Shades from Shapes

Materials

Task 1: Beaker, water, ink, dropper.

Task 2: Wheat flour, tap water, food colour powder (green or red) – available with grocer, a bowl (for making the dough), 10 glass beakers (about 250 mL capacity- one for each shape, to submerge shapes in water and for collecting the coloured water for comparison), 5 tea cups.

Task 3: Gelatin powder without any added colour (any branded gelatin powder available with grocer), tap water or any potable water, phenolphthalein solution (1%), plastic cups (as moulds of different shapes—chocolate or cookie moulds can be used), glass beaker 100 mL capacity, a shallow wide container or bowl, measuring cylinder (100 mL capacity), heater or stove, dilute base: NaOH 0.1 N or soap solution (10 drops of any liquid soap in 100 mL of water), dilute acid: HCl solution (0.1 N) or bathroom cleaner acid (diluted 10 times with water) or lemon juice (juice from two medium sized lemons in a glass of water), butter paper/transparent plastic sheet.

Task 1: Movements of particles in liquids

Take a beaker filled with water. Add a few drops of ink to it.

Q1. What happens to the ink drop?

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Q2. What colour change do you see?

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Q3. Why doesn’t the drop of ink stay as a drop?

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Q4. Can you think of at least three similar examples from your daily life, where you see such phenomenon? Try to think of such phenomena in air or gases as well.

1. ______________________________
2. ______________________________
3. ______________________________

Q5. Imagine what will happen to a drop of thick sugar syrup in water?

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When you add a drop of ink to a beaker full of water, the ink diffuses in the water, eventually spreading evenly in the beaker. This phenomenon of mixing of fluids (liquids/ gases, as in examples above) happens on its own, even without anyone stirring or mixing the fluids. This phenomena, though widely observed, was very difficult for scientists to explain. A clear explanation could only come after it was recognised that matter must be consisting of very small particles (later called atoms and molecules) and these particles must be in constant motion.

The small particles in fluids cannot be seen by our eyes. These particles can move in any direction. When there is a movement of large number of particles, from one region where they are more to another region where they are less, it is known as diffusion.

Q6. Based on above discussion, tick the appropriate option:

Diffusion of a substance happens from a region of

a) low concentration to a region of high concentration

b) high concentration to a region of low concentration

Task 2: Effect of surface area on diffusion

Procedure

i. In a bowl, add a tea-cup full of wheat flour.

ii. Add food colour (use adequate to get very dark colour) to the bowl and mix it well with the dry flour. Keep some coloured flour aside.

iii. Add water to the remaining flour in small quantities. Mix the flour and water well after each addition of water.

iv. Continue kneading the wheat flour till it becomes a nice smooth dough with uniform colour. The dough should be slightly soft, not hard.

v. In case you add extra water and the dough gets sticky, add more remaining coloured flour till it gets the firm and smooth consistency.

vi. Divide the dough into four equal parts, making small balls (spheres) of approximately 4 g each. The exact mass of the balls is not important but all the balls should be same in size and mass. You may use a rough balance or a small bowl/cup/medicine bottle cap to compare size/mass of the balls (for more accuracy).

vii. Using different moulds or by hands, mould each ball of dough into different shapes: a cylinder, a flat round disc, a sphere, a cone and a brick or a cube.

viii. Measure the dimensions for each shape, such as the diameter and height of the cylinder; diameter for the sphere; slant height and diameter for the cone; height, length, and breadth for the brick etc., and record in your worksheet in Table 1.1.

ix. For each shape, take separate containers and add 150 mL of water to each. Label the beakers with names of the respective shapes.

x. Gently place the shape in the respective container without spilling any water.

xi. The shape should be completely immersed in water. Add more water to each beaker if any of the shapes is not submerged. All the containers should have equal quantity of water.

xii. Keep the containers undisturbed for about 30 minutes. Use this time to calculate the approximate surface area of each shape. You may use the expression for surface area given at the end of this unit.

Table 1.1

Sr. No.	Dough shape	Dimensions of the shape (diameter, height, length, breadth etc.)	Surface area
1.			
2.			
3.			
4.			

NOTE: One way to obtain the radius of a sphere is by wrapping a thread around it to find the circumference and use the circumference to calculate the radius.

- After 30 minutes, gently decant the water into a separate glass beaker or carefully remove the dough from the beaker.
- Arrange all the beakers side-by-side, starting with the darkest colour to the lightest.
- Place next to these another beaker with plain water, and record this as zero ('0').
- Record your observations in table 1.2. Indicate the intensity of colour of the solution in each beaker as "very light, light, dark, or very dark".

Table 1.2

Sr. No.	Dough shape	Colour score of the solution
1.		
2.		
3.		
4.		

Observations of the activity performed

- The shape that gave maximum colour to the solution is: ________________________________
- The shape that gave minimum colour to the solution is: ________________________________

Q1. Arrange the dough shapes on the basis of the colour score:

________________ < ________________ < ________________ < ________________.

Q2. Arrange the dough shapes on the basis of their surface areas:

________________ < ________________ < ________________ < ________________.

Q3. Is there any relation between the surface area and the rate of diffusion? Explain.

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Q4. Why did we initially make balls of approximately equal weight?

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Q5. Why should all containers have equal amount of water? What will happen if the volume of water across the beakers is unequal?

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Q6. Why should the shapes be completely submerged in water?

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Q7. Why does the colour intensity of water change with different shapes?

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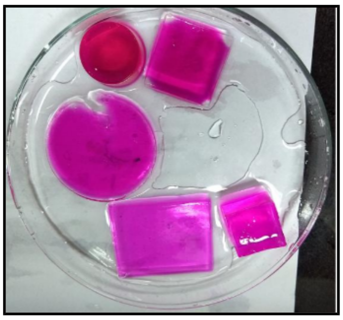
Task 3: Observing the diffusion in gelatin box

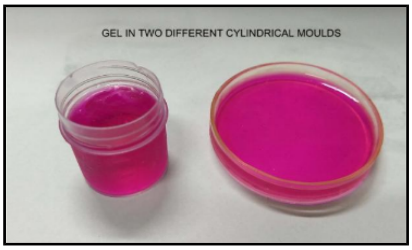
i. Take 100 mL water in a beaker, and heat till it boils.
ii. Add 5-6 g of gelatin powder. Stir to mix well.
iii. Continue heating the solution till the gelatin is completely dissolved.

iv. Stop the heating and let the solution cool down for 5-6-minutes.
v. Add 3-4 drops of phenolphthalein.
vi. Add 1 mL of NaOH or soap solution.
vii. Mix well to get a dark pink colour.
viii. Use a measuring cylinder to pour 10 mL of this coloured gelatin solution in each mould.



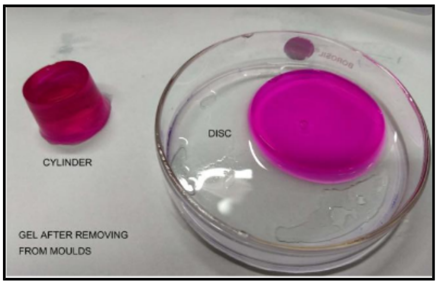
ix. One can also make one's own moulds by using household items, such as an empty match box for getting a cuboidal-shaped gel.

x. The amount of gelatin solution poured can be more or less, depending on the size of the moulds available. But pour same quantity of solution across all the moulds, i.e., one can put 15 mL of liquid gelatin in each mould instead of 10 mL.



xi. Allow the gelatin to set for 30 min. You may keep it in the refrigerator to speed up the setting.

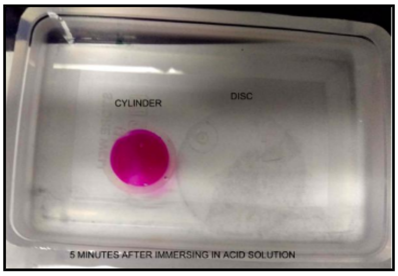
xii. Carefully take out the shapes from moulds, and put them on a butter paper/ a clean plastic sheet.



xiii. Measure the dimensions of the shapes prepared, and record them in table 1.3.

xiv. Take a shallow but wide container or a glass bowl. Pour sufficient quantity of a dilute acid solution so that the hardened gelatin shapes can completely submerge.

xv. Gently place all the gelatin shapes into the dilute acid solution. Try to put all shapes in the solution at the same time instead of putting them one-by-one.



xvi. Note the time when the shapes were placed in the acid solution.
xvii. Observe the coloured gelatin shapes and the time taken for every shape to become colourless. Record your observations in table 1.4.

Table 1.3

Sr. No.	Gelatin shape	Dimensions of shapes (diameter, height, length, breadth etc.)	Surface area
1.			
2.			
3.			
4.			

Table 1.4

Sr. No.	Gelatin shape	Time when the shape was placed in acid solution (min: sec)	Time when the shape became colourless (min: sec)	Time taken to become colourless (sec)
1.				
2.				
3.				
4.				

Observations of activity performed

- The shape that took the maximum time to become colourless is: ______________________
- The shape that took the minimum time to become colourless is: ______________________

Q1. Why was NaOH added to the gelatin solution along with phenolphthalein?

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Q2. Why did all the shapes turn colourless after immersing them in the acid solution?

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Q3. Why did the different shapes take different time to become colourless?

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Q4. What is the role of gelatin in this experiment?

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Q5. What would happen if phenolphthalein was added to the solution in the bowl and not to the gelatin?

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Q6. What will happen if we put these discoloured shapes in a strong basic solution?

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Q7. Can you suggest other easily available dyes/pH indicators instead of the one used in this activity? What changes do you expect when you use those indicators?

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Task 4: Diffusion in living beings

Have you ever wondered how nutrients from our food enter the bloodstream? The process is similar to what you observed in the above activities. However, in humans and other living beings, diffusion occurs across membranes. A membrane is a material that acts as a barrier or divider between two regions. A permeable membrane allows most substances to pass across it. On the other hand, a semi-permeable membrane allows only certain substances to cross the membrane, but not others. Most biological membranes such as cell membranes are selectively permeable.

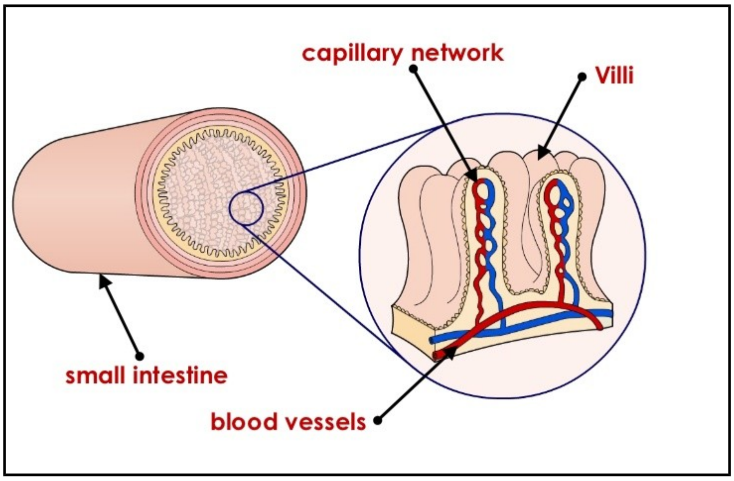

Figure 1: *Small intestine showing villi with capillary networks*

Q.8. Can you think of more examples, of organs in the body, or in nature, where larger surface area affects diffusion? Here is one example:

a) Diffusion of oxygen from lungs into red blood cells.

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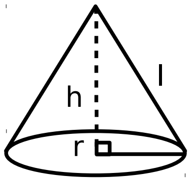
Expressions for surface area

Sr. No.	Shape	Shape diagram	Expression for surface area
1	Sphere	r	$4\pi r^2$
2	Cube	side	$6 \times side^2$
3	Brick (Cuboid)	H L W	2LW + 2HW + 2LH
4	Cylinder and flat disc	r h	$2\pi r(r + h)$

5	Cone		$\pi r(r + \sqrt{h^2 + r^2})$ (students can use the Pythagoras theorem to calculate the height of the cone)