Glass

Contents: Reading, questions and optional practical work on the manufacture, uses and recycling of glass.

Time: 2 periods (more if glass is made).

Intended use: GCSE Chemistry and Integrated Science. Links with work on sodium carbonate, calcium carbonate and silica.

Aims:

- To complement work on carbonates
- To show something of the technology of glass manufacture and fabrication
- To develop awareness of the many uses of glass, and the problems and opportunities involved in recycling it
- To provide opportunities to practise skills in reading, comprehension, the application of knowledge, and certain practical skills.

Requirements: Students' worksheets No. 410. A selection of items made from glass would be a useful aid. Requirements for the optional practical work are given later.

If the optional practical work making glass is to be used (see below), it is suggested that it should precede the use of the students' worksheets.

Making glass in the laboratory

It is simple and rewarding to make glass in the school laboratory. Making soda glass requires impractically high temperatures, but lead borate glass can be made at bunsen burner temperature.

The experiment could be done as a class practical, though in view of the relatively large quantities of lead oxide involved teachers may prefer to demonstrate it, unless the laboratory has excellent ventilation facilities.

Method

7.5g lead(II) oxide, 3.5g boric acid and 0.5g zinc oxide are placed in a plastic bag and thoroughly mixed.

CARE: The mixture is poisonous.

The mixture is heated strongly in a porcelain crucible on a pipeclay triangle.

While melting the glass mixture, a casting plate is prepared by heating a metal plate on a second tripod using a yellow bunsen flame. When the glass mixture is molten, it is carefully poured onto the hot casting plate using a pair of tongs. Small glass beads are formed which can be tipped onto a heat-resistant mat and examined when cool.

Coloured glass can be made by adding tiny quantities (just a few grains) of metal oxide to the glass mixture before melting. Suitable oxides include iron (III) oxide (for brown glass), manganese (IV) oxide (pink), cobalt (II) oxide (blue), and copper (II) oxide (turquoise).

The porcelain crucibles can be cleaned by soaking overnight in aqua regia.

Notes on some of the questions

Qs 1 to 3 The advantages of glass include the facts that it is relatively cheap, transparent, durable, chemically inert, impermeable, easily shaped into different forms, easily cleaned and therefore reusable, and resistant to heat. The elemental analysis of soda-lime-silica glass is remarkably similar to that of the Earth's crust. Hence there is a virtually limitless raw materials supply. Its main disadvantage is its brittleness, and the fact that when broken it forms dangerous sharp fragments. Furthermore, it is not biodegradable. Plastics are the materials most commonly used to replace glass. Examples are polythene bottles, perspex windows (for example, in aircraft) and plastic spectacle and contact lenses. But plastics are difficult to make perfectly transparent, and can seldom be recycled.

Qs 4 to 10 Glass is a serious form of litter because it does not degrade naturally, and when broken it is dangerous to humans and animals. Unbroken glass containers can act as animal traps: small mammals enter empty bottles, attracted by traces of the original contents, but cannot get out again because of the slippery sides. Fragments of glass can also cause forest fires, by acting as a lens and focusing the Sun's rays onto combustible material.

It is worth spending a little time discussing the question of recycling, particularly if students have experience of Bottle Banks.

Other recyclable household materials include metals, particularly aluminium, and paper, though for economic reasons there are few large-scale collection schemes in operation. Plastic containers are difficult to *reuse* because they cannot be heat sterilized, and it is difficult to *recycle* them by melting because of the wide range of different colours and different plastics materials in use. It is worth discussing with students whether economics and convenience should be the only factors determining whether recycling is viable, and the extent to which environmental factors should override these others.

Qs 11 and 12 The Float Glass process, developed by the British firm of Pilkingtons, took seven years and cost £7 million (over £50 million at today's prices) to develop. It is now used on licence all over the world. The use of a liquid on which to form the glass ensures the absence of the blemishes inevitably present on the surface of a solid. The liquid chosen needs to remain in the liquid state between about 600°C and 1050°C, so that the glass may be satisfactorily formed and cooled. It also needs to be denser than glass.

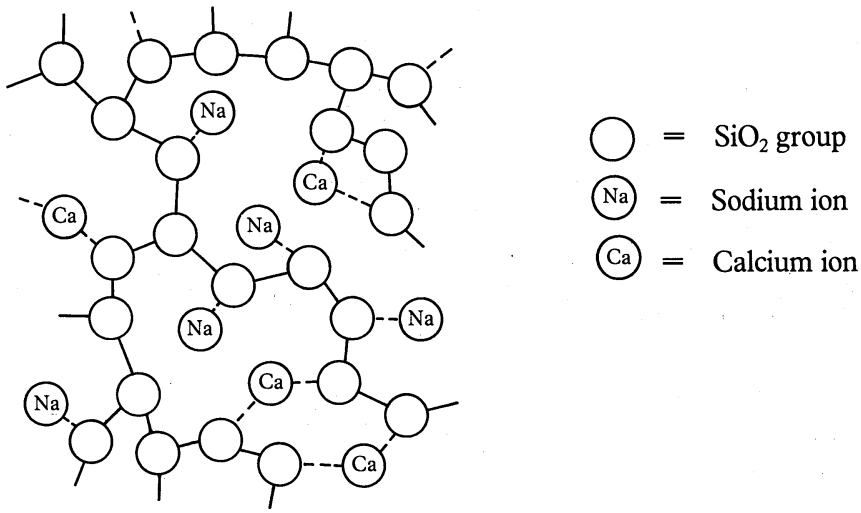
Q. 13 Windows are often coated on the outside to reflect solar radiation and keep the building cool in summer. They may also be coated on the inside to reflect warmth back into the interior of the building, helping to keep it warm in winter.

Q. 14 Glass fibre is used as a reinforcing material for strengthening plastic, and is also finding application in the reinforcement of cement, where it is a safe substitute for asbestos.

Notes on the structure of glass

Depending on the ability of the students involved, the teacher may wish to make some mention of the molecular structure of glass.

When the ingredients that make glass are heated to 1500°C, they melt forming a liquid. The liquid is then cooled rapidly so that the atoms and ions do not have enough time to form a regular crystal structure. Hence glass consists of a collection of silicon and oxygen atoms bonded together, with sodium and calcium ions associated in a disordered way with the negatively-charged silica groups (see diagram).



Because of the absence of crystalline order, glass can be regarded in some ways as a 'supercooled liquid', although sadly the story that panes of glass in very old buildings are thicker at the bottom than the top belongs to fiction rather than fact.

Extension work

Recycling glass There are plenty of opportunities for home-based work. For example, students could keep a record of the amount of glass (a) reused (returnable containers), (b) recycled (through Bottle Banks), and (c) discarded in their home in a typical week.

Further resources

The Keep Britain Tidy Group Schools Research Project, based at Brighton Polytechnic, has produced a resource pack on glass which includes practical work, worksheets, demonstrations and audio-visual materials, with particular emphasis on glass as litter and on recycling. It is available from: The Keep Britain Tidy Group, Bostel House, 37 West Street, Brighton BN1 2RE.

Acknowledgements Figure 1 supplied by The Glass Manufacturers Federation; Figure 4 is adapted from *Science Unit 2: Glass* (Keep Britain Tidy Group Schools Research Project).

GLASS

Glass was first made by the Egyptians over 3000 years ago. Only small amounts could be made so it was a precious and valuable material. As ways of making glass improved, larger quantities could be made. Today automatic machines produce millions of bottles and jars every day. In fact, 6400 million bottles and jars were sold in Britain in 1980!

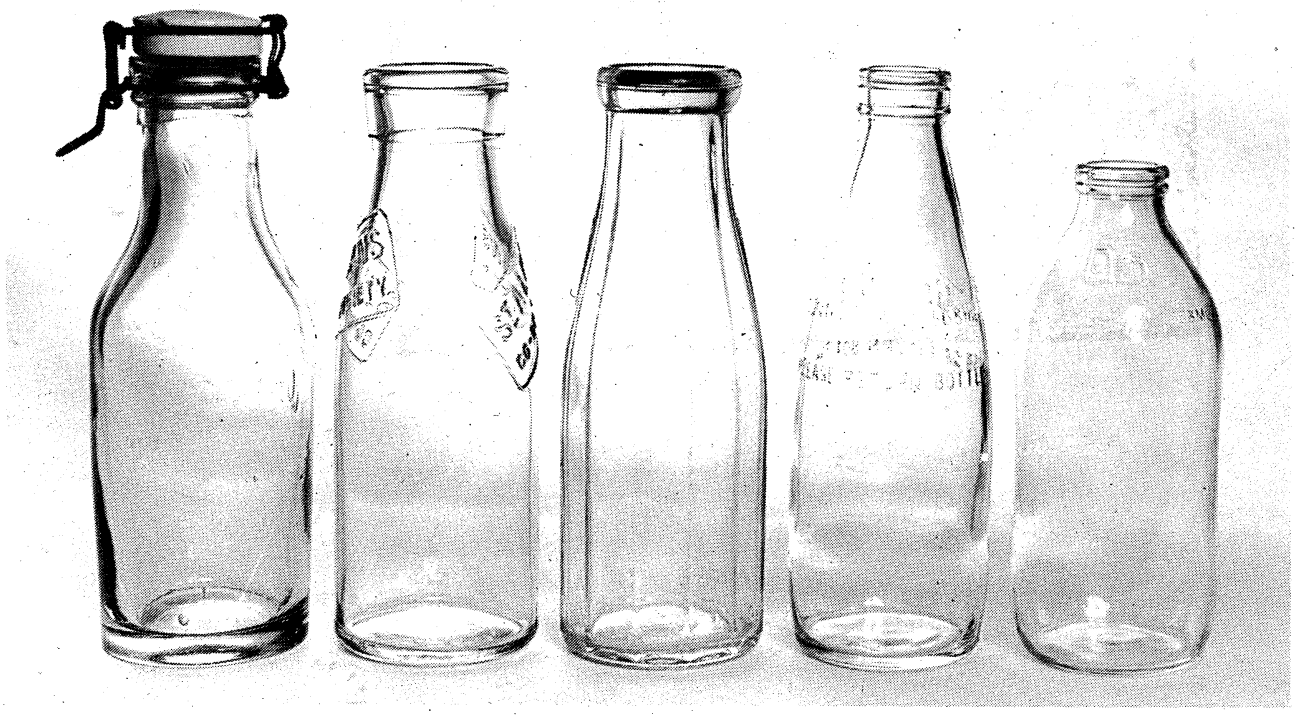


Figure 1 How the glass milk bottle has changed over the years

What is glass used for — and why?

How many things can you think of which you use, or see, every day that are made of glass?

Draw up a table like the one below, and list as many different glass items as you can. Give the reasons why glass is used for each item. Mention any disadvantages you think glass has. One example has been done for you.

Item	*Reasons why glass is used*	*Disadvantages of glass for this use*
Windows	fairly cheap, transparent, fairly good insulator	Breaks easily

Questions

1 *What you do you think are the three main* general advantages *of glass as a material?*

2 *What do you think are its two main* disadvantages?

3 *Give two items from your list which are sometimes made from a material other than glass. What advantages does this other material have?*

How is glass made?

There are many kinds of glass, but the most common is soda-lime-silica glass, or soda glass for short. Figure 2 summarizes the way it is made.

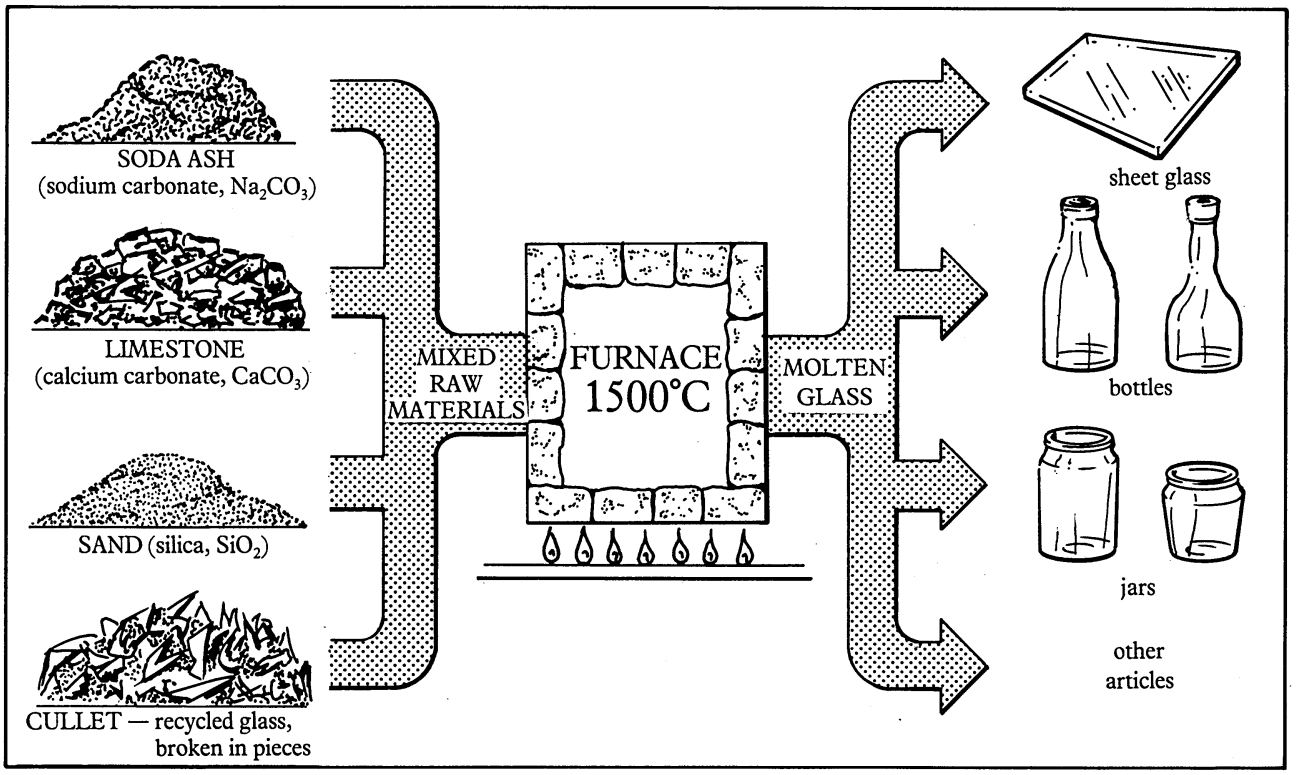


Figure 2 How soda glass is made

All the raw materials are cheap, but the process uses a lot of energy to heat the furnace. Other materials such as metal oxides are often added to colour the glass. You may have a chance to make your own sample of glass in the laboratory.

Recycling glass

There are two ways glass can be recycled (used again).

1 Refillable containers

Because glass is strong and hard-wearing, glass containers can be used again and again. Milk bottles are an excellent example. In Britain each milk bottle makes an average of 25 trips to the doorstep and back.

But milk bottles are the exception. In fact, only 3 out of every 20 bottles and jars are designed to be refillable. The main problem is collection. Many people do not want the nuisance of taking bottles and jars back to the shop, and many shops do not want the nuisance of collecting them. As a result about 10 per cent of British household waste is glass — two million tonnes a year!

2 Recycling cullet

Cullet is broken glass that is mixed with the ingredients fed into the glass-making furnace. One way of collecting cullet is through Bottle Banks (Figure 3). These are usually situated in public places so people can bring their used bottles for recycling.

Figure 3 Bottle banks situated on a prominent corner near a shopping area

One problem is that cullet has fairly low value. This is because the raw materials for making glass are very cheap anyway. The main cost is the energy needed to melt them — and cullet needs melting just the same as the raw materials do.

It turns out that the value of cullet from a Bottle Bank only just pays for the cost of collecting it. But there are good reasons for recycling glass apart from cost. We should save our natural resources, however cheap they are. And by recycling glass we help prevent a serious litter problem.

Questions

4 *Why is glass a particularly bad form of litter?*

5 *Does your family recycle glass containers? Do you know where your nearest Bottle Bank is?*

6 *Bottle Banks usually have separate compartments for green, brown and clear glass. Why do you think this is?*

7 *You should always remove metal tops before putting a bottle in a Bank. Why is this? Why do paper labels not matter?*

8 *Why should milk bottles never be put in Bottle Banks?*

9 *Apart from glass, what other household materials can be recycled?*

10 *Suggest a reson why it is difficult to recycle plastic containers.*

Shaping glass

Containers

Figure 4 shows one way that containers like bottles and jars can be made from molten glass.

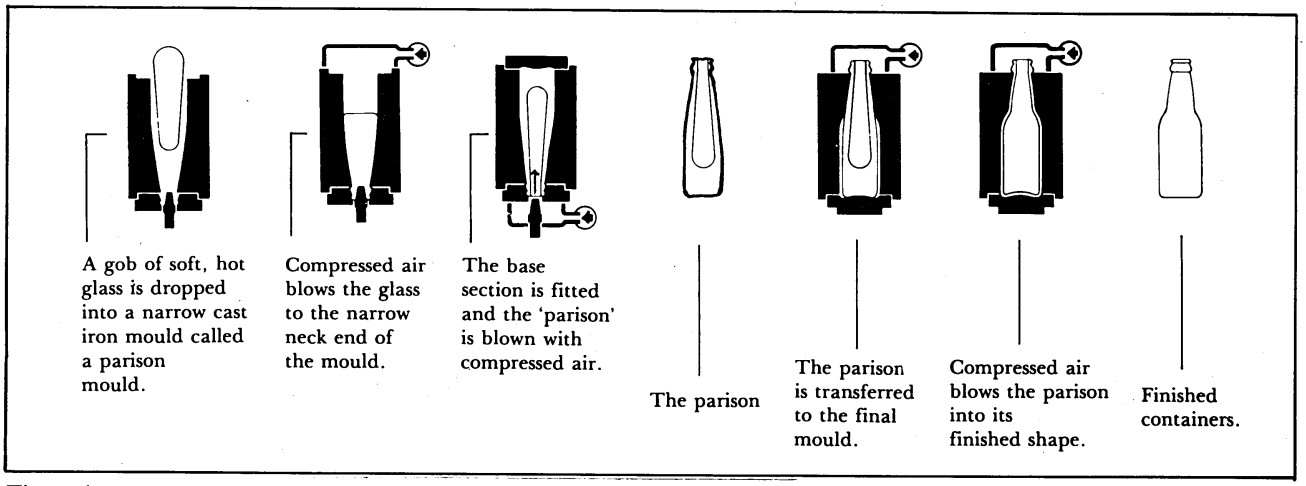


Figure 4

Glass sheets

Glass sheet is mainly used for windows. The important thing is that the sheet should be quite flat, with polished surfaces. One of the most successful ways of making this kind of glass is called the Float Glass Process. It involves floating molten glass on top of a bath of molten tin. The temperature is kept high enough to allow any irregularities in the glass to melt out. This makes the two surfaces completely flat and parallel.

Figure 5 illustrates the process.

Questions

11 In the Float Glass Process, why is the glass floated on molten *tin, and not on a solid metal?*

12 Give two reasons why a molten metal *is used, and not another liquid such as water or oil.*

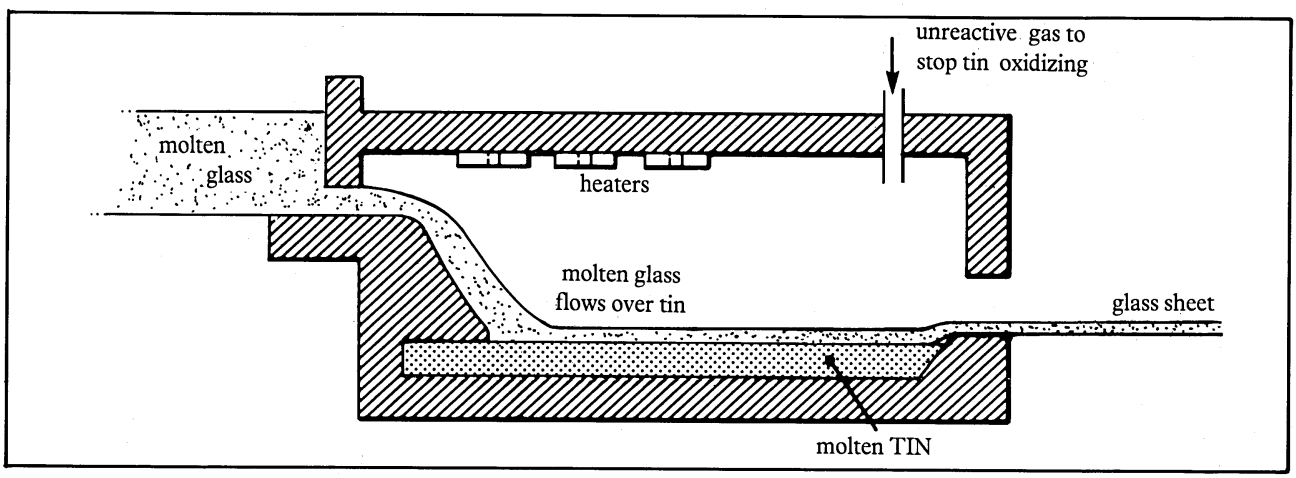


Figure 5 Making float glass

Special kinds of glass

Soda glass is the most common type, but there are many others. Three are given below:

Heat resistant glass ('Pyrex' or 'Pyrosil') does not crack when it is heated or cooled quickly. It is very useful for oven dishes and bowls. It is made by replacing some of the silicon in the glass by boron.

Light sensitive glass ('Reactolite') contains an additive which darkens in bright light. It is useful for spectacle lenses.

Slow-dissolving glass Some types of glass dissolve slowly in water. This is used to help farm animals get the small quantities of trace elements which they need to keep healthy.

The glass contains copper, selenium and cobalt — three elements which cows and sheep need in tiny quantities. The glass is made in the shape of a small cylinder which the animal swallows. The glass cylinder stays in the animal's stomach all year. It slowly dissolves and releases the elements the animal needs.

Questions

13 Why do the windows of some buildings have a gold or silver coating on the outside?

14 What is 'glass reinforced plastic'?

15 What special types of glass are used in road vehicles?

SATIS 4

List of units in this book

The Association for Science Education
College Lane
Hatfield
Herts AL10 9AA

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