

## Recycling Aluminium

*Contents:* A home survey investigating the extent to which households consume aluminium, leading to a discussion of the question of recycling aluminium.

*Time:* Homework plus 2 periods or more, depending on amount of discussion.

*Intended use:* GCSE Chemistry and Integrated Science. Links with work on the manufacture, properties and uses of aluminium.

*Aims:*

- To complement work on aluminium
- To develop awareness of the opportunities and problems involved in the recycling of materials, in particular aluminium
- To show some aspects of the economics of aluminium production and fabrication
- To provide opportunities to practise skills in the collection and handling of data.

*Requirements:* Students' worksheets No. 310. Balance, accurate to 0.01g. Aluminium foil, scissors, 10 clean milk bottle tops.

A week will be needed for the survey to be carried out at home. The follow-up calculations could be done at home or in class. Less able students will probably need some help with the calculations.

The questions are best answered and discussed in class, perhaps in small groups, though they could be done for homework.

### Notes on the survey and estimation of mass of aluminium used

Milk bottle tops are manufactured to a consistent thickness of about 0.025mm. One top weighs about 0.25g, though students should do this measurement themselves, preferably by weighing a number of milk bottle tops to get an average mass.

The thickness of household foil varies from about 0.018mm to about 0.014mm. 100cm<sup>2</sup> weighs about 0.4g, though students should make this measurement themselves.

### Notes on some of the questions

*Q.1* Apart from wrapping foil and bottle tops, many families will use aluminium foil dishes for pies, cakes, tarts, etc.

*Q.2* Not much aluminium foil is recycled, because of the difficulty of collecting. Some milk bottle tops are recycled.

*Qs 3 to 9* The idea of these questions is to bring out the importance of recycling non-renewable resources, and some of the difficulties involved in recycling. The advantages of recycling are many, in particular the conservation of non-renewable resources and the avoidance of waste disposal problems. But several factors combine to make recycling difficult in practice. The crucial factor is the problem of collecting waste metal and keeping it separate from other waste. Other important factors are the cost of melting and purifying the recycled metal, and the intrinsic value of the metal itself.

**Notes on further questions and activities***The price of aluminium*

Calculations will show that aluminium foil is a great deal more expensive than the metal direct from the factory. The difference can be attributed to fabrication costs for foil, and the cost of packaging, transporting, and marketing the foil.

*The cost of electricity in aluminium manufacture*

This difficult calculation is intended only for the most able students. It shows the high cost of the electricity needed to produce aluminium. Other factors contributing to the cost of the metal include labour costs, transport costs and the cost of mining and purifying bauxite.

**Further resources**

*Siting an aluminium plant (DALCO)* is a computer simulation which enables students to consider some of the factors to be considered when planning the siting and production targets of an aluminium smelting plant. Available from: Micro Software Unit, Longman Group, Burnt Mill, Harlow, Essex CM20 2JE.

*Aluminium* is a programme in the Granada Television series *Chemistry in Action*. It can be recorded off-air for school use. See ITV for Schools annual programme booklet for transmission times.

*Acknowledgement* Figure 1 supplied by British Alcan Aluminium Ltd.

## RECYCLING ALUMINIUM

Aluminium is obtained from the mineral bauxite. Bauxite is impure aluminium oxide. At present, we know that there is enough bauxite to provide all the aluminium we need for about thirty years. This assumes that our use of aluminium continues at the present rate.

With this in mind, it is worth thinking about how we could save our reserves of aluminium. Two ways in which many of us waste aluminium is in milk bottle tops and in aluminium foil.

In this unit you will try to:

- Estimate how much aluminium we use each year in Britain for milk bottle tops and aluminium foil
- Look at the savings that we could make by recycling aluminium used in our homes.



Figure 1 Passing coiled aluminium sheet through rollers to reduce it to the required thickness for foil.

### What you do

- A** Estimate the number of milk bottle tops your family uses each week.
- B** Estimate the area of aluminium foil (in square centimetres) which your family uses each week for cooking, wrapping food, etc.

One way of doing this is as follows:

- (i) Find out approximately how often, on average, your family buys a roll of aluminium foil
  - (ii) Work out the area of aluminium foil in a roll (you can do this using the length and width of the foil, which are marked on the packet)
  - (iii) From (i) and (ii), work out the area of foil used in a week.
- C** Find the mass of a milk bottle top. The most accurate way of doing this is to weigh ten tops, then work out the mass of a single one.

- D** Weigh a piece of aluminium foil  $100\text{cm}^2$  in area.
- E** Use your answers to **A** and **C** to work out the mass of aluminium your family uses each week in milk bottle tops.
- F** Use your answers to **B** and **D** to work out the mass of aluminium your family uses each week in foil.
- G** Collect results from the rest of the class. Find an average value for the mass of aluminium used per family per week in milk bottle tops and foil.
- H** Estimate the number of families in Britain. (The population of Britain is 55 million.)
- I** Using your answers to **G** and **H**, estimate the total mass of aluminium milk bottle tops and foil used in Britain:
- (i) per week      (ii) per year.

*Questions to answer and discuss*

- 1 *What other consumable forms of aluminium are used by your family? ('Consumable' means the aluminium is used once and thrown away. Do not include non-consumable aluminium articles like saucepans and bicycle frames.)*
- 2 *How much of the aluminium in your survey gets recycled? Do you know of any families which collect and recycle aluminium?*
- 3 *Work out the cost of the total mass of aluminium in the milk bottle tops and foil you estimate are used each year in Britain. (In 1985, aluminium cost £900 per tonne direct from the factory. 1 tonne = 1000kg.)*
- 4 *Would we save the amount of money estimated in question 3 if we recycled aluminium milk bottle tops and foil? Explain your answer.*
- 5 *What is meant by a 'non-renewable resource'?*
- 6 *Why is it important to recycle non-renewable resources like aluminium?*
- 7 *About 35 per cent of the aluminium used in Britain gets recycled. What difficulties are there in trying to recycle more?*
- 8 *Which forms of aluminium would be easiest to recycle? (Remember aluminium is used to make aircraft, parts of cars and lorries, caravans, saucepans and many other things as well as household foil.)*
- 9 *Practically all the gold we use gets recycled. Why is so much more gold recycled than aluminium?*
- 10 *List some other common household materials which can be recycled.*

## Further questions and activities

- *The price of aluminium*

Find the mass and cost of a roll of aluminium foil. Calculate the cost per tonne of aluminium in the form of foil. Why does it cost so much more than aluminium direct from the factory (which costs £900 per tonne)?

- *The cost of electricity in aluminium manufacture* (This question is harder!)

- Calculate the number of moles of aluminium in 1 tonne (1 tonne = 1000 kg) of the metal. (Al = 27).
- When aluminium ore is electrolyzed, each aluminium ion is neutralized by three electrons:  
$$\text{Al}^{3+} + 3\text{e}^- \longrightarrow \text{Al}$$
How many moles of electrons are needed for each mole of aluminium produced?
- How many coulombs of electric charge are needed to make 1 mole of aluminium? (1 mole of electrons = 1 Faraday = 96 500 coulombs)
- How many coulombs are needed to make 1 tonne of aluminium?
- Suppose the electrolysis is carried out at a voltage of 6V. Use your answer to (d) to find how many joules must be supplied to make 1 tonne of aluminium. (1 volt = 1 joule per coulomb.)
- From your answer to (e), calculate the number of units of electricity needed to make 1 tonne of aluminium. (1 unit = 1 kilowatt-hour = 3 600 000 joules.)
- If aluminium producers pay 3p a unit for electricity, calculate the cost of the electricity needed to make 1 tonne of aluminium.
- Apart from electricity, what other costs are involved in the manufacture of aluminium?

## SATIS 3

List of units in this book

### **301 AIR POLLUTION — WHERE DOES IT COME FROM?**

A data-analysis exercise concerning sources of air pollution.

### **302 LIVING WITH KIDNEY FAILURE**

A structured discussion concerning the treatment of kidney failure and some of the related problems.

### **303 PHYSICS AND COOKING**

Information, recipes and questions relating to some of the physical principles involved in cooking.

### **304 A MEDICINE TO CONTROL BILHARZIA**

#### **Part 1: How can we Control Bilharzia?**

Reading, questions and discussion concerning the nature of a tropical disease, and approaches to its control.

### **305 A MEDICINE TO CONTROL BILHARZIA**

#### **Part 2: Developing a Medicine to Control Bilharzia**

Reading, questions and discussion concerning the development, testing and production of a pharmaceutical product for the control of a tropical disease.

### **306 FIBRE OPTICS AND TELECOMMUNICATIONS**

Reading and questions on the use of optical fibres in telecommunications.

### **307 CHEMICALS FROM SALT**

Problem-solving exercises concerning the production of sodium hydroxide and chlorine by electrolysis of salt.

### **308 THE SECOND LAW OF — WHAT?**

Reading and questions explaining very simply the ideas behind the Second Law of Thermodynamics and relating them to everyday problems such as pollution and the provision of energy.

### **309 MICROBES MAKE HUMAN INSULIN**

Reading, questions and discussion on the use of genetic engineering techniques to produce human insulin.

### **310 RECYCLING ALUMINIUM**

A home survey investigating the extent to which households consume aluminium, leading to a discussion of the question of recycling aluminium.

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