OCR
RECOGNISING ACHIEVEMENT

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A2 GCE APPLIED SCIENCE

G628/01/CS Sampling, Testing and Processing

PRE-RELEASE CASE STUDY – CANDIDATE INSTRUCTIONS

G611520613

INFORMATION FOR CANDIDATES

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

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Notes for Guidance

1. This Pre-release Case Study contains two articles, which are needed in preparation for the externally assessed examination in 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 75% 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.

Iodine, its occurrence, extraction and uses

The element iodine was discovered accidentally at the start of the 19th century as a result of the wars with France. The British Navy blockaded France in order to cut off the supply of potassium nitrate used in the production of gunpowder. An alternative source of this compound was to be found in the ash of plants, particularly the ash of certain seaweeds, formed from the plants by burning. In 1811, Bernard Courtois isolated iodine, which is a black, volatile solid, from this ash.

Later in the 19th century, an impure form of sodium nitrate known as caliche was mined in Chile. Caliche occurs in bands up to 2 m thick, resting on a bed of impervious clay. The major component of caliche is sodium nitrate but sodium iodate is also present. Caliche is often found as a pale yellow solid, but both sodium nitrate and sodium iodate are white solids when pure. Caliche is separated from rock by blasting and then broken into smaller pieces. The next stage of its purification involves adding these pieces to water in a large tank. An evaporating tank is then used to obtain solid sodium nitrate by fractional crystallisation. The crystals of sodium nitrate obtained by this process are 96% pure. One problem with sodium nitrate is that it is deliquescent and therefore cannot be used directly in explosives.

Another important product that is obtained from the Chilean caliche industry is sodium iodate. This compound remains dissolved in the solution (the mother liquor), from which the sodium nitrate has been crystallised. The Chilean caliche industry, for the extraction of nitrates, was at a peak in 1914 when the British Navy again intervened, this time to block the export of Chilean nitrates to Germany, where they were being used in the production of explosives. The need for another source of nitrates resulted in Fritz Haber discovering a new method of making ammonia, and from it, nitric acid and nitrates. As a result of this new method the demand for caliche became less and the industry suffered a slow decline.

However, this has not led to the end of the caliche industry. The world's current annual production of iodine is 13 000 tonnes and about 40% of this quantity is obtained from Chilean caliche. These Chilean deposits can contain up to 6% of sodium iodate.

Another current source of iodine is from brine, particularly brine that is found near oil and gas fields. This brine can contain 100 to 150 parts per million (ppm) of iodine. Iodine is produced from this brine by passing chlorine gas into the solution, followed by subsequent purification.

An older source of iodine, which is not currently being exploited, is kelp – a type of seaweed. Kelp seaweed provided a source for a local iodine industry up to about 1910. Dried kelp contains about 0.45% of iodine by mass, which increases to about 1.5% in its ash. Calculations show that 15 kg of iodine can be obtained from 1 tonne of this seaweed ash.

Iodine is an essential element for healthy living and is added, as iodine-containing compounds, to animal feeds. Humans need iodine too, and much of it is found in the thyroid gland which helps to regulate body temperature. Uses of iodine are summarised in the pie chart, Fig. 1a opposite.

Iodine compounds occur naturally in the sea and also in soils. Some studies have been carried out to assess the extent and availability of this iodine to humans. A recent study has found the distribution of iodine in streams and soils in Northern Ireland. In previous years, the analysis of these iodine-containing samples would have been carried out using weighing (gravimetric) methods or by volumetric analysis, often involving a titration with sodium thiosulfate solution (using starch as an indicator). Modern instrumental methods have largely superseded these 'wet' methods and X-ray fluorescence spectroscopy (XRF) is now the preferred option. One method of processing the results obtained from the use of XRF is by plotting a graph, from which the percentage of iodine present in the sample can be found by extrapolation. An example of this is shown in Fig. 1b opposite.

The Chilean caliche miners, who suffered much unemployment after 1914, would be amazed to learn that almost 100 years later their product was once again in demand, as a result of the increasing need for iodine-containing materials.

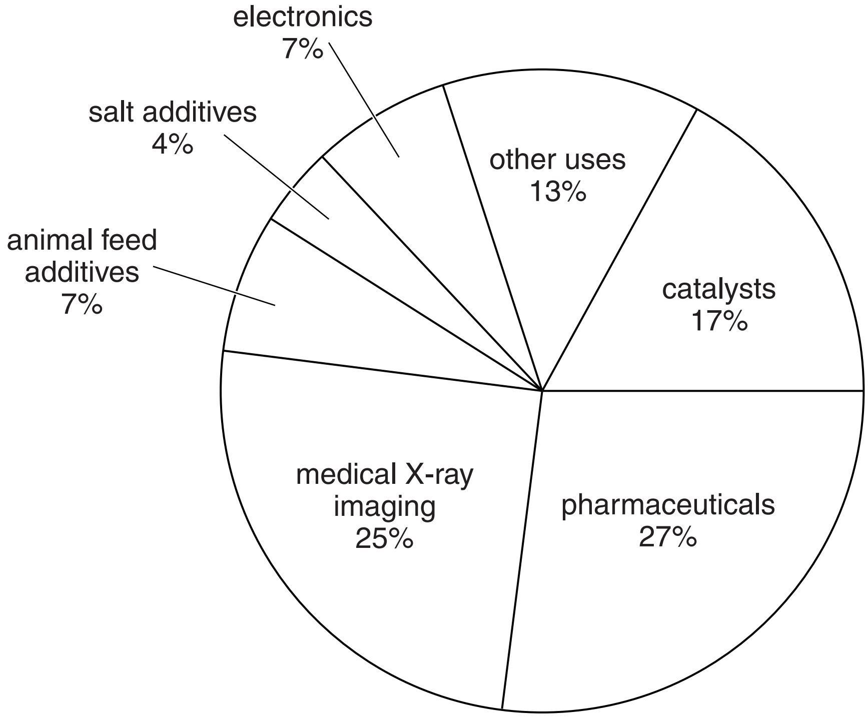

Fig. 1a

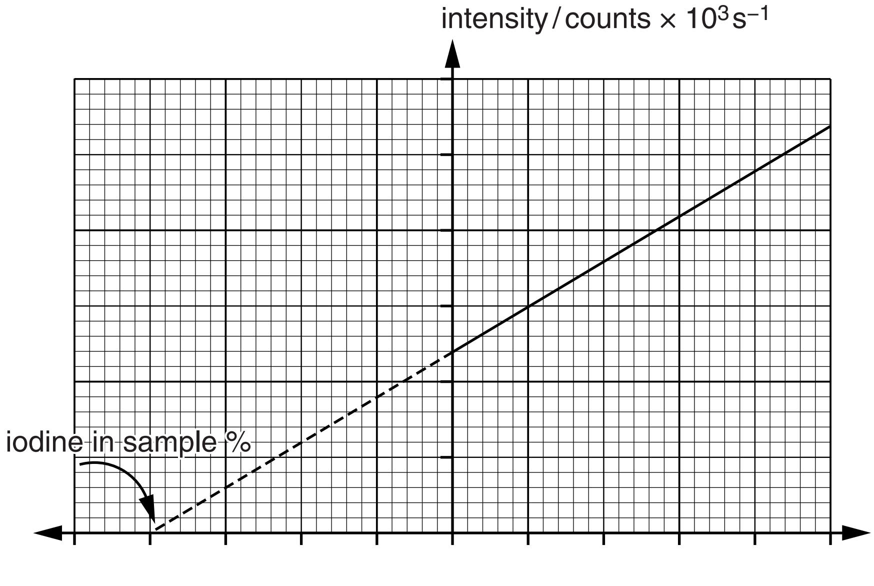

Fig. 1b

Tea

Tea is the name given to the plant *Camellia sinensis* and also to the drink that is made from it. The tea plant grows mainly in tropical and sub-tropical climates but some varieties can tolerate a marine climate and this enables tea to be grown in Pembrokeshire! Generally, the plants need at least 127 cm of rainfall every year and prefer an acidic soil. Plants that produce high-quality tea generally grow at higher altitudes where they grow more slowly and the tea obtained from them has a better flavour. Only the top 4 to 5 cm buds and leaves (the flush) are picked for tea production.

More flushes are then produced by each plant and these are hand-picked every 10 days or so during the growing season. Experiments show that 10 kg of these green shoots produce about 2.5 kg of dried tea. The picked leaves are left in large trays to dry out, with occasional shaking, depending on the variety of tea that is required. During this drying process, chemical changes take place in the leaves. The time taken for this drying period, called oxidation or fermentation, also depends on the tea variety that is required. Many teas are blended mixtures of various types that give the best well-balanced flavour. Additional flavours can be introduced to give floral teas, one of the best known is Earl Grey, which contains bergamot. The Indian sub-continent produces between 1200 and 2000 $kg\,ha^{-1}$ of freshly picked flushes.

As with most plants, tea bushes are susceptible to attack by pests and various types of disease. Some of these problems are outlined below.

<u>Mosquito bug</u> These insects are about 1 cm long.

They are sucking insects and feed mainly during periods of low light and during the night. Suitable contact insecticides to treat attack by these bugs include Endosulfan© and the naturally occurring pyrethroids. Of these, Endosulfan© has been shown to be more effective. Other suitable products include oil isolated from the neem plant. A mixture of neem oil and liquid soap at 1% concentration offers the best control of these insects.

<u>Carpenter moth</u> The caterpillars of this moth feed on the soft bark of the tea bushes. This loss of the soft bark prevents water and nutrients travelling effectively through the plant.

<u>Fungal diseases</u> Certain species of fungi, particularly blights, attack the leaves giving discoloured patches.

Hot water is added to produce a ‘cup of tea’. In the West, black tea is the most commonly used tea. Black tea has the longest ‘fermentation’ period in its preparation. Typically, boiling water is added to the tea and the mixture left for two to three minutes. Many of the active substances in tea are not extracted below 90 °C. The longer the tea is in the hot water the ‘stronger’ the tea becomes. Leaving the tea brewing for too long or if the tea is stirred too much, causes an increase in the dark brown tannins in the drink. These tannins tend to have a bitter flavour. The rate at which these tannins ‘dissolve’ in the water could be measured by colorimetry. Tea leaves contain more than 700 different substances but most people only know that tea contains caffeine. A cup of tea contains about 45 mg of caffeine, roughly half that found in a cup of coffee. In recent years there has been a move to remove the caffeine from tea (and coffee) and decaffeinated tea is now commonly sold. The removal of caffeine can be done in two ways. In one method the leaves are treated with the solvent dichloromethane or ethyl ethanoate. This dissolves the caffeine, which can be recovered from the solvent by evaporation. In the other process the leaves are treated with liquid carbon dioxide under pressure. Of these two processes the carbon dioxide method is now preferred.

In 1953, teabags were introduced to the United Kingdom and these have become immensely popular. However, the tea used in many of these bags is often very fine and tends to be the waste from the production of quality teas. A recent development has been the pyramid shaped bag, whose manufacturers claim gives a better cup of tea, as the leaves have space to expand while the tea is brewing. However, it appears that some of these pyramid teabags are made of synthetic material that does not break down in landfills.

Tea continues to be an extremely important commodity for India, Sri Lanka and China. In 2003, world tea production was 3.21 million tonnes per annum but in 2008 this output had risen to 4.73 million tonnes per annum.