OCR RECOGNISING ACHIEVEMENT

ADVANCED GCE

APPLIED SCIENCE **G628/CS**

Unit 9: Sampling, Testing and Processing

PRE-RELEASE CASE STUDY – CANDIDATE INSTRUCTIONS

For issue on or after 17 November 2008

CUP/T78675

INFORMATION FOR CANDIDATES

- This document consists of **8** pages. Any blank pages are indicated.

Notes for Guidance

1. This pre-release case study contains two articles, which are needed in preparation for the externally assessed examination in Unit 9: Sampling, Testing and Processing.

2. You will need to read the articles carefully and also have covered the 'what you need to learn' section of the unit. In the examination, the first section of the paper will contain questions based on the two articles. You will be expected to apply your knowledge and understanding of the work covered in the unit to answer these questions. The marks available for this section will be approximately 70% of the marks for the paper.

3. You can seek advice from your teacher about the content of these articles and you can discuss them with others in your class.

4. You will **not** be able to bring your copy of the case study material, or other materials, into the examination. The examination paper contains fresh copies of the two articles. You will find these as an insert in the examination paper. You will not have time to read these articles for the first time in the examination if you are to complete the paper within the specified time. However, you should refer to the articles when answering the questions.

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Brown shales in the sunset?

One day crude oil will run out – it may not be tomorrow – but it will come. Before that occurs, governments need to find alternative sources of energy to keep their economies afloat.

Perhaps nuclear power is the answer, but this has long lasting, highly radioactive, fission products.

Before oil and gas were the essential commodities for providing energy, Britain relied on coal. There are still vast reserves of coal in Britain and in a number of other countries. The use of coal might be another solution to the need for energy, but it has gained the reputation of being a 'dirty fuel'.

Estonia, a modern European country on the Baltic Sea, relies almost entirely on oil shale for the provision of its electricity. The oil shale deposits are vast, one deposit is 2.5 m in thickness and covers an area of 5 000 km^2. About 13 million tonnes of oil shale are mined annually.

The oil shale occurs in bands, alternating with limestone.

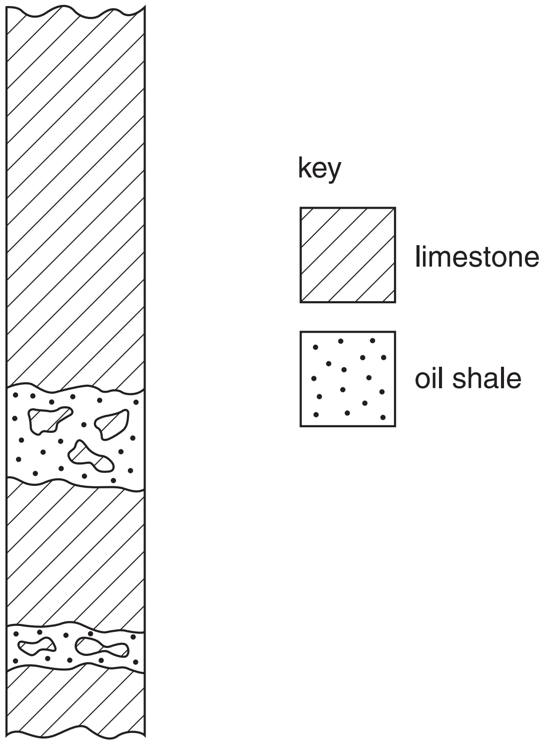

Fig. 1.1

Oil shales are misnamed because they contain no oil. They are toffee-coloured sedimentary rocks of relatively low density (2 500 $kg\,m^{-3}$) containing, typically, an inorganic matrix (67%) together with an organic kerogen (30%) and a little bitumen.

The inorganic matrix of oil shale is mainly calcium and magnesium carbonates, together with some sulphur-containing iron pyrites.

The organic kerogen consists largely of long chain aliphatic hydrocarbons, with a phenolic end group, made by the breakdown of marine algae over several hundred million years. On heating this organic kerogen reactions occur that produce a variety of gaseous hydrocarbons and other volatile organic materials. These are the components of 'crude oil'.

One way of comparing oil shales is to heat them in a similar way.

The results obtained for a number of oil shales from different countries are shown in Table 1.1.

Table 1.1

	percentage			
country	water	oil	gases	solid residue %
USA	1.7	10.3	2.7	85.3
Jordan	5.2	11.0	3.7	80.1
Estonia	2.1	21.7	5.7	70.5

In Estonia, the mined oil shale is treated in two ways to produce energy.

1. Retorting is a process by which the oil shale is heated in the absence of oxygen. This produces a little water, ‘crude oil’ and gases, and leaves a solid residue. The kerogen starts to decompose around 300 °C but the optimum retort temperature is around 500 °C. The volatile material leaving the retort is cooled. Water and oils condense, leaving the gases to be collected separately.

On average, the oil shale yields 147 kg of ‘crude oil’ per tonne of raw shale. This ‘crude oil’ is generally contaminated by fine particles of shale that have been carried over during this primary distillation. This fine material is removed during a further distillation that gives a diesel oil fraction, a light gas oil fraction and a heavier gas oil fraction.

The water obtained during ‘retorting’ contains toxic dissolved phenols. These are removed using a suitable organic solvent that is immiscible with the aqueous liquid but preferentially dissolves this phenolic material.

In a modern development in the United States, ‘retorting’ is being carried out ‘in situ’.

The shale is heated electrically, under ground, to 400 °C and the oil that is produced is vapourised and collected over a period of three to four years. Up to 70% of the available ‘carbon’ can be obtained in this way. This is a much more effective method than conventional mining and ‘retorting’. Energy is used in heating the rock and scientists estimate that 3.5 units of energy are obtained for every 1 unit of energy needed in its production.

2. Combustion involves pulverised oil shale being used directly as the fuel for power stations. The heat generated turns water into steam, which then turns turbines to produce electricity.

This is a convenient process that is similar to conventional coal powered stations. This process has disadvantages in that a very large amount of ash is produced and any acidic gases produced may cause corrosion of the heat transfer surfaces. The process of combustion causes the carbonates of calcium and magnesium present to decompose to give the oxides. Basic oxides are effective in removing sulphur dioxide from the oxidised iron pyrites and thereby reducing the acidity of the flue gases. This helps in reducing acid rain. Typically calcium and magnesium oxides remove about 70% of the sulphur dioxide that would otherwise be present in the flue gases.

Unfortunately, emission of some of these fine alkaline materials from the stack can lead to 'alkaline rain' being produced. Very fine ash is carried away in flue gases and is responsible for pollution at some distance from the power station. This fine ash can contain heavy metals at concentrations far greater than allowed by the European Union.

The effective disposal of solid residue from these two processes is a major problem because of the large quantities of the potentially harmful compounds it contains. Washing the residue with water produces aqueous solutions of phenols in unacceptably high concentrations.

One use for these solid residues is in the production of cement but the production of the solids greatly exceeds its present uses.

Despite the many problems associated with the use of oil shale as an energy source, the material is an increasingly valuable commodity as reserves of crude oil continue to decline.

Many uses for stinging nettles

During the First World War, before the development of synthetic textiles such as nylon or terylene, cotton was in great demand for the manufacture of clothes and furnishings. Cotton is a crop that requires a hot climate to grow and had, therefore, to be imported to European countries. A British naval blockade meant that Germany ran short of cotton and had to look for suitable alternatives. Stinging nettles had been used as the basis of woven materials for over 2000 years and Germany began to look at the possibility of producing nettle fabric. They were successful in this venture and even some German Army uniforms were made of textiles derived from nettles.

In the 21st century there is now a move towards alternative textiles to cotton. This is partly because of economic concerns over the long distances that cotton has to be transported. Cotton growing needs very large quantities of water and the plant itself is very susceptible to insect pests. About one quarter of all the pesticides used in the world are sprayed onto cotton plants.

Natural alternatives to cotton include hemp, flax and nettles. Hemp and flax produce coarse fibres that make a strong but rather rough fabric. Hemp has the longest and strongest natural fibre and also has anti-mildew and anti-microbial properties. It can be used to make sails, paper and carpets and can also be used as a substitute for glass fibres. Flax fibres can be used in place of asbestos but only nettles have the potential to produce a soft fabric, making it a possible alternative to cotton.

Nettles have a big advantage because they grow well in climates similar to those in the United Kingdom. They can manage without much water and are not susceptible to pest attack or by being overrun by weeds.

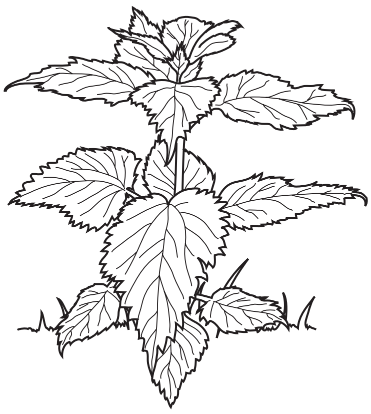

Fig. 2.1

Cross breeding of nettle strains has led to a sturdy nettle plant that grows easily and gives high yields of thin elastic fibres. The fibres comprise 17% of the mass of the plant with each fibre being 2-6 cm in length.

Tests in Austria have produced nettles up to 180 cm in height and gave yields of 0.34 kg of dry stem mass per 1 m^2 of growing space.

One problem with the production of nettle fibre is extracting the fibre from the plant stems. Each of the fibres is held together by pectin. The nettle stems used to be cut and simply left in fields to be rotted by wind and rain. The rate of this rotting could be accelerated by soaking the stems in water, but this was very time consuming. Recent research has been aimed at speeding up this separation process. Scientists have been using enzymes to break down the pectin, at varying temperatures, acidity and concentration of the enzyme.

Nettle products are not solely the concern of European countries. Fibre products, made from nettles, are already available from Nepal, where fibre is obtained from the giant Himalayan stinging nettle that can reach 3 m in height. Each of the stems has a mass of up to 100 g, producing 5% of dried fibre. The process of preparation is labour intensive; the stems are soaked in cold water, which is then boiled for 2 to 3 hours and the products pulped. The pulp is then dried and the fibres are pulled apart, before spinning them.

Nettle fibres are hollow, so the air inside can act as an effective insulator. For winter clothes, a looser twist enables the hollow fibre to retain its air and to act as an effective insulator against the loss of body heat. For summer clothes, the lengths of fibres are twisted, closing the hollow core and reducing insulation.

Traditionally, nettle plants have not only been used for making fabrics, but also for medicinal purposes. Extracts from the plant are said to act as a diuretic, to 'strengthen' the blood and to relieve the symptoms of arthritis and rheumatism.

Used externally, nettle extracts are said to help with oily hair and dandruff. Many of these claims have not been substantiated in a scientifically meaningful way.

However, clinical studies have been carried out with nettle leaf extracts, to test their anti-inflammatory action in arthritis and allergic problems. In a trial with 69 patients, nettle extract rated higher than a placebo, in tests on allergic rhinitis. 58% of those taking the extract reported that it relieved most of their symptoms and 48% said that its effect was more beneficial than 'over the counter' medications.

Stinging nettles have fine white stinging hairs on their leaves. On contact these break off and pierce the skin, injecting methanoic acid (formic acid). As well as the acid, the toxin contains histamines, which also cause pain and swelling.

The future for the stinging nettle is promising. It is surprising how a plant known for its nuisance value has now been found to have an increasing number of beneficial uses.