

Unit 3 The ocean

Sea water: A vast solution

Sea water covers over 70% of the earth surface. It is a vast solution containing about 3.5% of dissolved solids called salts.

Percentage by mass of different salts obtained in a typical sea water sample

Name of salt	Percentage by mass
Sodium chloride (Common salt)	68%
Magnesium chloride	14.6%
Sodium sulphate	11.4%
Calcium chloride	3.1%
Other salts	2.9%

The salts are brought to the sea by rivers. The salt composition of sea water may vary slightly according to location and depth.

What is a solution?

A **solution** forms when a **solute** (usually a solid but can be a liquid or a gas) dissolves in a **solvent** (usually a liquid).



Substances that dissolve in a solvent are said to be **soluble** in that solvent. For example, sugar is soluble in water. Substances that cannot dissolve in a solvent is said to be **insoluble** in that solvent. For example, sand is insoluble in water.

The **concentration** of a solution is the amount (e.g. mass) of a solute dissolved in a certain volume of solution. It is a measurable quantity and can be expressed as:

$$\text{concentration} = \frac{\text{amount of solute (e.g. expressed in g / kg ...etc.)}}{\text{volume of solution (e.g. expressed in m}^3 \text{ / dm}^3 \text{ / cm}^3 \text{...etc.)}}$$

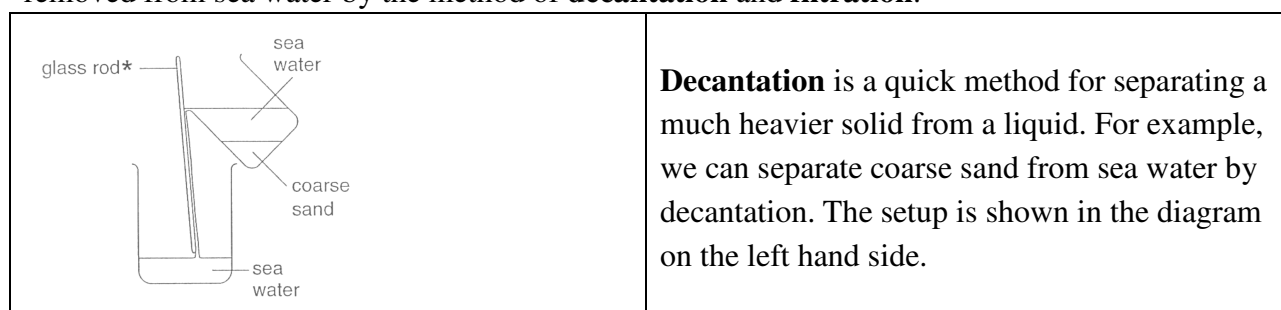
A **dilute solution** has a small amount of solute dissolved in a given volume of solution. It has a low concentration.

A **concentrated solution** has a large amount of solute dissolved in a given volume of solution. It has a high concentration.

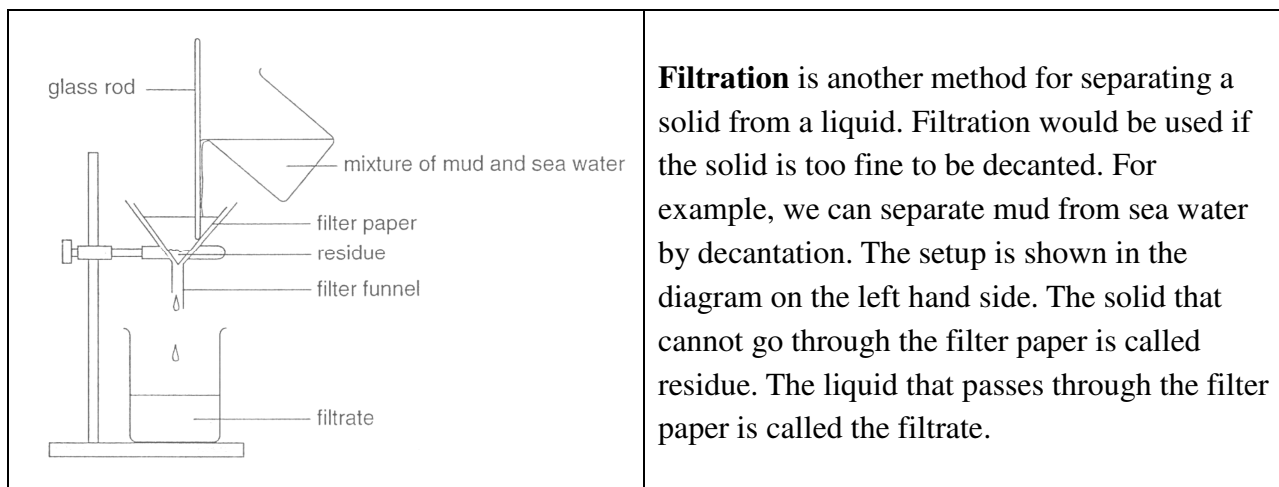
A **saturated solution** has the maximum amount of solute dissolved in a given volume of solution at a given temperature. A solution cannot dissolve any more solute into it once it becomes saturated. The actual concentration of a saturated solution would be different a different temperature. For many solids solutes, the concentration of the solutes in saturated solution would increase if the temperatures of the solutions increase.

Obtaining common salt from sea water

Sea water may contain insoluble substances such as sand or mud. They can be separated and removed from sea water by the method of **decantation** and **filtration**.

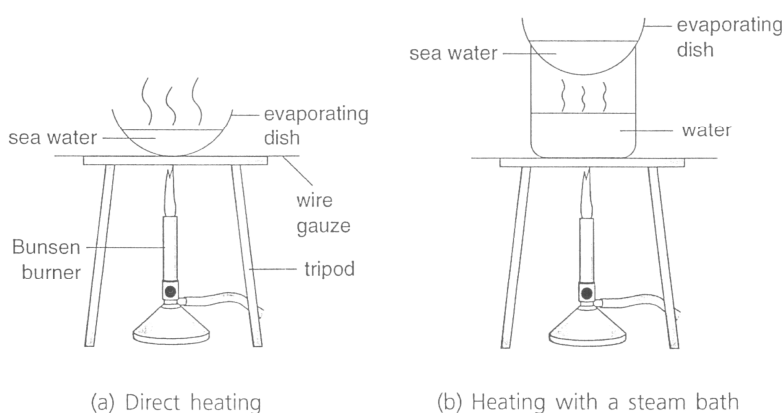


Decantation is a quick method for separating a much heavier solid from a liquid. For example, we can separate coarse sand from sea water by decantation. The setup is shown in the diagram on the left hand side.



Evaporation

Common salt can be obtained from purified sea water by evaporating away the solvent (water). Evaporation is the changing of a liquid into its vapour (gas). It can be used to separate a soluble solute from the solvent in a solution. It needs a heat source to evaporate the liquid solvent. The sun is heat source in salt industry. However, it would be much quicker if a Bunsen flame is used instead in the laboratory. (Refer to the diagrams below for the setup of evaporation in the laboratory.)



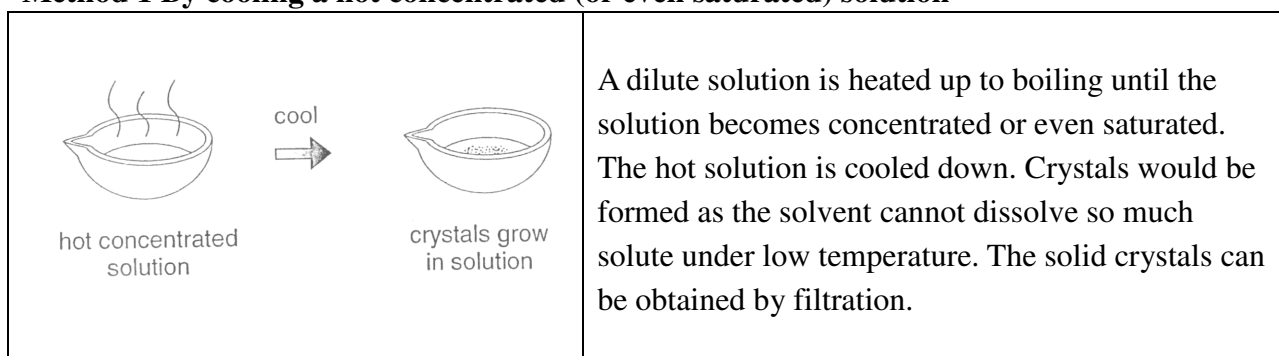
Do you expect that the common salt obtained by the evaporation of sea water is consisted of pure sodium chloride? Why?

No. The sodium chloride will not be pure because the impurities will also become solid after all the solvent has been evaporated.

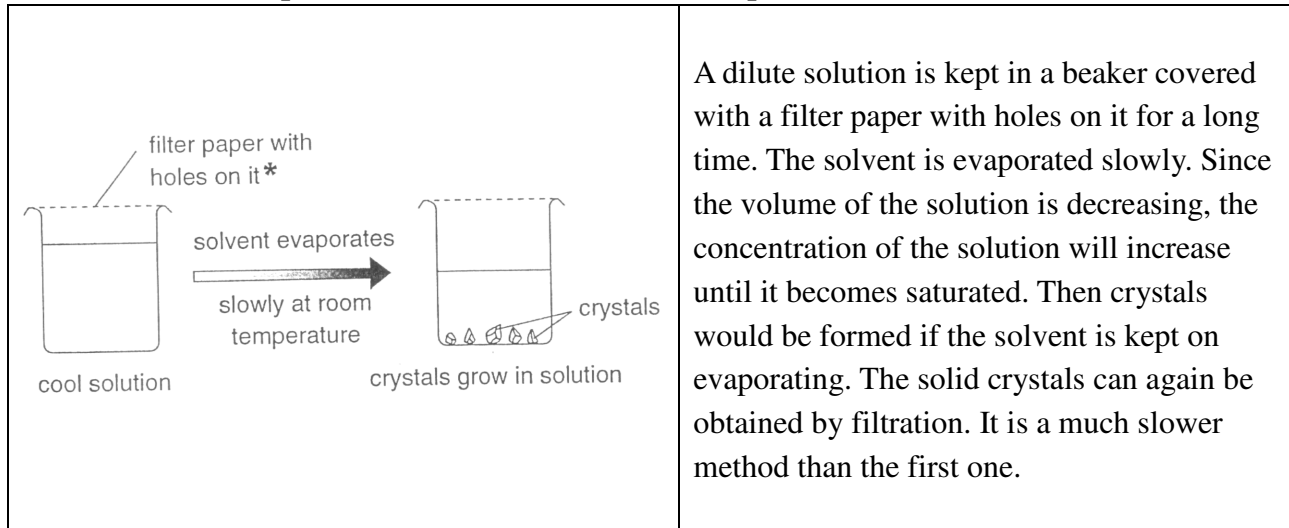
Crystallization

A crystal is solid with a regular shape. Crystallization is the process of forming crystals. It can also be used to obtain common salt from sea water. There are two different ways to carry out crystallization.

Method 1 By cooling a hot concentrated (or even saturated) solution



Method 2 Slow evaporation of a solution at room temperature



Solids obtained by crystallization of a solution are often much purer than those obtained by evaporation. Why?

The solvent is not completely evaporated in crystallization. The impurities can stay in the solution left.

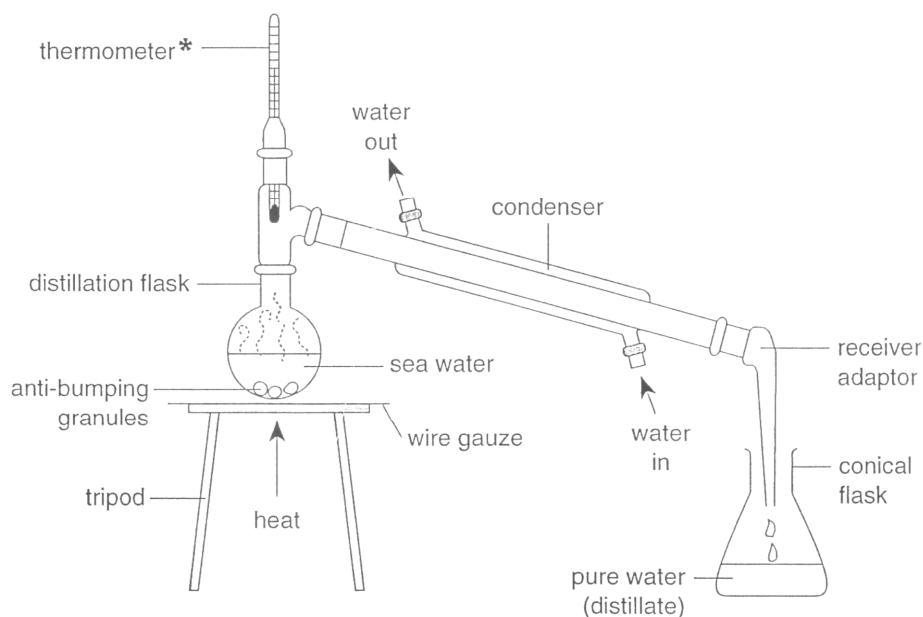
Obtaining pure water from sea water

Sand and mud can be removed from sea water by filtration. However, common salt is soluble in water. It would be too fine to be filtered and it will pass through the filter paper together with water and will end up in the filtrate obtained. To obtain water from sea water, another method called **distillation**, would be used.

Evaporation is a process of changing a liquid into a vapour. Condensation is a process of changing a vapour into a liquid. The process of evaporating a liquid and subsequently condensing the vapour is called distillation.

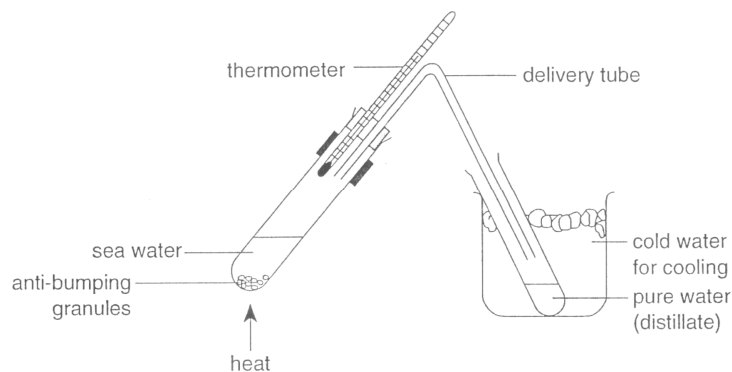
distillation = evaporation + condensation

The setup of the distillation of sea water is shown in the diagram below.



Sea water is heated up to boiling in the distillation flask. **Anti-bumping granules** are added to ensure even boiling. Water vapour is condensed to liquid by the **condenser**. The liquid (pure water) collected is called the **distillate**.

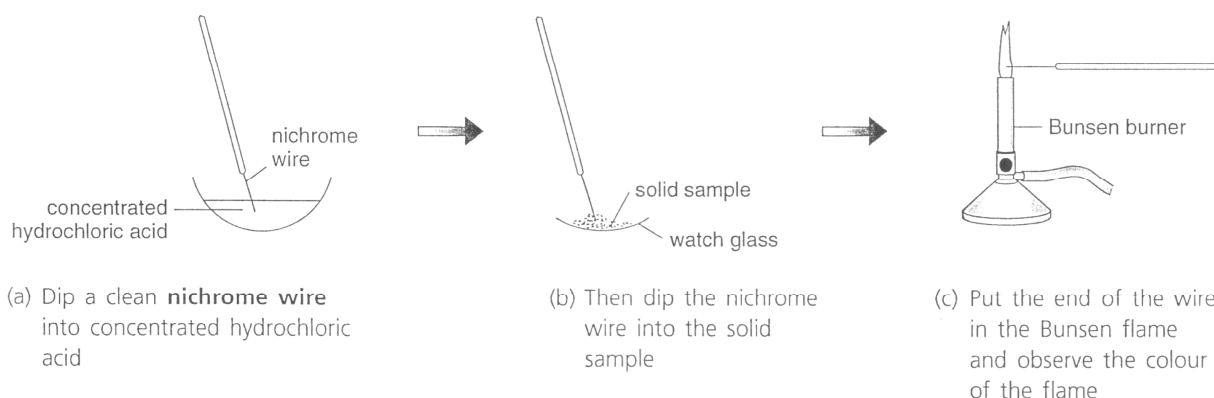
A simpler setup for distillation is shown in the diagram below.



Tests for the chemical composition of common salt

Flame test

When compounds of some metals are heated in a Bunsen flame, different brightly coloured flames will be produced. The metals in a compound can be identified by the flame colour produced. The procedures are called flame test. They are shown in the diagram below.



The table below shows the flame colour produced for different metals in a compound

Compound of	Flame colour
Potassium	lilac (pale purple)
Sodium	golden yellow
Calcium	brick-red
Copper	bluish green

The flame colour of common salt is golden yellow. Common salt contains sodium.

Test for chlorides – silver nitrate test

Compounds made up of **chlorine** are called **chlorides**. A solution containing a chloride can be tested by the following procedures.

Procedures	Result
<ol style="list-style-type: none"> ① add excess dilute nitric acid ② add silver nitrate solution <p>solution of a chloride sample</p>	<p>a white precipitate appears</p>

When the silver nitrate test is carried out on seawater, a white precipitate is formed. Common salt contains chloride. It is a compound of chlorine.

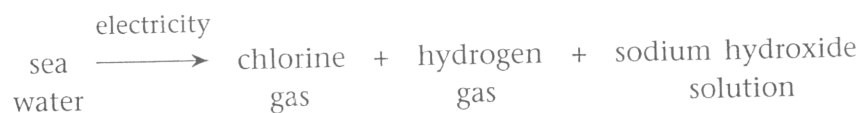
Test for the presence of water in a sample

Water turns blue cobalt(II) chloride paper pink.

Electrolysis of sea water

Electrolysis is a chemical change caused by passing electricity into a substance. Substances that can be decomposed by passing through electricity are called **electrolytes**. Sea water is an electrolyte.

The products that can be obtained from electrolysis of sea water are shown below.



The products obtained depend on the chemical composition of the electrolyte. For example, electrolysis of water can only produce hydrogen and oxygen gas.

