Name of the Student:_____
Max. Marks : 22 Marks **Time : 22 Minutes**

Q1.

Desalination is a technique for making drinking water by the removal of salts from sea water. It is used in parts of the world where fresh water is in short supply. A problem with this technique is the increase in the concentration of salts, particularly of sodium chloride, in the effluent (the solution returned to the sea).

Desalination uses a process called reverse osmosis. In this process, sea water under high pressure is passed over a special membrane which allows only pure water to pass through it.

The owners of a desalination plant have asked for the effluent to be analysed at different operating pressures. This is needed to find an **approximate** value for the maximum operating pressure that gives an effluent that has a minimum harmful effect on the environment.

A chemist sampled the effluent at different pressures. For each pressure, a 250 cm^3 sample of effluent was taken in a measuring cylinder and poured into a weighed beaker. The water was evaporated by heating and the beaker reweighed. The following results were obtained.

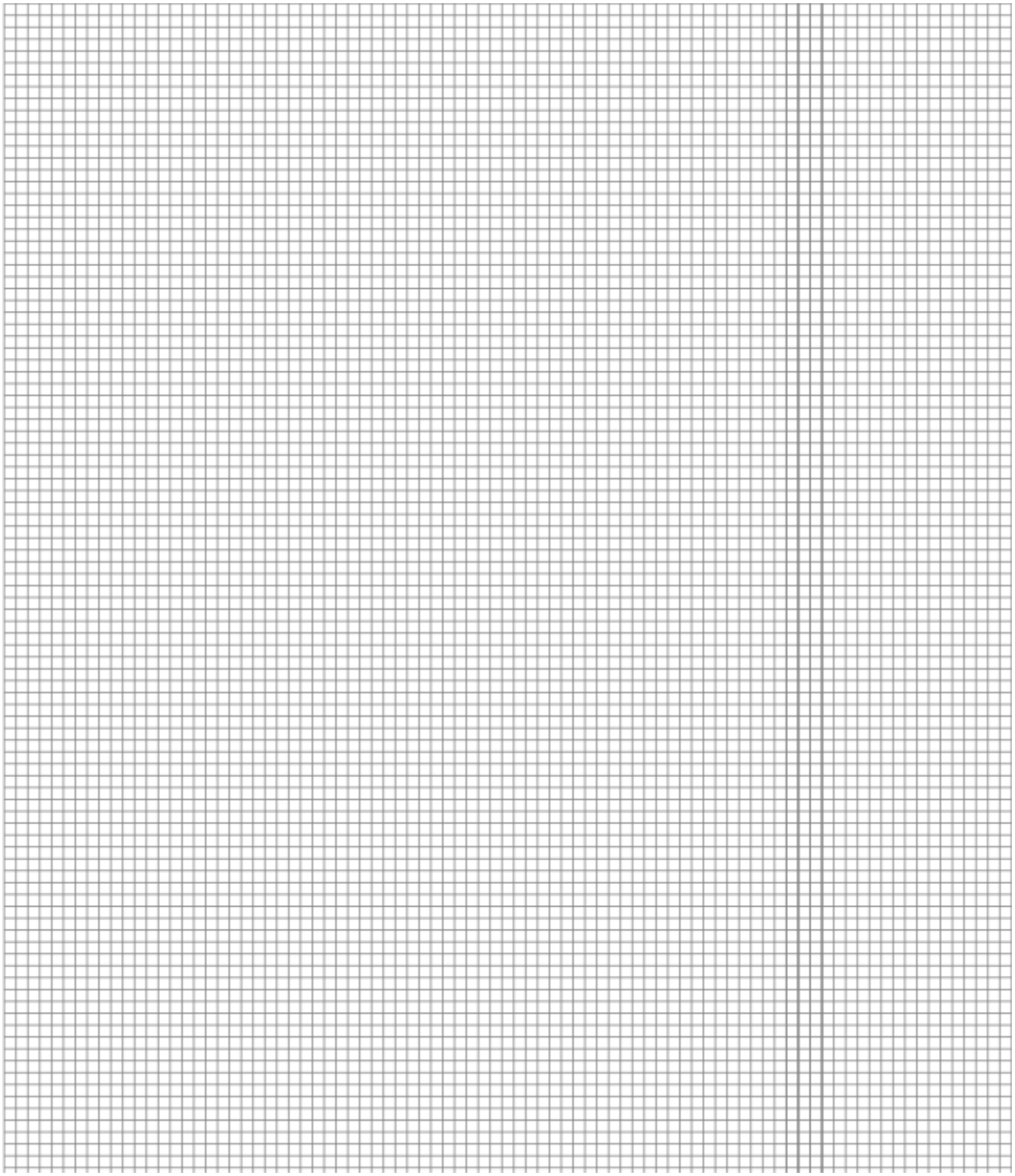
Experiment	**1**	**2**	**3**	**4**	**5**	**6**
Pressure / MPa	0.1	0.5	1.0	2.5	4.0	8.0
Beaker mass before heating / g	55.3	55.5	55.0	55.1	55.3	56.3
Beaker mass after heating / g	62.5	64.9	65.3	66.6	67.5	69.4
Mass of solid in beaker / g						

(a) Complete the table above to determine the mass of solid that remains in the beaker at each pressure.

Plot a graph of mass of solid (*y*-axis) against pressure on the graph paper.

Draw a smooth curve through the points.

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(4)

(b) To minimise harmful effects on the environment, the concentration of sodium chloride in the effluent should not exceed 44.0 g dm^{-3}. Use your graph to find a value for the pressure, in MPa, that the chemist should advise to be the maximum operating pressure.

Assume that all the solid left in the beaker is sodium chloride.

_____

_____

(1)

(c) In Experiment **1** the 250 cm^3 sample of the effluent contained the same amount of sodium

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chloride as the original sea water. Calculate the concentration, in mol dm^{-3}, of sodium chloride in sea water.

Assume that all the solid left in the beaker is sodium chloride.
Show your working.

_____

_____

_____

(2)

(d) For the measuring cylinder and the balance, the maximum total errors are shown below. These errors take into account multiple measurements.

250 cm^3 measuring cylinder	±1.0 cm^3
balance	±0.1 g

Estimate the maximum percentage error in using these pieces of apparatus, and hence estimate their combined error.

You should use the mass of the solid in the beaker in Experiment **1** to estimate the percentage error in using the balance.
Show your working.

_____

_____

_____

_____

(2)

(e) Consider your graph.

(i) Is the curve good enough to use with confidence to predict the intermediate values? Explain your answer.

_____

_____

_____

(1)

(ii) Identify the anomalous results, if any.

_____

_____

(1)

(f) Give **one** reason why the owners of the plant were satisfied with the maximum operating pressure determined in part (b) despite the combined errors you have calculated in part (d).

_____

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(1)

(g) (i) Suggest **one** harmful effect that effluent with a high concentration of sodium chloride might have if it is returned to the sea.

_____

_____

(1)

(ii) Suggest **one** low cost method of treating the effluent so that this harmful effect could be reduced.

_____

_____

(1)

(h) Bromine can be obtained by reacting the bromide ions in the concentrated sea water using chlorine gas in a displacement reaction. Write an equation for this reaction.

_____

_____

(1)

(i) The solid obtained by the chemist after heating the effluent to dryness was treated with concentrated sulfuric acid. A vigorous reaction resulted, including the formation of a purple vapour of iodine. Give **one** reason why this procedure could **not** be adapted to be an economic method for producing iodine from sea water on an industrial scale.

_____

_____

(1)

(j) Sea water contains some organic material. After removing all the water, by heating the effluent samples strongly, it was noticed that the solid formed contained black particles.
These particles are insoluble in water.

On heating very strongly in air these particles burned to give a colourless gas.

(i) Identify these black particles.

_____

(1)

(ii) Suggest how these black particles are formed by heating the effluent strongly.

_____

_____

(1)

(iii) Suggest how a sample of the black particles could be separated from the solid formed.

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(2)

(k) The water produced by some desalination plants is acidic due to the presence of hydrochloric acid. Lime, $Ca(OH)_2$, is added to neutralise this acid. Write an equation for this reaction.

_____

(1)

(l) Lime is used because it is relatively inexpensive and available in large quantities. Identify **one** other large-scale use of lime.

_____

(1)

(Total 22 marks)

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