For issue on or after 17 November 2012

A2 GCE APPLIED SCIENCE

G628/01/CS Sampling, Testing and Processing

PRE-RELEASE CASE STUDY – CANDIDATE INSTRUCTIONS

G611420113

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 Sampling, Testing and Processing.

2. You will need to read the articles carefully. 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 Unit G628/01 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.

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Pomegranates

In recent years there has been increased interest in the beneficial effects of naturally-occurring products, particularly fruits from plants and trees, and the juices obtained from them.

The pomegranate (*Punica granatum*) is a small tree, often around six metres high, which originated in the area that is now Iran. It has been cultivated in the Mediterranean area since ancient times. In 1769 Spanish settlers introduced the pomegranate tree to California and from there its growing area has spread to other southern states of the United States. The tree is affected by humid climates and is damaged by temperatures below about –10 °C. Pomegranate trees, which can live for up to 200 years, are cultivated for their fruit but they have reached their growing and fruiting maturity after about 15 years.

As with many crops grown for their fruit, the pomegranate tree suffers from pest attack and from diseases. There are problems from the pomegranate butterfly, whose caterpillars are fruit borers. Smaller insects such as aphids and whiteflies can cause considerable damage but their effects can be lessened by predatory ladybirds and by parasitic attacks.

Commercial insecticides such as Lannate (Methomyl) are quite effective against aphids and whiteflies but they can also disrupt the biological control of these problems by predatory insects. The naturally occurring insecticide pyrethrum has also been shown to combat attack by aphids and other pests. Pyrethrum can be easily extracted from some *Chrysanthemum* species and is a 'homemade' insecticide. A number of oils can be added to pyrethrum to act as synergists. All these measures involve contact insecticides rather than the more effective systemic insecticides. Soap solution can also be used to reduce aphid attack. Pomegranate trees also suffer from fungal attack and this can be a serious problem, particularly if extensive rainfall occurs. Spraying with a contact fungicide helps to reduce fungal diseases. The ripening pomegranate fruits also provide tempting food for birds, bats and squirrels.

Pomegranates are grown commercially for their fruits, Fig. 1a. This roundish fruit, up to 12 cm across, has a thick leathery skin. Inside the fruit are a number of seeds, each surrounded by a sweetish pulp called aril, Fig. 1b.

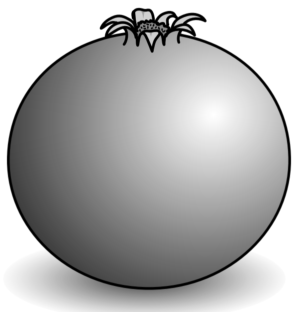

Fig. 1a

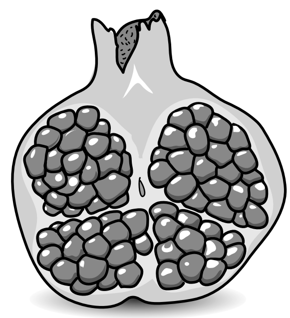

Fig. 1b

Many people find the aril to be the most tasty part of the fruit although the seeds are also edible. Raw pomegranates can be awkward to open and separate out the more edible parts. There has been a move towards consumers demanding pomegranate juice rather than the fruit. A 100 cm^3 serving of the juice provides about 16% of an adult's daily requirement of vitamin C (ascorbic acid). The total acid content of a pomegranate can be found by a simple acid-base titration with an alkali and this forms a method of determining when the pomegranates are ripe enough to harvest. The fruits are also ready for harvesting when the soluble solids in the juice (largely sugars) reach 15% by mass.

There have been various studies on the effectiveness of pomegranate juice in the treatment of serious diseases such as diabetes and cancer, as well as its effects in combating common colds. Preliminary evidence has suggested that the juice may also be effective in reducing some of the factors that contribute to heart disease. However, some of these studies have been very limited in nature and the American Food and Drug Administration has issued a warning letter to some manufacturers and promoters of pomegranate juice for using unpublished and unproven results to make unsubstantiated claims about the efficacy of their juice.

Certainly fruits like the pomegranate can provide a highly nutritious and useful part of our diet but it has yet to be shown that the polyphenol antioxidants that the fruits contain have any major part to play in combating serious diseases.

Arsenic – a favourite poison for crime writers

Human contact with arsenic goes back at least 5000 years. The body of a Bronze Age man, who had been preserved in an Alpine glacier, contained high levels of arsenic. This suggested that he may have been a coppersmith.

A number of authors of crime fiction have used arsenic as the material that poisons a victim featured in their books. In this context the word 'arsenic' refers to arsenic compounds rather than the chemical element. The usual arsenic compound referred to is the white powder arsenic(III) oxide, As_4O_6. A lethal dose of this material is thought to be just 100 mg. However, although this lethal dose is very small, effective antidotes are available if arsenic poisoning is diagnosed quickly enough. In the nineteenth and early twentieth centuries arsenic was widely available for use as a weed-killer. This led to it being a favourite choice for many of those who were setting out to poison others. In the early days of chemical analysis there was no reliable way to detect small quantities of arsenic in the body and it is probable therefore that a number of murderers were able to get away with their crimes. Indeed, it has been suggested that arsenic was sometimes used as a convenient way of disposing of rulers who 'needed to be replaced'.

Sometimes mass poisonings occurred inadvertently. In 1900, 600 beer drinkers were poisoned by beer containing arsenic and, sadly, 70 died. Analysis showed that the beer contained 15 parts per million (ppm) of arsenic. Drinking six pints of this contaminated beer would provide a dose of around 51 mg of arsenic – a dangerously high quantity. Tests showed that the sugar used in the beer making had been treated, during purification, with sulfuric acid that contained arsenic compounds. The sulfuric acid had been made from arsenic-contaminated iron pyrites.

Before the advent of modern medicine, arsenic had been prescribed as a cure-all for many ailments. 'Dr. Fowler's solution', first formulated in 1780, contained potassium arsenite flavoured with lavender water. It was used to reduce fevers – a few drops were added to water or drunk with wine. The use of this solution continued into the nineteenth century, when it was regarded as a tonic and was even taken by the novelist Charles Dickens.

During the nineteenth century, wallpapers were often printed using dyes that contained arsenic, for example, Scheele's Green. This can be made by reacting together sodium carbonate, arsenic(III) oxide and copper sulfate. Dampness in houses caused moulds to form on these wallpapers, which in turn, released toxic gaseous arsenic compounds into the surrounding air. It has been suggested that Napoleon, exiled to the island of St. Helena, suffered from accidental arsenic poisoning. Samples of his hair revealed high levels of arsenic when tested by neutron activation analysis. A sample of wallpaper from his room was found to contain Scheele's Green (Fig. 2a).

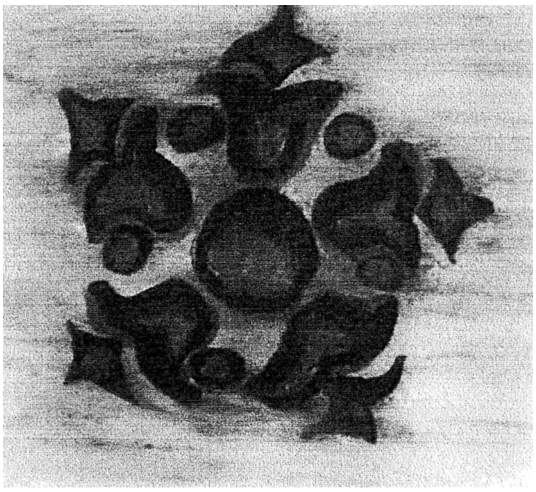

Fig. 2a

Even today, chronic poisoning by arsenic still occurs. In Bangladesh and surrounding countries, where groundwater from wells is used for drinking, the arsenic content has been found to be up to 4 mg dm^{-3}, when the safe limit used in Bangladesh is 0.01 mg dm^{-3}. As a result, a very serious ongoing problem is occurring.

Arsenic present in the environment can cause serious problems. Volcanoes release about 300 tonnes of arsenic every year, but this is exceeded by the 80 000 tonnes that are released each year as the result of burning fossil fuels. Arsenic is not mined directly, but is obtained as a by-product when extracting other metals such as copper and lead. As a result, arsenic contamination of the ground is common near to older mining areas such as the Zimapan area of Mexico, which is around 200 km north of Mexico City. In Zimapan, attempts are being made to reduce the groundwater concentration of arsenic from its present high level to below 0.05 mg dm^{-3}, which is the upper level of arsenic in drinking water allowed in Mexico. A low cost and low-tech method of reducing the amount of arsenic in this groundwater is needed. One such method is for the arsenic to be absorbed into suitable clays.

In other areas, another promising method is the removal of arsenic from contaminated soils by growing the Chinese Brake Fern (*Pteris vittata*). In a typical study, one plant removed 24.4 mg of arsenic from the soil during an eight-week growing period.

Meaningful conclusions from experimental work on arsenic removal rely on an accurate method of analysing for arsenic. The analysis of materials for their arsenic content has traditionally been very difficult as the methods used and the results obtained are affected by the presence of other elements, principally phosphorus. Titration methods using potassium bromate have been used but any significant quantities of copper or iron present will interfere with the method. Weighing methods can be used but these are of limited use when only small quantities of starting material are available. A colorimetric method for arsenic is very effective and will give accurate results at low arsenic concentrations but any phosphate present must be separated first. The arsenic is removed from the phosphate by producing very toxic gaseous arsenic compounds.

Fortunately, modern instrumental methods will give accurate results for very low concentrations of arsenic. These methods include graphite furnace atomic absorption spectrophotometry (GF-AAS), neutron activation analysis and mass spectrometry. However, some of these methods are very expensive.

Arsenic and its compounds are very toxic but there is a need for arsenic as an essential trace element, although the daily dose required by a human may be as little as 0.01 mg. There is no doubt that the substantial quantities of arsenic taken by humans in the past must have had dire consequences, with severe illness and death from acute poisoning being all too common.

Nevertheless, despite their toxicity, arsenic and its compounds remain an essential part of modern technology.