PUPIL RESEARCHER INITIATIVE

Sea Chemistry

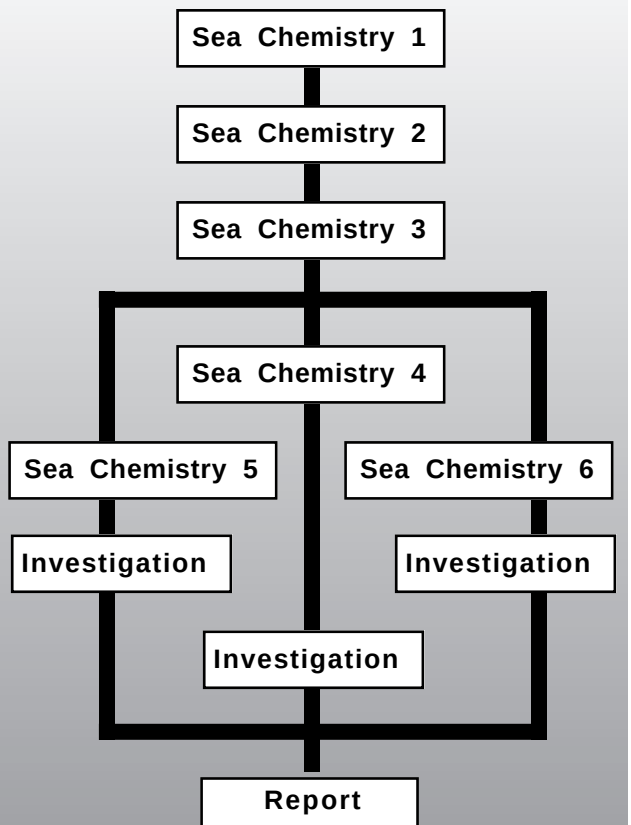
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- ❑ mixtures contain constituents that are not combined
- ❑ mixtures can be separated by evaporation and distillation
- ❑ solutes, such as salts, have different solubilities in water
- ❑ the solubility of most solutes increases as the temperature increases
- ❑ the boiling point of water is used to test for the purity of water
- ❑ distillation of sea water leaves all dssolved compounds behind and produces pure water
- ❑ when an ionic substance, such as salt is dissolved in water the ions are free to move about allowing the solution to conduct electricty

Route through the Brief



Introduction

In this Brief pupils carry out one or two investigations into sea water and solubility. They can conduct an experiment to determine the solubilities of salts found in sea water, they can investigate ways of obtaining pure water from sea water, they can also find out if sea water conducts electricity.The investigations are based on asking a question, testing an hypothesis or testing a prediction.

Experimental and investigative skills

- planning experimental procedures
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Pupils should be familiar with the terms solute, solvent, solution, salt and ionic solid. They should also have a basic understanding of the processes of evaporation and distillation and how a simple electrolytic cell can be set up.

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Running the Brief

Pupil grouping

Pupils could work in a number of groupings during this Brief. Suggestions are :

Initial briefing	-	whole class; teacher introduces topic and sets the context for the activities
Background papers - Sea Chemistry 1 and 2	-	individual or pairs
Carrying out investigation	-	pairs, threes or fours (depends on equipment availability). Possibly a group of 6 pupils working as three pairs for **Sea Chemistry 4**
Analysis of results	-	pairs, threes or fours, or individually if the work is to be assessed
Communication	-	compilation of written reports (individual or small groups). Small group presentation to whole class (optional)

Timing

The Brief should take about 1.5 hours for reading background information and doing one investigation. You may however decide that pupils should tackle more than one investigation. Extra time will most probably be needed to write up individual investigation reports if these are to be used for examination assessment purposes. Optional follow-up or extension work may add 1 - 2 hours to the teaching time.

Activities

This Brief does not require the pupils to get into role. The teacher should issue the pupils with the **Study Guide** which provides a summary of what they should produce as they work through the Brief. It can also act as a checklist for pupils to monitor their own progress. The teacher should then issue the first two background information papers, **Sea Chemistry 1** and **2.** The first two papers are intended mainly as stimulus material to lead into the investigative work on sea water. You will see that sea water offers a good and relevant context for learning some basic chemistry which hopefully will help to motivate pupils.

If time is available pupils could tackle all three investigations which are based on: asking a question **(Sea Chemistry 4**); testing an hypothesis **(Sea Chemistry 5)** or testing a prediction **(Sea Chemistry 6)**. We suggest that different groups tackle a different investigation and present their findings to the whole class.

Investigation details

After reading through the background papers, **Sea Chemistry 1** and **2**, pupils can be given their respective investigation sheet, **Sea Chemistry 4**, **5** or **6**. They should also be given a copy of the **Investigation Flowchart** (see appendix to General Teachers' Notes) and **Sea Chemistry 3** to help them with their planning.

Sea Chemistry 4: a group of pupils could investigate the solubilities of each of the three salts NaCl, MgCl and $CaSO_4$. However, it might be a good idea if a group of 6 pupils was divided into 3 pairs and each pair determined the solubility of a different salt and then pooled their results.

Another useful question for them to think about is: "will the solubility of these salts affect the order in which they will form crystals when sea water is evaporated on a large scale?" They could imagine that they were engineers at a plant which evaporates large quantities of sea water to obtain sodium chloride. How would they design a process which used a system of 'evaporating pools' in order to obtain sodium chloride which was not contaminated by the calcium and magnesium salts also present in sea water?

Sea Chemistry 5: small groups of 2 or 3 pupils could plan and carry out this investigation into obtaining pure water from sea water. They could design a very simple distillation apparatus which could be made more efficient using a Liebig condenser. If they have already used this apparatus then it will be a good revision exercise particularly, for example, if they are left to work out where the inflow of cold water should enter the condenser for most effective condensation.

They will need to check that 'pure water' is being produced and will probably suggest doing a boiling point determination. This will relate to them being

Teachers' Notes continued

asked to hypothesise about the affect of solutions containing dissolved solids needing more or less heat energy to boil them than distilled water.

Sea Chemistry 6: again small groups of 2 or 3 pupils could plan and carry out this investigation to determine if sea water conducts electricity. Readily available apparatus is needed for this investigation. (See **Technical details** section).

Pupils are also invited to predict how the electrical conductivity of sea water might be affected by temperature or the amount of dissolved salts it contains. Should you decide that they can investigate this, some suggestions and apparatus are given in the **Technical details** section. However, it may be more desirable to carry out these experiments as teacher demonstrations, since some of the apparatus required may not be available for a class practical.

Technical details

Sea water composition

Calcium carbonate	0.11g
Calcium sulphate	1.36g
Iron (III) oxide	0.003g
Magnesium chloride	3.22g
Magnesium sulphate	2.42g
Potassium chloride	0.50g
Sodium bromide	0.56g
Sodium chloride	29.42g

Made up to 1 litre with de-ionised water.

You may simply wish to use a 35g/l sodium chloride solution as the sea water sample.

Sea Chemistry 6.

1. Investigating if sea water conducts electricity.

Equipment: sea water sample; small beaker; carbon rod electrodes; power supply (1 or 2, 1.5V batteries or power pack); bulbs or a UNILAB meter with a 10/100mA a.c. shunt, leads and crocodile clips.

2. Investigating if conductivity increases with increasing electrolyte concentration.

Equipment and procedure: using a basic a.c. power supply (e.g.Philip Harris - 'AUTO TRIP' (2-12V)), milliammeter and graphite rod electrodes, it is possible to demonstrate that an increase in concentration of electrolyte solution causes an increase in conductivity.

Note: set electrodes very close together (2mm apart) - in a strip of card or wood. A voltage of 4V supplied by an a.c. power supply gives reliable results. Use 50cm^3 of sea water sample in beaker and add NaCl in ~ 10g amounts, using a magnetic stirrer throughout the experiment to ensure that solid is dissolved before taking readings.

Only switch on the power supply when ready to take measurements and allow 10 seconds for the milliammeter reading to stabilise before taking a reading, since electric current from the power supply can heat the solution, affecting accuracy of results.

Results show a steady increase in current as concentration of electrolyte increases e.g 35g/l (1.10 mA) to 215g/l (3.66 mA) using a voltage of 4V supplied by a.c. power supply unit.

3. Investigating if conductivity increases with increasing temperature.

Equipment and procedure: using a 1.5V battery, milliammeter (e.g. UNILAB - 'Basic Student Meter' fitted with a 0-10 mA d.c. shunt) and graphite rod electrodes, it is possible to demonstrate that when a sea water sample is heated an increase in conductivity takes place.

Note: set electrodes 2cm apart - in a strip of card or wood. Use 50cm^3 sample of sea water in beaker and a magnetic stirrer - hotplate. Allow a few minutes for the temperature of the solution to stabilise before taking the reading on the thermometer at room temperature. Heat solution slowly, disconnect battery between readings, and allow 1 minute for the milliammeter reading to stabilise before taking each reading. Take readings at approx. 10^{o}C intervals.

Results show a steady increase in current as temperature of solution increases e.g.22^{o}C (1.98 mA) to 80^{o}C (4.98 mA) using 1.5V battery power supply.

Safety issues

PLEASE NOTE: It is also important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Sodium chloride, magnesium chloride, calcium sulphate: all minimum hazard, unless ingested in quantity. Seek medical advice.

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Assessment issues for *Experimental and Investigative Science* (National Curriculum for England and Wales, Northern Ireland Curriculum)

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

Three sheets taking pupils through the Planning process:

Sea Chemistry 4	Asking Questions
Sea Chemistry 5	Hypothesising
Sea Chemistry 6	Making predictions

There is also an Investigation Flowchart (see appendix to General Teachers' Notes) which pupils can use to record the planning process. The use of these sheets will have to be taken into account when assessing **Skill Area P**, although the full range of marks should be available for investigations based on Sea Chemistry 5 and Sea Chemistry 6 since no investigation methods are provided. Investigations based on Sea Chemistry 4 may be restricted to low-middle marks.

Skill Areas 0, A and E. Full mark range should be available for investigations based on Sea Chemistry 5 and Sea Chemistry 6. Low to middle marks for those based on Sea Chemistry 4. Analysis and evaluation of evidence could require pupils to demonstrate knowledge and understanding of kinetic theory. How they do this could influence their achievement in **Skill Areas A** and **E.**

Scottish syllabus coverage

Standard Grade - electrochemistry in Sea Chemistry 6 - *Corrosion*

Further pupil research opportunities

1. Investigations to **compare** river, rain or tap water with sea water.

- Work out how much dissolved solids are present in sea water - compare with other additional water samples.
- Compare conductivities (may be an interesting project to examine dilutions of sea water in estuaries by measuring conductivity with time and tide).
- Electrolysis of water - design an experiment using simple, everyday materials to demonstrate electrolysis of water, e.g. aluminium foil (folded into 2 thin strips) to act as connecting leads; 1.5V battery; paper clips as electrodes.

Note: carry out in a well ventilated area as small amounts of chlorine gas evolves during electrolysis. (Pupils' ideas could be demonstrated by the teacher, or by a group using a fume cupboard).

- Compare pH values.
- Compare densities. Make a simple hydrometer using a plastic straw (10cm long) block off one end with Blu-Tack and add iron filings to a depth of about 2cm in bottom. Calibrate in distilled water and mark graduations downwards at 2.5mm intervals for about 2cm. Float straw in other water samples and compare densities.

2. Investigation of salts in sea water.

- Evaporate sea water - flame test for sodium.
- Test for anions - e.g. chloride and sulphate.
- Design a mini desalination plant using solar energy or wave energy.

3. Investigation of effects of sea water.

- Contamination of rainwater by salt - the nearer the coast, the saltier the rain (particles of sea water created by breaking of waves give rise to salt particles in the air).
- Corrosion of metals in sea water is much faster than in rain water.