Noise

Contents: Reading, questions and optional survey on the problem of noise pollution.

Time: 2 periods or more, depending on how many parts are used.

Intended use: GCSE Physics and Integrated Science. Links with work on sound.

Aims:

- To complement work on sound
- To develop awareness of some of the social and medical problems caused by noise
- To show some of the problems involved in reducing noise
- To provide opportunities to practise skills in reading, comprehension and the collection of information.

Requirements: Students' worksheets No. 407.

This unit is in five parts:

Part 1 Noise and hearing
Part 2 Where does noise come from?
Part 3 How can noise affect your health?
Part 4 How can we cut down noise?
Part 5 How noisy is your school?

Part 5, the noise survey, can be omitted if time is short, though it makes an interesting exercise. The survey is best tackled by students working in small groups, or as a whole-class exercise.

Notes on some of the questions

Q.6 Students might be interested to discuss the psychology of noisy machines. Does a noisy vacuum cleaner seem more powerful than a silent one would? Why do some motor cyclists enjoy riding noisy machines?

Q.7 After exposure to a noise level of 100 dB for 10 minutes a person is likely to experience a shift of hearing threshold from 0 to 20 dB. This loss of hearing would wear off after half an hour or so. 100 minutes' exposure to 100 dB might cause a shift of hearing threshold to 30 dB which would take 36 hours to wear off. The loss of sensitivity is most pronounced at a frequency of around 4000 Hz. As a result of such hearing loss, speech sounds muffled and high frequencies sound unnaturally strong.

Q.10 It is interesting to speculate what the British attitude to Concorde would have been had the airplane been developed and built in another country.

Q.12 People with particularly noisy working environments include workers in bottling plants and boiler factories, truck and tractor drivers, printers, swimming bath supervisors, some typists, pop musicians, disc jockeys, and perhaps teachers.

Q.17

(a) Double glazing and possibly cavity wall insulation.
(b) Carpets and soft wall coverings would help. Rubber feet or absorbent mats under the typewriters are also effective.
(c) The best plan would be to have a word with the neighbours, or bang on the wall.

Note on the decibel

No attempt has been made in the students' materials to explain the basis of the decibel unit — it is simply used as a relative scale. For high ability students, the reason for using a logarithmic scale could be explained, and related to the very wide range of sound intensities with which the ear has to cope. (For instance, the sound produced by a jet engine is about 10^{12} times more intense than that of rustling leaves. This is expressed logarithmically by saying that the jet is 12 Bels, or 120 decibels, louder than the rustling leaves.) The figures quoted in the students' materials are actually in dB(A) units. This is a modified dB scale which takes into account the fact that the ear is more sensitive at one frequency (about 4000 Hz) than at lower and higher frequencies.

Further activities: possible experimental work

1 *Noise meters* A great deal of interesting practical work can be done if a noise level meter is available, particularly as part of the school survey.

2 *Why are jet aircraft so noisy?* The following simple demonstrations illustrate why jets produce a variety of noises, from a deafening roar to a high-pitched scream:

(a) Light a bunsen with the air hole open.
(b) Start a fan (for example, a vacuum cleaner).
(c) Hit a sheet of metal. Place a noise-producing device (for example, a ticking clock or a small electric motor) on the metal to show how the noise is amplified.

Discuss, in terms of air vibration, why each of these produces a noise. Then point out that a jet engine combines all three.

Other resources

Materials relating to noise abatement can be obtained free by sending a stamped address envelope to: The Noise Abatement Society, PO Box 8, Bromley, Kent BR2 0UH.

Acknowledgements Figure 1 supplied by Farmers Weekly; Figure 3 supplied by the Noise Abatement Society; the graphs in Figure 4 are adapted from *Physics in Society*, a text produced by the Department of Physics, The Free University of Amsterdam, The Netherlands.

NOISE

Sit still and listen to the sounds around you. Some may be pleasant, but there may be some sounds you would prefer to do without.

Noise is sound we do not want to hear.

Noise can pollute the environment in the same way as smoke and oil can be pollutants.

This unit is in five parts:

Part 1 Noise and hearing

Part 2 Where does noise come from?

Part 3 How can noise affect your health?

Part 4 How can we cut down noise?

Part 5 How noisy is your school?

Questions

1 *List five sources of noise that you often hear.*

2 *Some sounds are pleasant to certain people, but unpleasant noises to other people. Give two examples.*

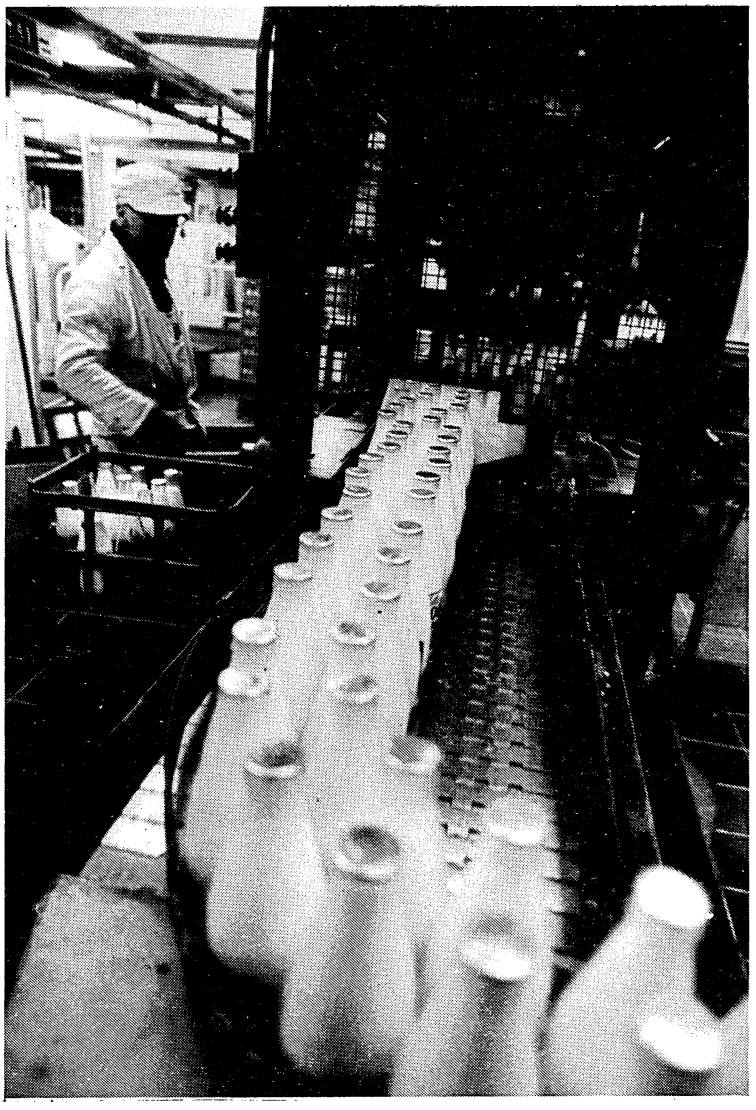

Figure 1 A bottling plant is one of the noisiest working environments

Part 1 Noise and hearing

The **frequency** of a sound vibration decides its pitch. A high frequency gives a high pitch. Frequency is measured in hertz (Hz). The **amplitude** of the vibration decides how loud it is. A high amplitude gives a loud sound. Loudness is measured in **decibels** (dB).

Comparing the loudness of different sounds

Using the decibel scale, we can compare the loudness of different sounds (Figure 2).

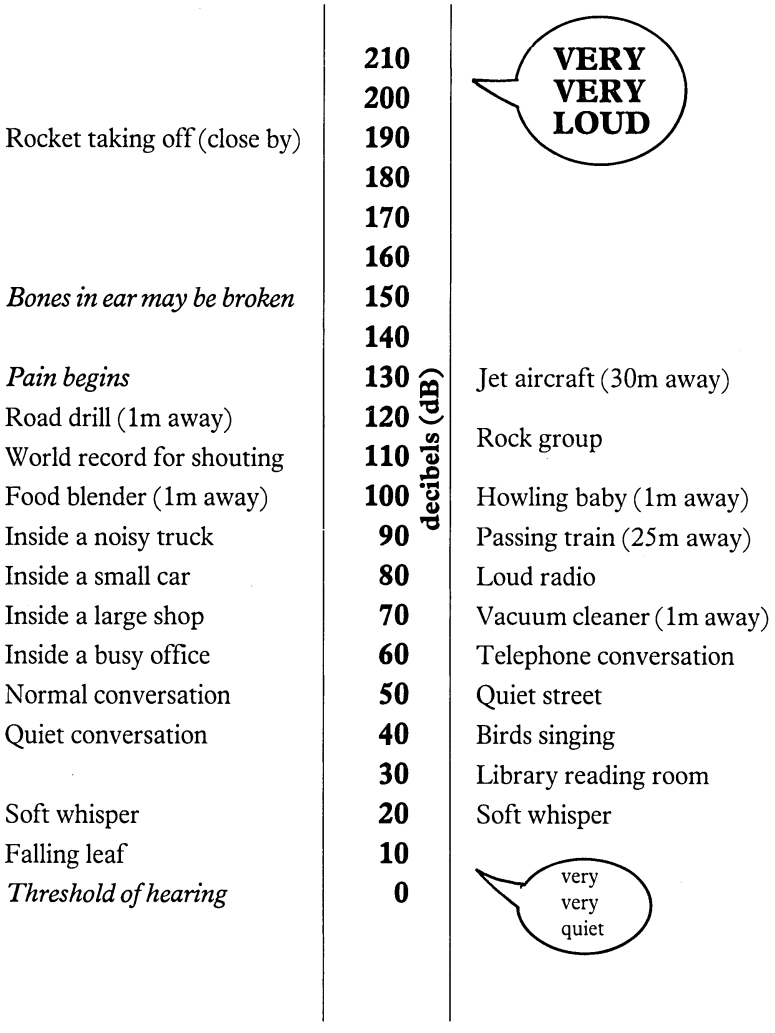

Figure 2 The decibel scale of loudness

Questions

3 *Using the scale, estimate the noise level in decibels inside your classroom at this moment. (If you are doing this at home, try to imagine your classroom noise level on an average day.)*

4 *What is the highest noise level you think you could put up with all day?*

Part 2 Where does noise come from?

At home

Noise can be very irritating at home because it invades people's lives. The commonest culprits are regular party-givers and do-it-yourself enthusiasts. Other people's noise is always worse than your own!

Questions

5 *What are the most annoying noises in your home?*

6 *People sometimes seem to enjoy using noisy machines. Why do you think this is? Give some examples.*

Pop music

The average sound level in a disco is about 103 dB. In a pop concert it can be about 115 dB. Roger Daltry of The Who admits he has a hearing problem because of years spent on stage close to loudspeakers.

Personal stereos can generate over 100 dB at the ear, and some may go as high as 124 dB. A noise level of 124 dB would be illegal in a factory for more than 15 seconds a day.

Question

7 *What do you notice about your hearing after you come out of a loud disco or pop concert, or after you have been listening to loud music on a personal stereo?*

Road traffic

Road traffic noise comes particularly from the tyres and exhaust of vehicles. Faulty silencers are often a serious source of noise.

Question

8 *Which types of road vehicles are noisiest? Why?*

Air traffic

Jet engines are among the noisiest human inventions. The problem is worst for people who live near airports. There are 173 airports in the United Kingdom, and it is estimated that 10 per cent of the population suffers from noise pollution by aircraft. Even the Queen suffers — Windsor Castle is often disturbed by the noise of jets from Heathrow. Prince Philip has his own noise meter to keep a check on noise levels.

Figure 3 Aircraft taking off or landing cause noise pollution for people living nearby

Questions

9 Aircraft are noisiest when taking off. Why?

10 Concorde is the noisiest civil airplane, with a peak noise level of 138 dB. This has led to its being banned in several countries. Why was it never banned in Britain?

Industry

Some factories are very noisy. Inside a boiler factory the noise level can be 120 dB, and a hydraulic press has a level of 130 dB at a distance of 1m. Workers who are constantly exposed to noise risk damaging their hearing. It is recommended that workers should not be continually exposed to noises louder than 90 dB during an 8-hour day. If the noise level is higher, the worker should be exposed to it for a shorter time, as shown in Table 1. Unfortunately, these recommendations are not always followed.

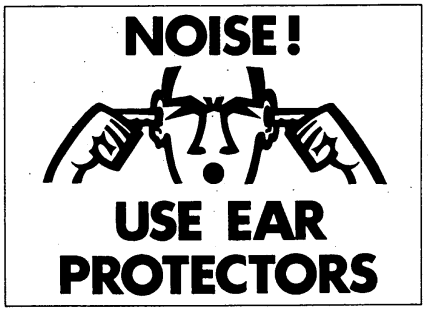

Table 1 Maximum noise exposure times

Sound level/dB	90	93	96	99	102	105
Maximum exposure time (hours per day)	8	4	2	1	0.5	0.25

Questions

11 Suppose you work in a disco where the noise level is 103 dB. According to Table 1, roughly how long should you work in the disco per day? Comment on your answer.

12 List five workers who are particularly at risk from loud noise.

Part 3 How can noise affect your health?

Very loud noises (above 150 dB) can actually break the tiny bones inside the ear. Noises above 130 dB cause ear pain. Below this level, constant exposure to loud noise can cause loss of hearing.

But even if noise is not loud enough to affect hearing, it can cause stress and tension. Look at these facts:

- Secretaries are 20 per cent less efficient when they are surrounded by office noise.
- A survey was recently carried out in a district near Heathrow Airport in London. It showed that eight times as many people were admitted to mental hospitals compared with people living in quieter areas.

- A London man set fire to a record shop below his flat because he could not stand the constant noise.
- A Middlesex man committed suicide after a motorway was built a few metres from his cottage. He left a note saying: 'The noise, the noise, I couldn't stand the noise'.

Evidence from the Netherlands

In the Netherlands the effects of air traffic noise on people's health have been investigated. The surveys compared the number of pills taken per adult per year in two similar areas:

Area A on the flight path near Amsterdam airport
Area B near Amsterdam airport, but away from the flight path.

The airport was opened in 1969, and in late 1973 a restriction on night flights was introduced.

Look at the four graphs in Figure 4, then answer question 16.

Questions

13 Do you ever find noise irritating? If so, when?

14 What signs of stress and tension have you noticed in a teacher in front of a particularly noisy class?

15 Research has shown that the hearing of a 70-year-old person from Sudan in North Africa is as good as that of a 20-year-old American. Suggest a reason for this.

Question

16 Comment as fully as you can on each of the four graphs. What do the graphs suggest about the effect of aircraft noise on health?

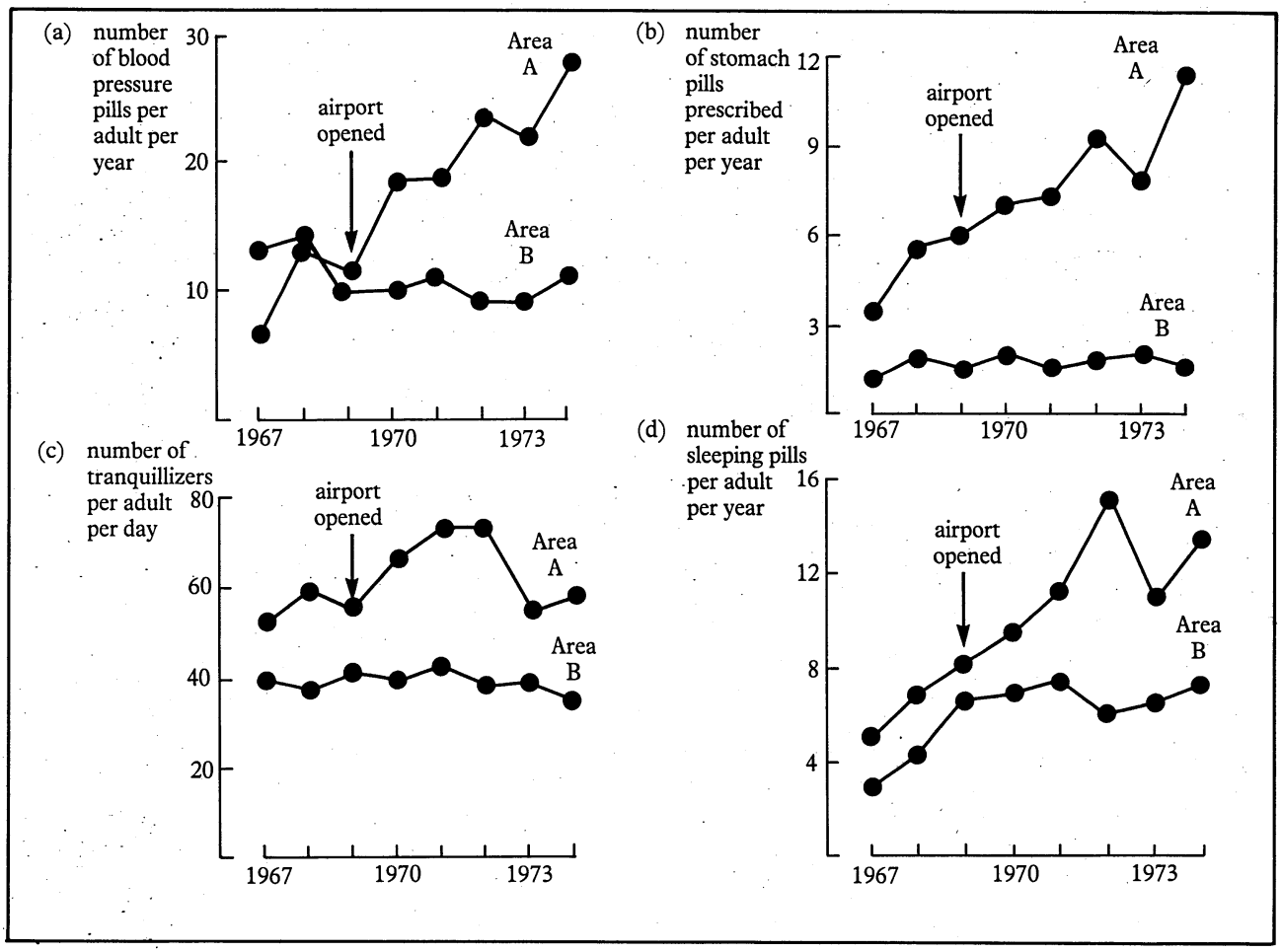

Figure 4

Part 4 How can we cut down noise?

There are three general ways to cut down noise:

- **Stop it at source** — for example, by making quieter machines and passing laws to prevent people making too much noise
- **Stop it travelling** — for example, by sound-proofing
- **Stop it at your ears** — for example, by wearing earmuffs.

Many ordinary things are unnecessarily noisy, and they can be made quieter by changing their design.

For example, in aircraft and cars a serious cause of noise is the release of hot, fast-moving exhaust gases from pipes. This noise is reduced if the gas comes out of a large number of holes. The jet engine exhaust shown in Figure 5 reduced noise by 6 dB.

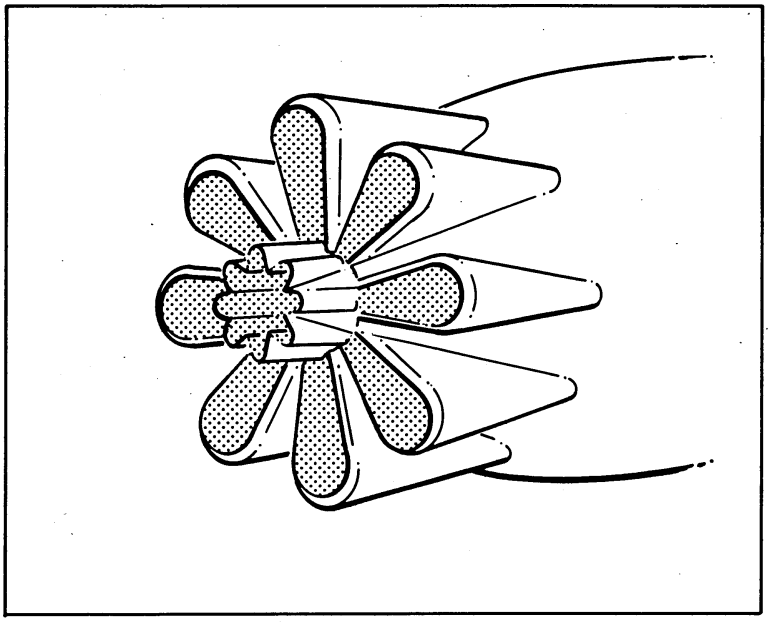

Figure 5 A jet exhaust designed to reduce noise

The amount of noise people are allowed to make in public is controlled by law. But the law is often broken, and it is difficult to catch people and prosecute them.

The general principle of **sound-proofing** is to absorb vibrations. Anything that vibrates will carry sound well. Thus glass, stone and metal carry sound well, but cloth and foam rubber do not — they muffle sound. Double glazing is effective. People living near large airports sometimes get grants to fit their homes with double glazing. Barriers can be used to reduce noise. Walls or screens of trees are often put near busy roads to shield nearby housing.

Noise inside large, echoing buildings can be cut down by choosing the right furnishings. Thick carpets, heavy curtains, soft wall coverings and padded furniture all help cut down unwanted sound.

Question

17 How would you reduce noise nuisance in each of the following cases?

(a) A house built next to a railway line
(b) The inside of a noisy typing room
(c) A semi-detached house in which the neighbours often play loud music.

Part 5 How noisy is your school?

Imagine you are on a committee which is preparing a report on the problems of noise in your school. You can find out the opinions of those who work in the school with this survey.

What are the problems?

First you should decide where noise is a nuisance. Here are some possible problems to consider:

- Noise getting into rooms from outside, for example, traffic or aircraft.
- Noise carrying from room to room.
- Noisy activities, for example, metalwork, games, work in school kitchen, music, etc.
- Difficulties in hearing in a particular room because of the size or shape of the room itself.

Look and listen yourself, and talk to people in the school who will be able to suggest where there are noise problems. You might approach the headteacher, the secretary, the teaching staff (especially in craft, games and music, and those who teach nearby), and the kitchen staff.

Write down between five and ten noise problems which you consider exist in the school.

What do people think about the problems?

With your list of problems, carry out a survey of the opinions of students and teachers. Ask them to judge the nuisance value of each problem, using a table like the one below. (The problems given in this table are examples.)

Problem	*(1) not noticeable*	*(2) noticeable*	*(3) irritating*	*(4) very irritating*
Aircraft noise				
Traffic noise in art room				
Noise in rooms next door to music room				
Echoes in assembly hall				
Noise in canteen				

For each student you ask, put a letter S in the appropriate box according to their opinions. For each teacher, put a letter T. Then add up the total scores for each problem. Do this separately for students and teachers. Write out the list of problems in order of seriousness.

- *What are your recommendations to the committee on noise? You should include suggestions on how the problems might be solved.*
- *Do students and teachers agree about the problems? If not, can you explain why?*

Industrial Gases

Contents: Reading, questions and data analysis concerning the production and uses of industrial gases.

Time: 2 periods. Could be used for homework.

Intended use: GCSE Chemistry and Integrated Science. Links with work on the properties, manufacture and uses of oxygen, nitrogen, argon, helium and hydrogen, and the composition of air. Particularly useful for revision work on gases.

Aims:

- To complement and revise prior work on the properties, manufacture and uses of gases
- To show some of the uses of major industrial gases
- To develop awareness of some of the economic factors influencing the manufacture, distribution and use of industrial gases
- To provide opportunities to practise skills in data analysis and the retrieval of information.

Requirements: Students' worksheets No. 408

Suggested use of the unit

It is intended that Part 1 should be used to revise work on properties of the gases and establish some of their important properties. This should be tackled before students look at Part 2 and the Factsheet. Some of the information in Table 1 will need to be given by the teacher, unless students are given access to data books.

Alternatively, if time is short, the teacher may prefer to omit Part 1 and go straight on to Part 2.

Data for Table 1

Name of gas	*Oxygen*	*Nitrogen*	*Hydrogen*	*Argon*	*Helium*
Formula	O_2	N_2	H_2	Ar	He
Percentage of gas present in air	21	78	0.001	0.9	0.0005
Colour	colourless	colourless	colourless	colourless	colourless
Odour	odourless	odourless	odourless	odourless	odourless
Does it burn?	no	no	yes	no	no
Does it allow things to burn in it?	yes	no	no	no	no
Boiling point	−183°C	−196°C	−253°C	−186°C	−269°C
Relative molecular mass	32	28	2	40	4
Heavier or lighter than air?	heavier	lighter	lighter	heavier	lighter

Notes on the Factsheet

It should be noted that the prices are for gases in cylinders. Gas bought in the bulk liquid form tends to be much cheaper. No mention is made of the use of nitrogen and hydrogen to make ammonia, since the process normally uses air and natural gas to produce the gases *in situ*, rather than employing the pure, separate gases.

Notes on some of the questions

Q.7 The relative costs of nitrogen, oxygen, argon and helium correlate well with their abundance and production level, though it should be noted that price will itself determine demand, and hence influence the scale on which the gas is produced.

Qs 9 to 11 A major industrial gas like nitrogen is a fairly low value commodity with a high production volume. It is necessary to keep distribution costs low by ensuring that all customers are within a 300 km distribution radius from a production plant. An added factor is the heavy containment equipment (cylinders or heavy steel tankers) needed for the gas.

Q.14 In general, nitrogen is used in preference to the more expensive argon whenever possible. However, the tendency of nitrogen to react at high temperatures means that for applications such as welding or electric light bulbs, argon is preferred.

Q.15 Students may find this question difficult. It is intended to explore:
(a) the problems of breathing pure oxygen under pressure, leading to 'oxygen poisoning' due to increased metabolic rate; and
(b) the fact that solubility of nitrogen can lead to 'the bends' when the diver is depressurized.

Q.16 The low reactivity of nitrogen is the main factor here: by excluding oxygen, food spoilage reactions are inhibited.

Acknowledgements Figures 2, 5 and 6 supplied by Air Products; Figure 4 by courtesy of Thames Water.

INDUSTRIAL GASES

Most of the gases you meet in the science laboratory also have important industrial uses. In this unit you will be looking at five of the major industrial gases. The gases are oxygen, nitrogen, hydrogen, argon and helium. How are they manufactured, what are they used for — and what do they cost?

You may have cylinders of gases in your school laboratories. These gases will have been supplied by one of the two large British industrial gas manufacturers — Air Products and British Oxygen.

Gas cylinders are colour-coded, according to the gas they contain (Figure 1).

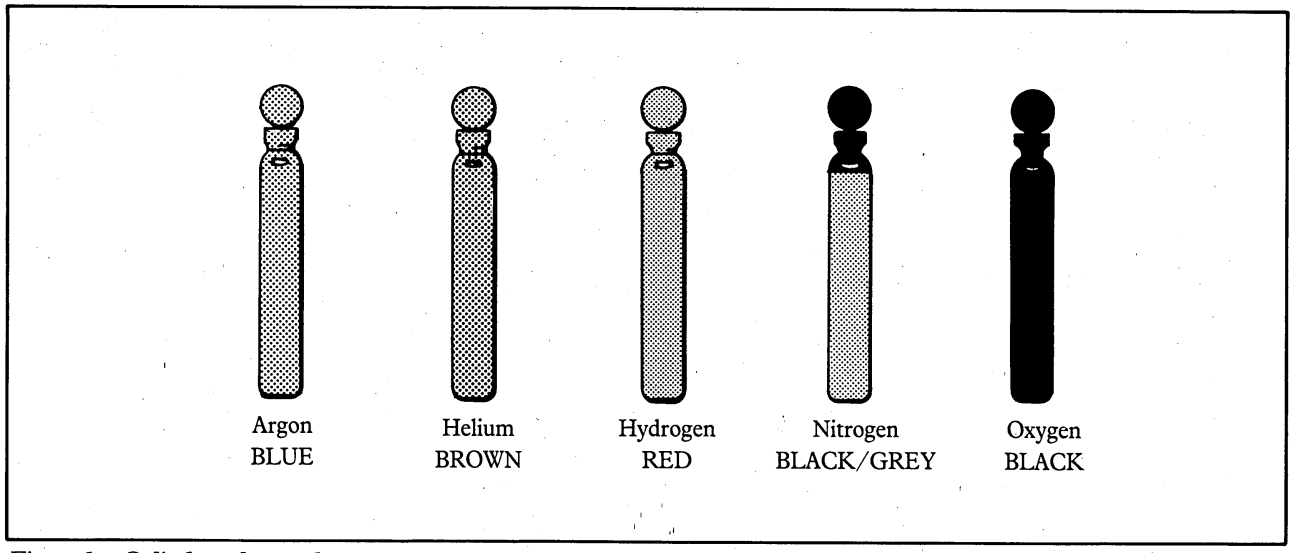

Figure 1 Cylinder colour codes

Buying gas in cylinders is quite expensive. For many large industrial uses, the gas is sold by the tanker-full. You have probably seen road tankers like the one in Figure 2. These tankers usually carry the gas in a liquid form. For really large-scale use, it is cheapest to make the gas on-site. For example, a steelworks might have its own oxygen-making plant.

Figure 2 A gas road tanker

Part 1 Properties of the gases

Before we look at the industrial uses of the gases, we will consider some of the properties of each.

Make a copy of Table 1. Then fill in as much information as you can about each gas.

Table 1 Basic properties of the gases

Name of gas	*Oxygen*	*Nitrogen*	*Hydrogen*	*Argon*	*Helium*
Formula					
Percentage of gas present in air					
Colour					
Odour					
Does it burn?					
Does it allow things to burn in it?					
Boiling point					
Relative molecular mass					
Heavier or lighter than air?					

When you have filled in as much as you can, get any missing information from your teacher.

Before going on to Part 2, answer questions 1 to 5.

Questions

1 *For as many of the gases as you can, give the* source *from which it is manufactured. If possible, explain* how *it is manufactured from that source.*

2 *Which two gases could together be used for rocket fuel?*

3 *Which gases could be used for filling lighter-than-air balloons? Which gas would be* safest *for that purpose?*

4 *When metals are welded they get very hot. An 'inert atmosphere' is needed to stop the metal oxidizing. Which gases could be used to provide this inert atmosphere?*

5 *Which gas is used to remove impurities from iron during steelmaking?*

Part 2 Industrial gases in use

The Factsheet gives information about each of the gases. First, use the Factsheet to check your answers to the questions in Part 1.

Then attempt the questions and activities below. Use the Factsheet to help you.

1 Costs of gases

Questions

6 *Present the costs of the gases in a way that makes it easy to compare them. (For example, you might draw a bar chart.) The cost of a gas depends on several factors. Three of the most important factors are:*
(a) How abundant is the gas? The commoner the gas, the cheaper it is likely to be.
(b) How easy is it to get the pure gas from its source?
(c) What is the demand for the gas? Gases can be produced more cheaply in large quantities.

7 *(a) Compare the costs of nitrogen, oxygen and argon. Try to explain the differences.*
(b) Compare the costs of argon and helium, and try to explain the difference.

8 *Compare the figures for amounts of the gases used per day. Classify each gas as low, medium or high level of use, relative to the others. Then try to explain why each gas has that particular level of use.*

2 Production and distribution of the gases

Gases are usually produced at a factory and distributed to the users by road or rail. Figure 3 shows the places where nitrogen is produced in Britain by one of the big industrial gas manufacturers. Look at the map, then answer questions 9 to 12.

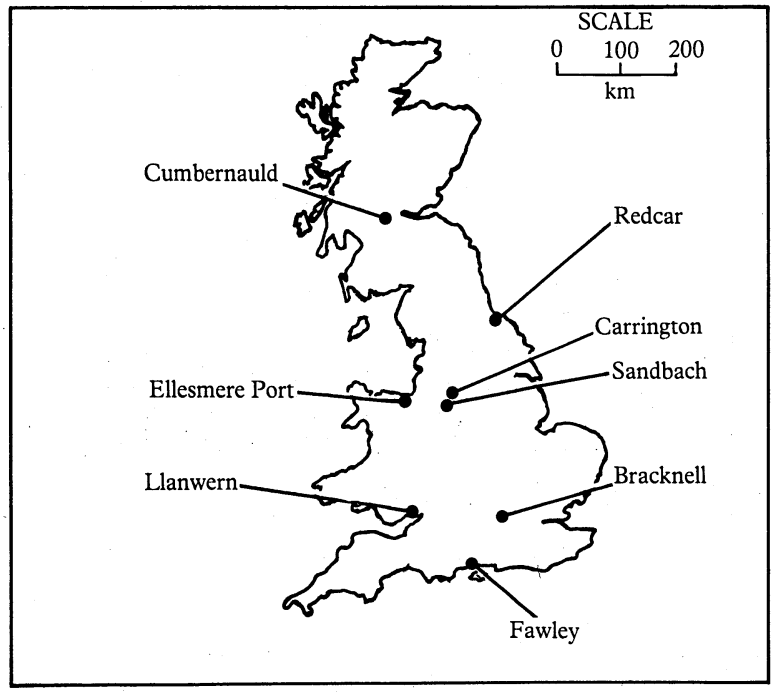

Figure 3 A map showing the places where nitrogen is produced in Britain by one of the big gas manufacturers

Questions

9 *Which part of Britain is furthest from a production plant?*

10 *Roughly how far would nitrogen have to be transported to reach a customer in that part of Britain?*

11 *Why does the company have several plants spread around Britain, instead of just a central one in, say, Birmingham?*

12 *Handling and transporting large amounts of compressed gases, such as nitrogen, oxygen and hydrogen, can cause safety problems. Suggest some possible hazards, and how they could be reduced.*

3 Uses of the gases

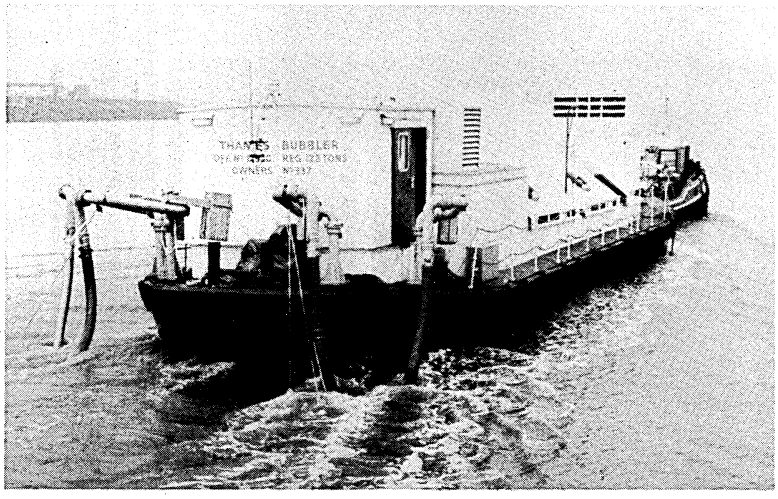

Figure 4 The 'Thames Bubbler' protects aquatic life in the river in emergencies

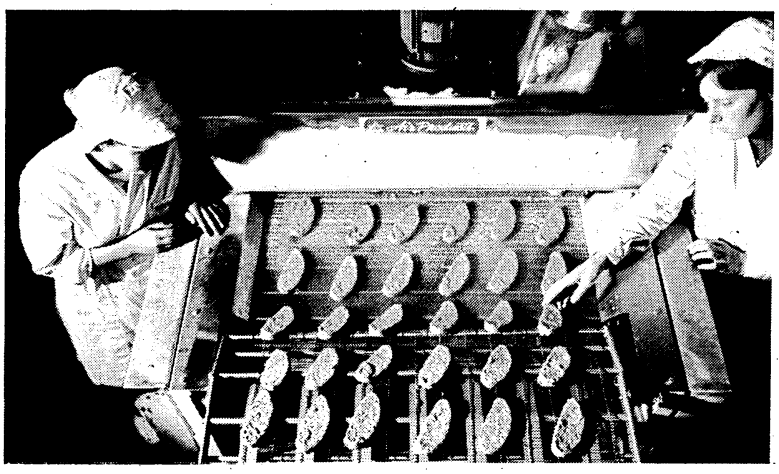

Figure 5 Freezing food

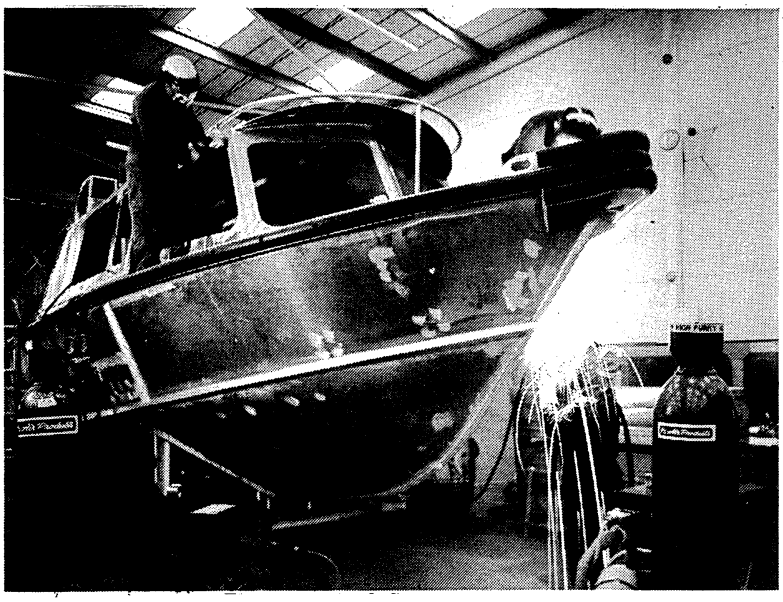

Figure 6 Welding an aluminium boat

Questions

13 Which gas or gases are in use in each of the photographs in Figures 4, 5 and 6?

14 Nitrogen and argon are both used as unreactive gases. When might argon be more suitable than nitrogen? When might nitrogen be more suitable than argon? (Bear in mind the costs of the gases. Remember that nitrogen, unlike argon, is not totally *unreactive.)*

15 Helium is mixed with oxygen to give breathing gas for divers. Try to find out:
(a) Why oxygen is not used on on its own
(b) Why helium is used instead of nitrogen, even though nitrogen is much cheaper.

16 Why is liquid nitrogen more suitable for freezing food than liquid air or liquid oxygen? (The difference between their boiling points is too small to matter.)

Industrial Gases Factsheet

Gas	*Source of the gas and how it is manufactured*	*Approximate cost of the gas bought in cylinders*	*Amount of gas used in U K in 1984 (tonnes per day)*	*Major uses of the gas*
Oxygen	Air. Manufactured by fractional distillation of liquid air.	£0.50 per cubic metre (volume measured at atmospheric pressure)	11 000	In steel making — used to remove impurities from iron by oxidizing them In hospitals — for patients with breathing difficulties For divers and high altitude climbers — as a breathing gas For welding — an 'oxy-acetylene' flame is hot enough to melt metal For treating sewage — oxygen helps micro-organisms to break down harmful materials Combustion processes — oxygen enriched air makes fuels burn better
Nitrogen	Air. Manufactured by fractional distillation of liquid air.	£0.50 per cubic metre	4 000	For freezing — liquid nitrogen is so cold (−196°C) it can be used to freeze food and biological material in order to preserve them As an unreactive atmosphere — nitrogen is used as a cheap, unreactive gas 'blanket' to stop things reacting with air (for example, in petrol storage tanks and food packaging)
Hydrogen	As a by-product from the manufacture of other chemicals. For example, the manufacture of sodium hydroxide and chlorine also produces hydrogen.	£1.50 per cubic metre	2 600	As a fuel In the refining of petroleum For making margarine — hydrogen is used to turn oils to fats In the treatment of metals
Argon	Air. Manufactured by fractional distillation of liquid air.	£2 per cubic metre	300	As an unreactive atmosphere — an inert gas 'blanket' to stop reaction with air (for example, inside light bulbs and in welding)
Helium	From natural gas wells in the USA.	£8 per cubic metre	1.5	As an unreactive gas — for mixing with oxygen in divers' breathing gas As a lighter-than-air gas — for air balloons For supercooling — liquid helium at −269°C is used to supercool magnets