#### HUMAN BIOLOGICAL SCIENCES (STAGE 2)

**FACTORS AFFECTING THE**

**RATE OF DIFFUSION**

**INVESTIGATION 1**

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Part A, Research: /15

Part B, Practical: /20

Part C, Assessment: /15

Total Marks: /50 %

HBS2A: Investigation 1

Factors affecting the rate of diffusion

You will be submitting three pieces of work for this investigation that will run over approximately one week.

**Part A: Research - Lesson 1**

One period of class time will be allocated to answering the following:

* 1. Define diffusion and give at least two examples of how diffusion allows a cell to be provided with the substances necessary for life functions. [3]
  2. Describe the structure of the cell membrane and provide examples of how substances may diffuse into a cell. [5]
  3. Define the terms hypotonic, hypertonic and isotonic and discuss the influence that these solutions can have on the effectiveness of diffusion. [3]
  4. Discuss the concept of surface area to volume ratio and how this affects the size of cells and consequently the evolution of multi-cellular organisms. [4]

This will be completed individually.

**Part B: Practical – Lesson 2 & 3**

Two periods of class time will be dedicated to completing the practical investigation on diffusion. The investigation procedure is attached. This practical will be completed in groups and the results are to be handed in for individual assessment.

**Part C: Validation Assessment – Lesson 4**

One period of class time immediately following the practical investigation will be dedicated to an in-class validation test where you will be assessed on the information and results you have researched and formulated over the previous lessons. This will be completed individually and you will be able to use the results from your investigation.

HBS2A: Investigation 1

Factors affecting the rate of diffusion

**Aims**

**1.** To determine the effects of time of immersion and concentration on the diffusion of potassium permanganate into potato cubes.

**2.** To determine the influence of the surface area: volume ratio on the effectiveness of diffusion.

**Theoretical basis**

The cell membrane determines what substances can diffuse into a cell. This characteristic of a cell membrane is called permeability. Membranes are selectively permeable, that is, they only allow the passage of certain materials. Potassium permanganate can pass through a cell membrane. However, its diffusion into a cell is influenced by such factors as concentration and the time allowed for diffusion. The effectiveness of diffusion is also determined by the size of the cell.

**Surface area to volume ratio calculations**

cube surface area = 6 x side2

volume = side3

regular rectangular block surface area = 6 (length x breadth)

volume = length x breadth x height

cylinder surface are = [2 π radius x height] + [2 π radius2]

= 2 π radius (height + radius)

volume = π radius2 x height

sphere surface area = 4 π radius2

volume = 4 π radius3 ÷ 3

**Requirements**

* potato
* 4 small beakers
* stop watch
* metric ruler
* potassium permanganate solutions (0.1 %,1 % and 5%)
* tweezers
* single-edged razor blade

**Method**

**A. Influence of time on diffusion**

1. Cut 5 cubes of potato 1 cm x 1 cm x 1 cm.
2. Cut 1 cube 2 cm x 2 cm x 2 cm.
3. Calculate the surface area and the volume for each cube size. Then work out the surface area to volume ratio for each cube size.
4. Place 4 of the small cubes and the large cube into a small beaker that is half filled with 5% potassium permanganate solution. Note the exact time the cubes are added to the solution.
5. With tweezers, remove one of the small cubes from the solution every 5 minutes. Remove the large cube after 10 minutes.
6. Cut the cubes in halves with the razor blade. Carefully clean and dry the blade before slicing each cube.
7. Measure the distance in millimetres that the solution has not diffused into each cube. Calculate the volume of the cube where diffusion has not occurred.



**Figure 1.10 Measuring diffusion into a potato cube**

1. Calculate the volume of the cube where diffusion has occurred by subtraction.

volume of diffusion = total volume of cube - volume undiffused cube

1. Calculate per cent diffusion.

per cent diffusion = (volume diffused ÷ total volume) x 100

1. Slice open the cube that was not added to the solution. This cube is the 'control' and can be considered the 'zero time' cube.
2. Tabulate your results, showing per cent diffusion and time in solution for each of the 1 cm3 cubes. Against the 14 minutes time slot also indicate per cent diffusion for the 2 cm3 cube. [6]
3. Compare the diffusion of each sized block at 14 minutes and relate this to the surface area: volume ratio of each cube. [2]

**B. Influence of the chemical concentration on diffusion**

1. Set up three small beakers with the following:
   1. a small amount of 5% potassium permanganate solution
   2. a small amount of 1 % potassium permanganate solution
   3. a small amount of 0.1 % potassium permanganate solution.
2. Cut three 1 cm x 1 cm x 1 cm cubes of potato and one 2 cm x 2 cm x 2 cm cube.
3. Place one small cube into each beaker and the larger cube into the 1% solution beaker. Note the exact time that the cubes are added to the solution.
4. After 25 minutes, use tweezers to remove each potato cube from its solution.
5. Determine the per cent diffusion for each cube as in Part A. Record the results in a table. [4]
6. Compare the per cent diffusion for the small and large cubes in the same solution and relate this to the surface area: volume ratio. [2]

**Interpretation of data**

Write a discussion of the results including the following points:

* relation of the effects of time allowed to the diffusion of material into or out of a cell [1]
* relation of the concentration of diffusing molecules to the diffusion of material into or out of a cell [2]
* relation of the surface area: volume ratio of the 'cell' to the diffusion of material into or out of a cell [2]
* consideration of the significance of cell size on the efficient functioning of the cell [1]

*This discussion must relate directly to your investigation using the specific results collected for each point. All results tables and calculations must be handed in along with this discussion.*

HBS Stage 2: Investigation 1

Factors affecting the rate of diffusion

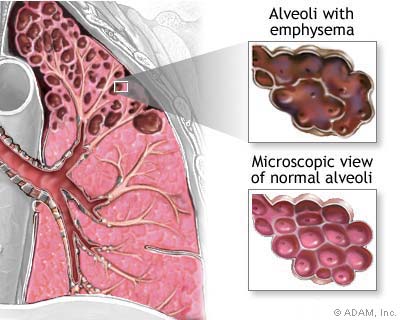
Validation Assessment

1. (a) Calculate the surface area to volume ratio of the following cells using the data provided. [2]

|  |  |  |  |
| --- | --- | --- | --- |
| **Cell** | **Surface area (µm2)** | **Volume (µm3)** | **SA:V** |
| A | 50 | 20 |  |
| B | 15 | 5 |  |
| C | 0.1 | 0.03 |  |

(b) Based on your calculations which cell would be most efficient at supplying the cell contents with the necessary substances for life processes? [1]

1. In part A of the practical (Influence of time on diffusion) a cube was not placed into a solution and was classified as the ‘control cube’. Why is a control necessary in an experiment? [1]
2. In the same practical, why was it necessary to clean and dry the blade before cutting the next cube? [1]
3. In reality it would be a substance such as glucose that would diffuse into a cell. Considering glucose is not lipid soluble and therefore cannot penetrate the lipid bi-layer, describe how glucose is able to move through a cell membrane. [2]
4. When a patient is dehydrated they are given an intravenous drip of saline solution. Why is it a bad idea to give a person an intravenous drip of pure water? [2]
5. When a person spends a long time in the ocean their fingertips look noticeable shrivelled. Explain what has taken place in the intracellular fluid of the person. [3]



1. A person suffering from severe emphysema undergoes oxygen therapy. This involves pure oxygen being pumped through a tube into the lungs. With reference to the diagram on the right explain why pure oxygen in used in the treatment for emphysema (remembering the normal concentration of oxygen in the atmosphere is only 21%). [3]