction, and explain what result would indicate contamination. **(2)**

(d) The original liver homogenate contained 2.4×10^7 mitochondria per cm3. After fractionation, the purified mitochondrial pellet was resuspended in 5.0 cm^3 of buffer, and a sample was found to contain 3.6×10^7 mitochondria per cm3. Calculate the percentage of the total mitochondria that were successfully recovered in the pellet, if the original homogenate volume was 20 cm^3. **(1)**

(Total for Question 5 is 8 marks)

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Mark scheme · 1.2 Cells: Test Pack

Question 1

(a) a molecule (usually a protein) on the surface of a cell that can trigger an immune response/be recognised by the immune system as self or non-self oe **B1**

(a) Answer: A molecule, usually a protein, on a cell surface that the immune system can recognise as self or non-self.

(b) a protein produced by plasma cells (B cells) that binds specifically to a complementary antigen oe **B1**

(b) Answer: A protein made by plasma cells that binds specifically to a complementary antigen.

(c) phagocyte oe (accept named example, e.g. macrophage/neutrophil) **B1**

(c) Answer: Phagocyte (e.g. a macrophage or neutrophil).

(d) the process by which a lymphocyte with a receptor complementary to a specific antigen is selected and stimulated to divide (clone) oe **B1**

(d) Answer: The selection and activation of a lymphocyte whose receptor is complementary to a specific antigen, leading it to divide and form a clone.

Question 2

(a) a measure of the tendency of water molecules to move (diffuse) out of a solution, relative to pure water, which has a water potential of zero oe **B1**

(a) Answer: A measure of the tendency of water to move out of a solution; pure water has a water potential of zero.

(b) identify the change in mass is zero between 0.2 (+5.0%) and 0.4 (-2.0%) mol/dm3, so linear interpolation is needed between these two points **M1**

(b) correct interpolation, e.g. fraction = 5.0 / (5.0 + 2.0) = 0.714 of the way from 0.2 to 0.4 **M1**

(b) approximately 0.34-0.35 mol/dm3 (accept any value obtained by a valid graphical or numerical interpolation between 0.2 and 0.4), cao **A1**

(b) Answer: Approximately 0.34-0.35 mol/dm3.

(c) the water potential of distilled water (0.0 mol/dm3) is higher than the water potential inside the potato cells oe **B1**

(c) so there is a net movement of water into the cells by osmosis, down the water potential gradient, causing the cells to gain mass/become turgid oe **B1**

(c) Answer: Distilled water has a higher water potential than the cell contents, so water moves into the cells by osmosis down the water potential gradient, increasing their mass.

(d) blotting removes surface water so that only the mass of water taken up/lost by the tissue itself is measured, not water clinging to the surface oe **B1**

(d) using percentage change accounts for small differences in the starting mass of each cylinder oe **B1**

(d) this allows a fairer comparison between cylinders of slightly different initial mass than comparing absolute mass changes oe **B1**

(d) Answer: Blotting removes surface water so only water taken up or lost by the tissue is measured. Using percentage change corrects for small differences in the cylinders' starting masses, making comparisons between cylinders fairer.

Question 3

(a) the 1 cm cube **B1**

(a) because it has the largest surface area to volume ratio, so the diffusion pathway/distance to the centre is shortest relative to its volume, so NaOH reaches the centre fastest **B1**

(a) Answer: The 1 cm cube, because it has the largest surface area to volume ratio, meaning NaOH has the shortest distance to diffuse to reach the centre of the cube

(b) converts time to minutes: 4 min 30 s = 4.5 min **M1**

(b) rate = distance / time = 5 / 4.5 (dependent on M1) **dM1**

(b) 1.1 mm/min awrt (1.11 mm/min to 3 s.f.) **A1**

(b) Answer: 1.1 mm per minute (1.11 mm/min to 3 s.f.)

(c) strength: agar cubes are cheap, safe and easy to prepare in precise sizes/shapes, allowing SA:V ratio to be varied systematically and quantitatively **B1**

(c) limitation: agar is non-living and has no cell-surface membrane, so cannot model active transport or membrane permeability **B1**

(c) limitation: real organisms/cells are not simple cubes and have specialised exchange surfaces, so the model may not accurately reflect real diffusion distances **B1**

(c) Answer: Strength: agar cubes are cheap, safe and easy to prepare in precise sizes, allowing SA:V ratio to be varied systematically. Limitation: agar is non-living and has no cell membrane, so cannot model active transport or membrane permeability; real organisms are not simple cubes, so the model may not accurately reflect real diffusion distances/exchange surfaces

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Question 4

(a) a measure of the tendency of water molecules to diffuse out of a solution; pure water has a water potential of zero and all solutions have negative water potentials (oe) **B1**

(a) Answer: A measure of the tendency of water molecules to diffuse out of a solution; pure water has a water potential of 0 kPa, and solutions have negative water potentials (the more concentrated the solution, the more negative the water potential)

(b) identifies the zero crossing point lies between 0.2 mol/dm3 (+3%) and 0.4 mol/dm3 (-2%) **M1**

(b) correct linear interpolation, e.g. 3/(3+2) x 0.2 (dependent on M1) **dM1**

(b) awrt 0.30 to 0.35 mol/dm3 (e.g. 0.32) **A1**

(b) Answer: Approximately 0.32 mol/dm3 (accept 0.30 to 0.35 mol/dm3)

(c) the sucrose solution has a lower (more negative) water potential than the cells/cytoplasm of the potato tissue **B1**

(c) water moves out of the potato cells across the partially permeable cell-surface membrane by osmosis **B1**

(c) down (from a higher to a lower) water potential gradient, so the tissue loses mass **B1**

(c) Answer: The 1.0 mol/dm3 sucrose solution has a lower (more negative) water potential than the potato cells. Water therefore moves out of the cells, across the partially permeable membrane, by osmosis, down the water potential gradient, causing the tissue to lose mass

(d) keep all sucrose solutions at the same controlled temperature, e.g. using a thermostatically controlled water bath (accept another suitable improvement not already stated in the method) **B1**

(d) temperature affects the rate of osmosis, so controlling it ensures temperature differences do not affect the comparison of mass changes (accept a valid reason linked to the suggested improvement) **B1**

(d) Answer: Keep all sucrose solutions at the same controlled temperature using a thermostatically controlled water bath. Temperature affects the rate of osmosis, so controlling it prevents temperature differences from affecting the comparison of mass changes.

Question 5

(a) ice-cold: reduces the rate of enzyme activity (including hydrolytic/lysosomal enzymes), reducing the breakdown/damage of organelles oe **B1**

(a) isotonic: prevents osmotic movement of water into or out of the organelles, which would otherwise cause them to burst or shrink and distort oe **B1**

(a) buffered: keeps the pH constant/prevents enzymes and proteins denaturing/being damaged by pH changes oe **B1**

(a) Answer: Ice-cold conditions slow enzyme-catalysed breakdown of organelles; isotonic solution prevents osmotic damage (bursting or shrinking); buffering maintains a constant pH, preventing denaturation.

(b) denser/larger organelles (such as nuclei) require less centrifugal force to sediment, so they pellet first at low speed oe **B1**

(b) smaller/less dense structures (such as ribosomes) require much greater centrifugal force to overcome their slower sedimentation, so they only pellet at the highest speed oe **B1**

(b) Answer: Larger, denser structures like nuclei sediment at low speed, while small structures like ribosomes need much greater centrifugal force and so only pellet at the highest speed.

(c) a valid method, e.g. examine a sample of the mitochondrial fraction under a light or electron microscope, or test for a marker/enzyme specific to nuclei oe **B1**

(c) seeing nuclei present in the sample (or a positive result for a nucleus-specific marker) would indicate contamination oe **B1**

(c) Answer: Examine the mitochondrial fraction under a microscope (or test for a nucleus-specific marker); seeing nuclei present, or a positive marker result, would indicate contamination.

(d) 37.5% (working: original total = 2.4e7 x 20 = 4.8e8; recovered total = 3.6e7 x 5.0 = 1.8e8; percentage = 1.8e8/4.8e8 x 100 = 37.5%), cao **B1**

(d) Answer: 37.5%

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