

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
ADVANCED GCE
G628/INSERT
APPLIED SCIENCE

UNIT 9: Sampling, Testing and Processing

TUESDAY 2 JUNE 2009: Afternoon

DURATION: 1 hour 30 minutes

SUITABLE FOR VISUALLY IMPAIRED CANDIDATES

INSTRUCTIONS TO CANDIDATES

- **Questions 1 and 2 are based on the articles which follow on pages 2–10 of this Insert.**

OLD AND NEW PRODUCTS FROM SEaweEDS

Seaweeds are a common feature on beaches and they have been used as a resource for many products over a long period of time.

During the 19th and early 20th centuries, certain species of seaweed were used as valuable sources of the element iodine. Nearly all seaweeds (marine algae) contain some iodine but the percentage present varies considerably between species. The highest amount of iodine is found in the red seaweed, Rhodophyta. This variety is always submerged and it only reaches beaches when it is torn by storms from the rocks on which it is growing. See Fig. 1.1.

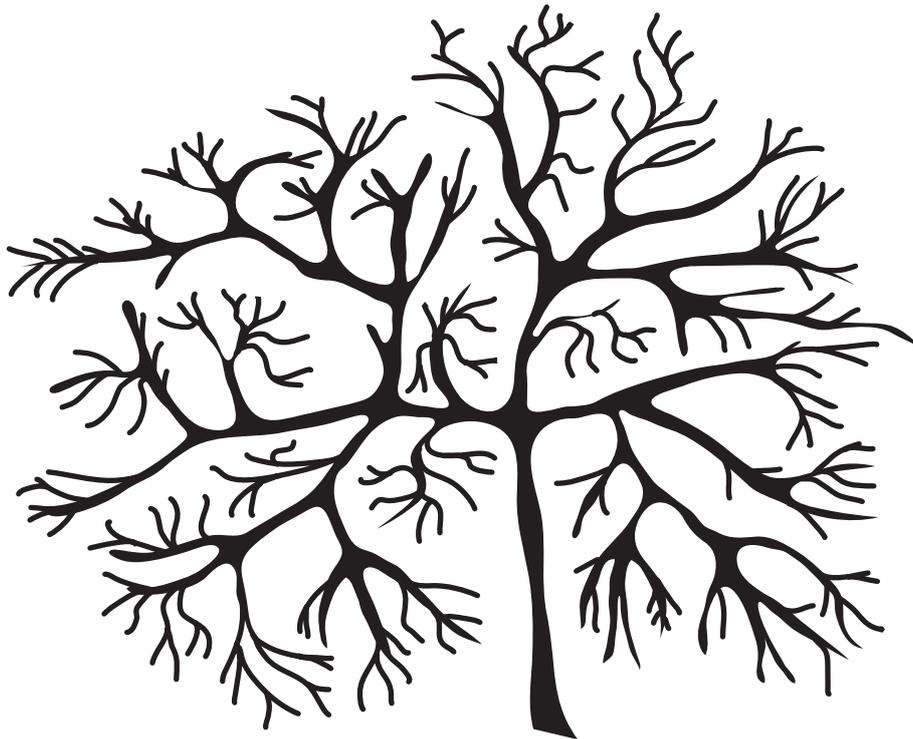


Fig. 1.1

Once on the beach, the seaweed may suffer damage from rain that washes out soluble salts, including those containing iodine. After collection, the seaweed is burnt in shallow pits, giving an ash, which retains most of the iodine. Excessive heat, however, causes some loss of iodine as vapour.

The ash is then treated with hot water, filtered and the resulting solution is concentrated. On cooling, unwanted salts crystallise, leaving a liquid containing soluble iodides. This liquid is then mixed with manganese(IV) oxide (manganese dioxide) and sulphuric acid before being strongly heated. Iodine is produced as a vapour and condenses in the cooler parts of the apparatus.

Fig. 1.2 shows a typical iodine still that was in use in 1900. The mixture was heated using an open fire and the volatile material distilled over into a series of earthenware collecting vessels.

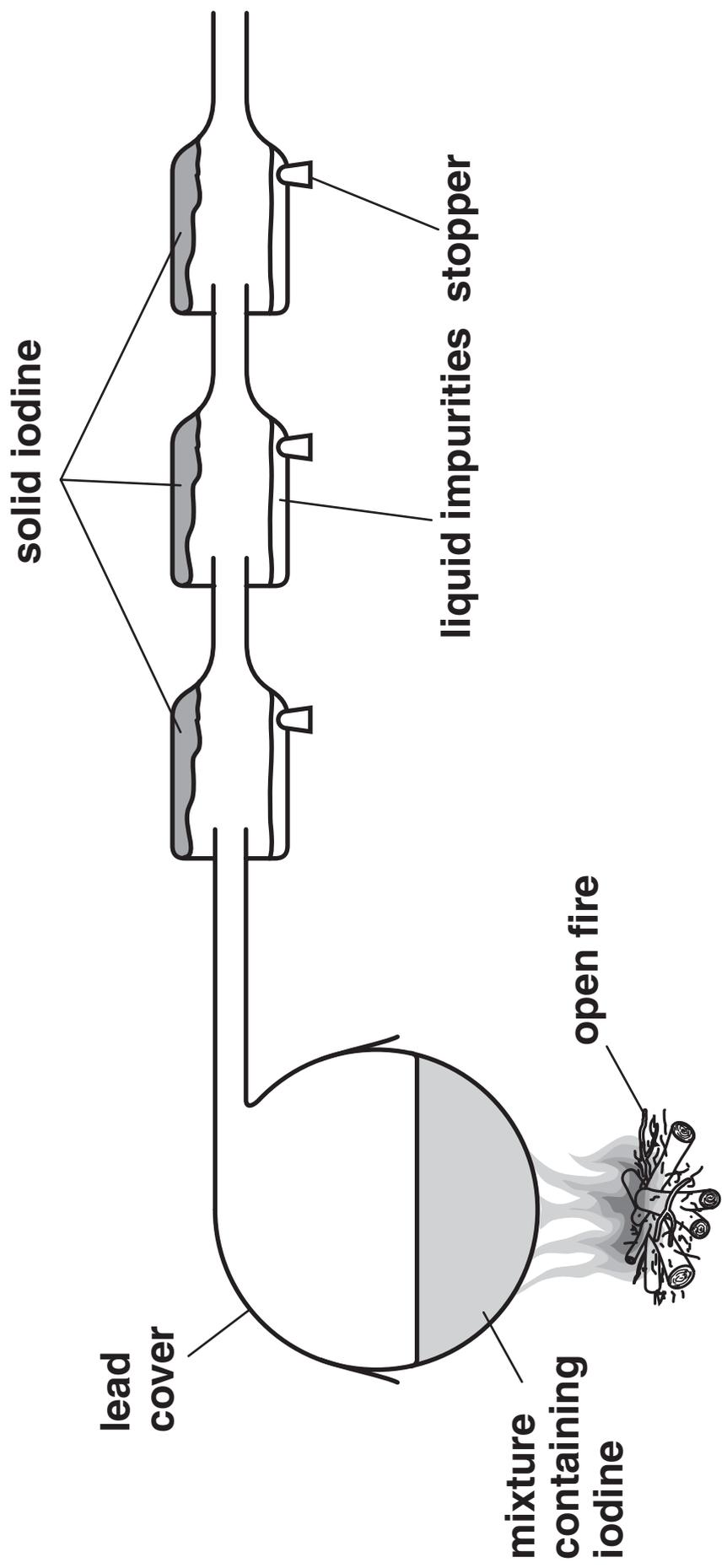


Fig. 1.2

Iodine continues to be used in antiseptics, in animal feeds and in photography.

A more recent product extracted from seaweeds is the natural polymer, carrageenan. This product is an important hydrophilic colloid that occurs as the stem matrix in a number of seaweed species, where it serves a similar function to cellulose in plants. One use of carrageenan (E407) is as a thickening agent in ice cream, toothpaste, yogurt and condensed milk.

To extract carrageenan, the dried seaweed is treated with hot water that contains a dissolved alkali. The carrageenan dissolves in this hot liquid, leaving behind insoluble material that is removed by filtration. The filtrate is then concentrated, and the carrageenan recovered by adding an alcohol to precipitate the product. This is then separated from the liquid. The solid carrageenan is dried and ground to the required particle size.

When added to water the carrageenan swells and produces a thick, jelly-like product. The viscosity of this 'solution' depends on the concentration of the carrageenan, the temperature and the length of polymer chain present.

The term 'carrageenan' describes a number of different complex compounds rather than a single substance. These differ in their gelling and thickening ability. 'Native' carrageenan, obtained directly from seaweed, has a relative molecular mass between one million and eight million. After treatment by acids to reduce the chain length, the 'degraded' carrageenan has relative molecular mass values of around 20 000 to 30 000.

Tests have been carried out on the health risks of these two types of carrageenan when used as food additives. There is some evidence that ‘degraded’ carrageenan can cause irritation to the intestines. As a result, carrageenan that is to be used in the food industry must be the ‘natural’ material. Whether acidic conditions in the stomach may cause the carrageenan to become ‘degraded’ is unclear.

Carrageenan has many present and potential uses but its complex structure and its varied properties present challenges to those intending to use it in their products.

LEAD – A USEFUL, BUT TOXIC, METAL

Pieces of solid lead and burnt lead ore have been found in early Bronze Age burial sites in Derbyshire. Evidence also suggests that lead was in use by the Ancient Egyptians, over 5000 years ago. They made statuettes from the metal and used white lead and red lead as pigments.

Lead mining in Britain was at its peak in the 19th century. This industry has declined as larger, more workable deposits have been discovered in Australia and in North America. Today, around 30% of lead is recycled material.

Although lead mining in Britain is largely a thing of the past, spoil heaps containing waste material from disused mines provide a source of previously unwanted minerals. These include barytes (barium sulphate) and fluorspar (calcium fluoride).

The method of extracting lead from its ore has been largely unchanged for hundreds of years. There are essentially three stages in the production of the metal.

1. **ORE SEPARATION** The main ore of lead is galena (lead sulphide). This ore always contains other 'unwanted materials' (gangue minerals). The mined ore is ground in water to give a particle size similar to fine sand, after which the lead containing minerals are separated by froth flotation. During this procedure the fine material is mixed with water and suitable chemicals. The mixture is vigorously shaken with air in a number of tanks. Unwanted rock particles are more easily wetted and fall to the bottom. The mineral particles stick to air bubbles and float to the surface where they are skimmed off and the

process is repeated. After separation of the lead-containing particles, the rock particles are removed from the bottom of the tank and the water is recycled. The starting lead ore may contain between 5 and 10% of lead, but after separation the particles contain about 50% of lead. An important impurity in this separated lead-containing product is silver, which may be present to the extent of 1.2 kg per tonne.

2. **SMELTING** The dried lead-containing material from the separation is mixed with limestone and then strongly heated in air, when most of the galena becomes lead oxide. Toxic sulphur dioxide gas is also produced as a co-product. The lead oxide is finally mixed with coke and strongly heated, producing molten lead at the bottom of the furnace.

3. **REFINING** Molten lead is mixed with zinc and the mixture heated. Any silver present dissolves preferentially in the liquid zinc layer. By further refining, extremely pure lead can be obtained.

Lead is toxic and this means special precautions have to be taken during its production, particularly because of its relatively low melting and boiling points.

Lead ore is now largely imported into the United Kingdom, whose annual production of lead is around 400 000 tonnes. This is about 6% of world production. Much of the metal is still used as sheeting and in batteries. However, during the 20th century many of the other traditional uses for lead declined, for example lead arsenate is no longer used as an insecticide and the use of tetraethyllead in petrol has been phased out.

Despite the toxicity of lead and its compounds, it has been used in medicine for the last 2000 years. Lead ethanoate (acetate) was claimed to be a cure for skin diseases and, even today, this material forms the basis of some hair gels for men because it has the ability to turn grey hair to brown.

Victorian doctors mixed opium with lead acetate and used it as a cure for diarrhoea. It was certainly effective for this purpose because the opium deadened the stomach pain caused by the lead compound, which, in turn, prevented movement through the intestines! Only 150 years ago as much as 1 g per day of lead acetate was prescribed for each person suffering from hysteria and for fits of coughing.

As traditional uses of lead have decreased, new uses have been found. A computer or television screen may contain around 250 g of lead to shield the viewer from radiation.

Lead and its compounds act as a cumulative poison. Tests have been carried out on men who have worked in the lead industry for 10 years. They had twice the average lead level in their blood but, in tests on memory and behaviour, they showed no difference when compared to a control group.

In 2007 there was serious concern about lead paint being used in children's toys. This led to the withdrawal of a number of items that had been produced and painted in China.

The analysis of lead-containing paints can be carried out in several ways. Rhodozonic acid can be used for the simple qualitative identification of lead in paint. For the

quantitative analysis of lead in paint, colorimetry or atomic absorption spectroscopy can be used. Both these quantitative methods rely on the preparation of a series of standard solutions containing lead; these cause the absorption of particular frequencies of visible or ultraviolet radiation. The solutions that contain lead are made up using distilled water. The absorption of a solution containing an unknown concentration of lead is then compared with the absorptions caused by the standard solutions. Quantitative analysis for lead can also be carried out using x-ray fluorescence spectroscopy.

Lead, its alloys and its compounds continue to have varied and developing uses despite their toxic nature.

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