The life raft

Introduction
Teachers who have not used the problems before should read the section Using the problems before starting.

Prior knowledge
Knowledge of ion exchange resins (including the terms anionic and cationic) and solubilities (you may have to point out the significance of the insolubility of silver chloride). A detailed knowledge is unnecessary as students are encouraged to consult textbooks and data books during the exercise.

Resources
Data books and textbooks should be available for reference.

Group size
4–6.

Results
For simplicity, students are told to treat sea water as sodium chloride solution; other ions such as magnesium and sulphate do not affect the conclusions.

(i) Cation exchanger loaded with H^+ ions This exchanges sodium ions with hydrogen ions giving a solution of acid, mainly HCl(aq).

(ii) Cation exchanger loaded with Ag^+ ions This exchanges silver ions for all the positive ions in the water; the silver ions combine with chloride ions forming insoluble AgCl which remains in the porous bag. This is the method used in converting sea water to drinking water.

(iii) Anion exchanger loaded with OH^- ions. This exchanges chloride ions for hydroxide ions giving a solution of alkali, mainly NaOH(aq).

(iv) Anion exchanger loaded with NO_3^- ions
This exchanges chloride ions for nitrate ions giving a solution of mainly sodium nitrate.

(v) The 'mixed bed' exchanger containing an intimate mixture of **(ii)** and **(iv)** When the packet of resin is dropped into sea water, silver ions from the resin exchange with sodium ions in the water. These ions immediately react with chloride ions in the water forming insoluble silver chloride, which remains inside the bag.

$Na^+(aq) + Ag^+(resin) \rightarrow Na^+(resin) + Ag^+(aq)$
$Ag^+(aq) + Cl–(aq) \rightarrow AgCl(s)$

Because there are equal numbers of sodium and chloride ions, all of the ions are removed ie the exchanger does work, but it is uneconomic since the anion exchanger is unchanged overall. This method is essentially the same as **(ii)**.

(vi) The 'mixed bed' exchanger containing an intimate mixture of (i) and (iii) This is an excellent method, whereby all cations are converted to H^+ and all anions to $OH^–$; which then combine to form water.

Suggested approach

During trialling the following instructions were given to students and proved to be extremely effective:

1. You should form two subgroups, one to consider methods **(i)**, **(ii)** and **(v)**, the other methods **(ii)**, **(iv)** and **(vi)**.

2. Working independently of the other group, discuss the advantages and disadvantages of your three methods. Write this up in note form.

3. When the two subgroups have completed their discussion, gather together as one group and discuss all six methods. Decide on the best method or methods.

4. Working as a group, prepare a short (ca 5-minute maximum) presentation to give to the rest of the class. If possible all group members should take part: any method of presentation (such as a blackboard, overhead projector, etc) can be used.

Outline the problem and the advantages and disadvantages of each method, and explain your choice of best method. After the presentation, be prepared to accept and answer questions and to discuss what you did with the rest of the class.

Possible extension

Discuss how easy it would be to regenerate each of the resins. This is not relevant to the life raft but could be considered either in a domestic or a laboratory context.

The life raft

Evaluate the advantages and disadvantages of each of the following resins and decide which one(s) would be best for producing pure water from sea water on a life raft.

(i) cation exchanger loaded with H^+ ions;
(ii) cation exchanger loaded with Ag^+ ions;
(iii) anion exchanger loaded with OH^- ions;
(iv) anion exchanger loaded with NO_3^- ions;
(v) a 'mixed bed' exchanger containing an intimate mixture of **(ii)** and **(iv)**; and
(vi) a 'mixed bed' exchanger containing an intimate mixture of **(i)** and **(iii)**.

Life rafts on ships are equipped with small porous packets of ion-exchanges resin – a compound that can be used to obtain drinking water from sea water, which is largely a solution of sodium chloride. The packets of resin are added to sea water and shaken gently so that the water moves through the resin and exchanges its ions.
Ion-exchange resins are of two main types: cation exchangers exchange positive ions; and anion exchangers exchange negative ions.

You should refer to any sources of information that you think might help such as your notebooks, textbooks and data books.

Ask for assistance if you get stuck.