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RECOGNISING ACHIEVEMENT

ADVANCED GCE

APPLIED SCIENCE

Sampling, Testing and Processing

G628

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INFORMATION FOR CANDIDATES

- Questions 1 and 2 are based on the articles which follow on pages 2–5 of this Insert.
- This document consists of **8** pages. Any blank pages are indicated.

Coffee – a stimulating plant

Coffee evolved as an understorey shrub in East Africa. An understorey plant is one that grows beneath a canopy of native forest trees – usually a shade-tolerant shrub. A legend says that a herder noticed that his goats became unusually active after eating bright red berries from a wild shrub. He shared these findings with local monks who made a drink by boiling the berries with water. This enabled them to stay awake during late evening prayers!

At first, coffee was made from the raw green seeds (or beans) at the centre of the red berry. After a time it was found that if the beans were roasted and then ground, the taste of the drink was greatly improved.

Over the years coffee was grown in other countries and by 1650 the Dutch were growing coffee in Sri Lanka and Indonesia. Today the growing of coffee is concentrated mainly in Latin America and in the Caribbean. Brazil is responsible for about 25% of the world's coffee production.

There are two main species of coffee plant, *Coffea arabica* and *Coffea robusta*. Both species need a hot moist climate, rich soil and abundant rainfall. *Coffea arabica* needs a temperature of around 21°C and thrives in mountainous areas at heights between 600 and 1800 metres. The other species, *Coffea robusta*, needs a similar temperature but grows well at lower altitudes. The growers are continually sampling and testing the beans to ensure that they are suitable for harvesting.

Fig.1a

Traditionally, coffee farms are part of a complex ecosystem that also contains fruit trees and hardwoods. This ecosystem can support a rich and varied wildlife habitat and evidence shows that this traditional ecosystem functions well without the need for pesticides, fungicides and man-made fertilisers. Birds, spiders and predatory insects keep harmful pests to a minimum. In addition, coffee leaves contain an alkaloid that makes them unattractive to many insects.

However, an increasing demand for coffee has led to the adoption of more modern farming methods. The coffee shrubs are grown in the full sun, 'protected' with chemicals and fed by man-made fertilisers. Although man-made fertilisers are being used, residues from the coffee making process are used as organic fertilisers for both traditional and modern farming methods. A 60 kg bag of this organic fertiliser contains 1 kg nitrogen, 0.8 kg phosphorus and 2.3 kg of potassium.

Modern coffee plantations have 6000 shrubs per hectare compared to only 1500 on a traditional coffee plantation. Consequently, yields from a modern plantation are much higher, producing as much as 1800 kg per hectare in a year. However, one downside is that modern coffee plantations will only last half as long as a traditional plantation.

Unfortunately, a large proportion of the coffee crop is being damaged by the coffee berry borer (CBB). This is a small beetle, around 2.5 mm in length. The female burrows into the coffee berry and spends most of its life cycle inside, laying large numbers of eggs. Over 60% of Colombia's coffee crop has been damaged in this way in the last ten years.

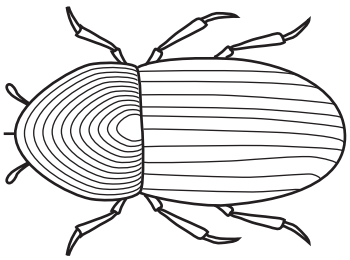


Fig.1b

Growers are becoming desperate to reduce the damage caused by this beetle and a number of methods of eradication are available. Many plantations resort to using several of the methods outlined below.

- A commonly used pesticide is endosulfan, which is poisonous to mammals (including humans) and persists in the environment. The CBB is becoming resistant to this pesticide. Endosulfan is a contact pesticide and so results are very dependent on spraying at the correct time. This is not specific in use and will also kill beneficial insects.

- An alternative to spraying with endosulfan is to use parasitic bethylid wasps imported from Africa. Trials are continuing to produce enough of these wasps to have a real effect and it will be some time before the effectiveness of the method is known.

- There is also interest in using the fungus *Beauveria bassiana*. This fungus can be cultured at home on rice contained in a bottle. Trials show that this fungus has low toxicity to humans and wildlife. Recent work shows that a concentrated aqueous mixture of the spores can kill a high percentage of the borer in two weeks.

- Growers have also resorted to trapping the borers before they enter the berry. The traps contain a liquid that is attractive to the borers. Experiments have shown that 15 traps to the hectare have brought about an 85% reduction in borer infestation. This method is effective where coffee growing is seasonal as the traps can be used at the precise time. However, in some countries coffee berries are produced all year and then traps are less effective. Nevertheless, tests have shown that as many as 12 000 borers can be trapped in one day with this method.

- Removing diseased berries from the ground before the next growing season is effective but too labour intensive.

The problem of the CBB is of major concern to coffee producing countries and research is continuing to find a really effective solution to this difficult problem.

The attraction of the coffee drinking habit for many people is not only its taste, but the stimulant effect of the caffeine that it contains. However, caffeine is mildly addictive and also acts as a diuretic; an increasing number of people prefer to drink coffee from which the caffeine has been removed.
Since it is the taste and flavour of coffee that is important, any extraction process needs only to remove the caffeine. Solvent extraction using dichloromethane was used but there is doubt about its safety. Liquefied carbon dioxide is now the preferred solvent.

The coffee plant has continued to provide many people with a stimulating drink for over 1500 years with little change to the drink itself, but there is some concern about the problems of modern production as a result of increasing demand for the product.

Some aspects of atmospheric pollution

The air that is all around us is essential for life. The proportion of gases it contains is delicately balanced to remain largely constant. Natural events in the past and, more recently, materials created by humans, have served to upset this balance, with serious and poorly understood long-term consequences.

Over the past millions of years, large-scale volcanic processes have spewed out huge quantities of sulfur dioxide and carbon dioxide into the atmosphere, together with large quantities of solid debris. Each of these events has caused severe damage to the environment.

The industrial revolution brought about a huge increase in atmospheric pollution. However, in recent years efforts have been made to reduce the levels of man-made atmospheric pollutants. One example of this is the removal of sulfur dioxide from the flue gases of coal-burning power stations to produce gypsum. Some of the problems that these pollutants can bring about are shown in the table below.

Pollutant	Effect
carbon dioxide	global warming
sulfur dioxide	acid rain, asthma and breathing problems
nitrogen oxides	acid rain, global warming, breathing problems
hydrocarbons	photochemical smog
chlorofluorocarbons (CFCs)	damage to the ozone layer and global warming
solid particles	inhalation problems, toxicity, abrasive

Carbon dioxide is one of the gases contributing to global warming, with its unforeseen but possibly irreversible chain reaction consequences. One impact of global warming may be the melting of the permafrost and the release of trapped methane. This gas is considerably more dangerous as a 'greenhouse gas' than carbon dioxide.

Sulfur dioxide reacts with rain water and gives acid rain, which has seriously damaged plant and marine life.

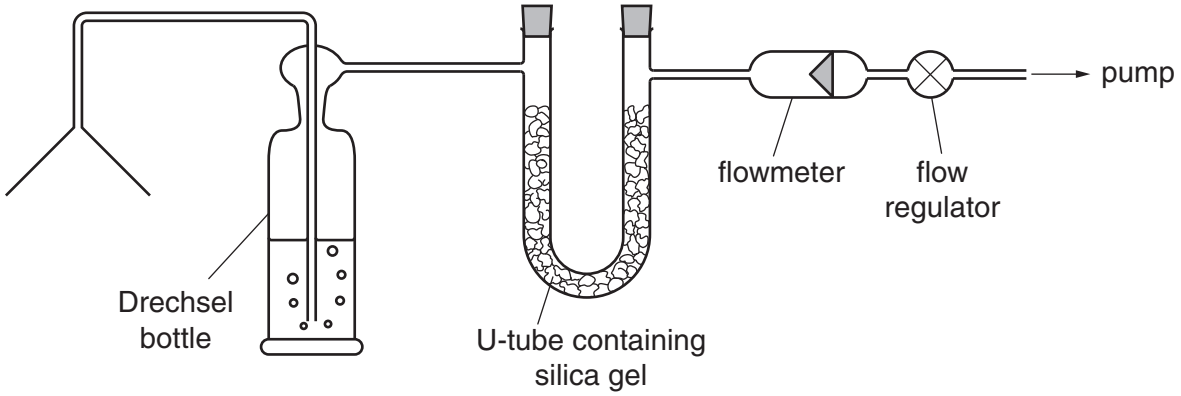
Photochemical smog is a major problem in Athens, Bangkok, Mexico City and Los Angeles. It is caused mainly by motor vehicles' exhaust gases reacting in bright sunlight to form a yellowish smog containing small liquid droplets.

The emission of dust and ash in volcanic eruptions, such as Mount St. Helens in 1980, can reduce the amount of sunlight, with serious consequences for photosynthesis and the plant life on which we ultimately depend. Much of this dust and ash is siliceous and its small particle size means that it can be inhaled, with possible serious consequences. The particles are of various sizes. Those with a size of greater than 10 μm (0.01 mm) are generally stopped in the nasal passages when breathed in. There is much more concern about particles smaller than 10 μm (described as PM10 particles). These can penetrate into the lungs.

Solid particles may contain heavy metals, which are toxic to plant and animal life. They can also be alkaline (such as cement dust) or contain hard, abrasive rock derived material.

The monitoring of atmospheric pollution has become increasingly important, as people have become aware of the short- and long-term effects of these materials. Until comparatively recently the analysis of atmospheric materials was carried out by wet methods. These were generally time consuming and not always appropriate or very accurate with low concentrations of materials. The introduction of instrumental methods and the use of modern technology have enabled the monitoring of atmospheric pollution to be a much quicker procedure. It has also led to the use of continuous monitoring. However, a number of traditional methods are still used, including acid-base titrations and chromatography work for sulfur dioxide and nitrogen oxides.

A typical traditional absorption 'train' is shown below.



The Drechsel bottle can be filled with the appropriate solution to react with the gas or gases being collected. A filtering device can be introduced if collecting solid particles.

Atmospheric pollution continues to be a serious problem. Photochemical smog is still common in Los Angeles. Prior to the 2008 Olympic Games held in Beijing, there were concerns about the smog levels and worries that they might cause respiratory problems and decreased athletic performances. Although some new world records were achieved it is unclear whether these records could have been bettered if the air had been less polluted.

Although the problems of air pollution are now better understood there is still a need for vigilance in a world where the industrialisation of developing world countries is rapidly increasing.

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