Brine evaporators and salt production

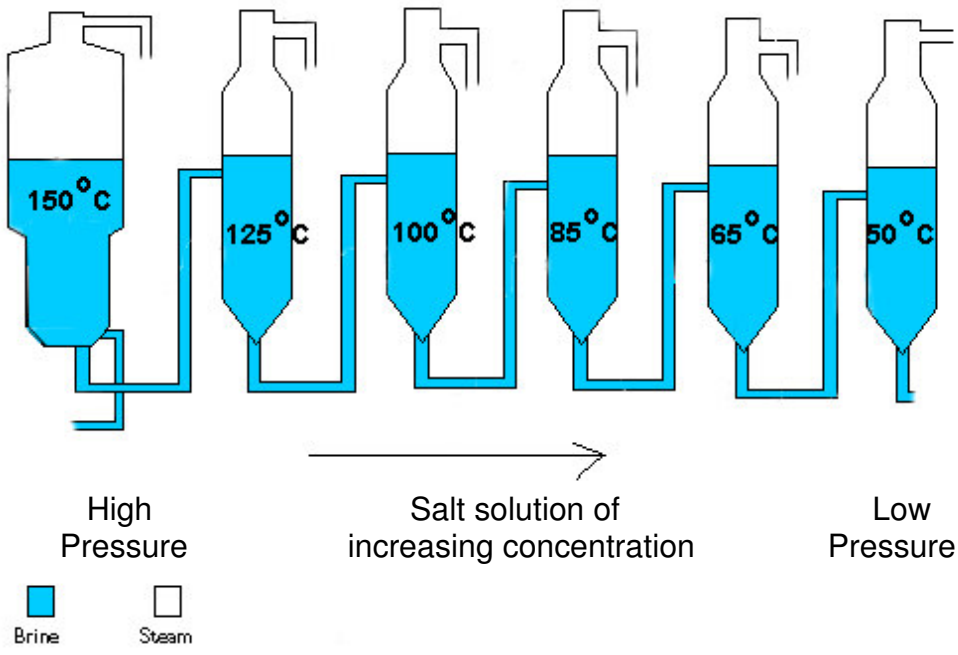
Salt is extracted from brine (salt solution) by evaporating away the water. Usually an industrial site for salt production would contain a series of evaporators through which the brine becomes progressively more concentrated.

Each evaporator contains a large number of tubes through which the brine is circulated. The tubes are heated by steam and the large number of tubes gives a large surface area for heat transfer to the brine. As the brine boils, salt crystals begin to form and sink to the bottom of the evaporator. This produces a thick mixture of salt crystals and salt solution, called a slurry, which is fed into another evaporator to repeat the process and concentrate the salt further.

Liquids that are under low pressure will boil at a lower temperature than normal. To exploit this, a series of brine evaporators are connected in line. Each evaporator runs at a lower operating pressure than the previous one. This results in the salt solution boiling at a lower temperature in each successive evaporator which allows waste steam from early evaporators to be used in later ones and so optimise energy consumption. The diagram below shows a typical series of six evaporators.

Slurry from the last evaporator will go through a final drying process. Salt destined for use in the chemical industry will be dried in a centrifuge (or "spinner") before being stored for bulk transport. Salt for the food industry needs to be drier and so it is passed from the centrifuge to heater-driers before being sieved, graded and packaged.

Series of evaporators. Note the reduced boiling points in evaporators with lower pressures.



Classroom contexts
These questions may provoke some discussion, or suggest further activities, within the classroom. Scroll down below the curriculum links for some suggested answers.

- What foods contain lots of added salt?
- What happens to the water in the brine when it is boiled?
- Use a hand lens to look at some salt crystals.
- Look at how cooling down water vapour can cause it to reform water. An example is condensation on the inside of a window in a steamy bathroom.

Links to the Primary Science National Curriculum

Key stage 2

Sc3 - 3d (Materials)	How to recover dissolved solids by evaporating the liquid from a solution.

What foods contain lots of added salt?
The most obvious way that salt is added to food is at the table, from a salt cellar. However, many processed foods contain quite large amounts of added salt. The Salt Manufacturer's Association have estimated the proportions of daily salt intake due to a range of foods:

% daily salt intake	Food responsible
30	bread, cakes, cereals, rice, pasta, flour
28	meat, meat products, fish, eggs
12	milk, cream, cheese, fats
15	vegetables, beverages, preserves
15	table and cooking salt

What happens to the water in the brine when it is boiled?
The animation shows the water level falling as the salt crystals begin to form. As the salt solution is heated, the water evaporates as molecules escape from the water in its liquid state to form water vapour in the air in the evaporator.

The same process is seen when a hot bath is run in the bathroom. Water vapour in the air makes the room appear "steamy". The atmosphere appears to be very "heavy" and humid.

Use a hand lens to look at some salt crystals.
Salt crystals will vary in their shape depending on their source. For example, sea-salt is readily available from food stores and has large irregular crystals. It should be possible to see that normal table salt has crystals with flat sides and form cube-shapes.

Look at how cooling down water vapour can cause it to reform water. An example is condensation on the inside of a window in a steamy bathroom.
Water vapour in the air cools and condenses on a cold surfaces. Breathing onto a cold window pane causes the glass to "mist over". Water molecules in the warm air breathed out quickly re-form their liquid state as they hit the cold surface of the glass.