GCE ADVANCED UNIT

G628/CS

APPLIED SCIENCE

Unit 9: Sampling, testing and processing

CASE STUDY

CUP/T43703

Pre-release Case Study – Candidate Instructions

For issue on or after 14 FEBRUARY 2008

This document consists of **7** printed pages and **1** blank page.

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 67% 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 at the back of 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.

BLANK PAGE

[Turn over

Acid rain – a soluble problem?

Acid rain has been described as ‘a creeping catastrophe and an invisible foe’. These words reflect a deep anxiety in the face of an extensive and all-embracing environmental problem.

The term ‘acid rain’ was coined well over one hundred years ago by Robert Smith, the first British ‘air-pollution officer’. He pointed out that ‘acidic air’ bleached the colour of fabrics, attacked metal surfaces and damaged vegetation. It is perhaps therefore surprising that the problem did not begin to be studied scientifically until after the Second World War.

At first the atmospheric transportation of pollutants received attention on a local scale, but gradually it became clear that air also served as a transport medium over long distances. The chemical pollutants it contained were dropped at points far distant from their origins.

As early as 1755 it was recorded that fine desert dust from the Sahara had landed in Britain. Black sooty particles can also be carried hundreds of miles and, in 1881, snow in certain parts of Norway turned grey from fine carbon particles that originated in Britain.

Gaseous pollutants, such as sulphur dioxide and various nitrogen oxides, can travel long distances. Research has shown that 75% of sulphur compound deposition in Sweden comes from other countries.

Much of the acidity is due to the gases sulphur dioxide and various nitrogen oxides. In small quantities, oxides of sulphur and nitrogen occur naturally. European rainwater, unaffected by humans, has a pH of between 5 and 6, but today, in many areas, the pH has fallen to between 4 and 4.5. These gases can persist in the air for a few days during which they can travel many hundreds of kilometres. During this time they become oxidised into droplets of sulphuric and nitric acids, which form acid rain. These oxides can have a direct and an indirect influence on organisms and materials, Fig. 1.1.

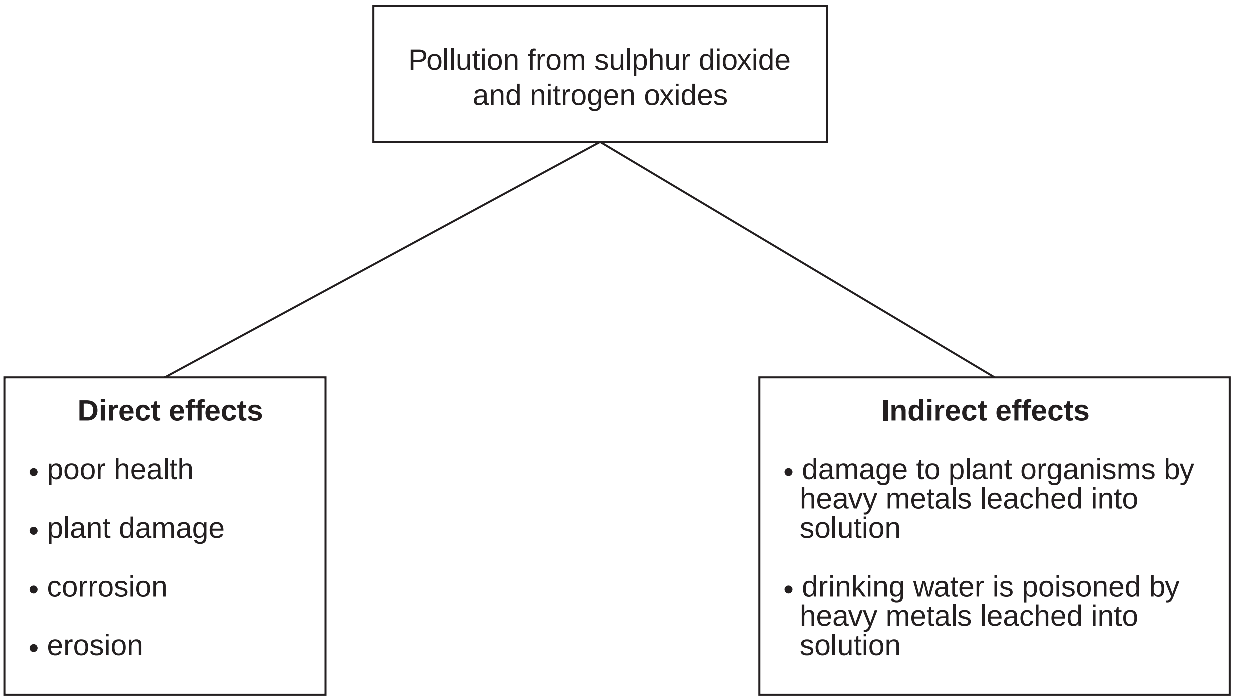

Fig. 1.1

Direct effects tend to be local to the source of the pollution and their effect declines rapidly as the distance from the source increases. The indirect effects are longer lasting and act at a greater distance from the source of the emissions.

The acidification of land and water is an ongoing environmental catastrophe. There are two main courses of action that can be taken to remedy this problem.

One is to treat the source of the problem. Much of the sulphur dioxide emission is caused by the combustion of the fossil fuels, coal and oil. The use of coal is decreasing in Western Europe but is increasing in Asia. Greater use of low-sulphur coal may reduce the problem but the removal of sulphur dioxide from power station flue gases would have a greater impact. The latter is an extremely expensive process. The removal of sulphur containing compounds from oil would be very effective but is, at present, not economically viable. A greater reliance on nuclear power would certainly reduce acidic emissions but would also bring the problem of increasing quantities of radioactive waste products with long half-lives.

The other approach is to reduce the acidity in the environment, particularly polluted water. A way to do this is to add lime to the water. This has been shown to be effective but is time consuming and increases the concentration of calcium ions in the water. Greater concentrations of reagents are needed over time if atmospheric acidity is still occurring.

The effects of acid rain have been measured over a long period. Observations can be made of plant and tree growth and the population sizes of fish and aquatic invertebrates. The pH of soil and lake/river water is also measured. However, care must be taken with the interpretation of results as changes to the pH can also occur when fertilisers are used. Seasonal variations in water flow rates must also be noted and considered.

There is no easy answer to the problem of acid rain, owing to an increasing, seemingly insatiable, demand for energy that, at present, means the burning of more and more sulphur-containing fuels.

[Turn over

Nickel – the devil's copper

The metal nickel gets its name from 'kupfernickel', meaning 'devil's copper', as early German miners were unable to make copper from the reddish nickel ore. Its only known use at that time was for colouring glass green.

Nickel, like iron, is a magnetic metal, although it is not as magnetic as iron.

Nickel and its compounds are common both in earth and in space. There are several types of meteorite and their identification is not easy. Metallic meteorites contain iron with up to 30% nickel and the core of the Earth is also made up of the same two elements.

Pure nickel metal was first made in 1775 but there was little demand for it until 1844 when it began to be used as the base metal for silver-plated cutlery. Impure nickel is produced by converting nickel ore to nickel oxide, and then reducing the oxide with carbon. Pure nickel is then made by reacting the impure metal with poisonous carbon monoxide to form the very toxic liquid, nickel tetracarbonyl (tetracarbonylnickel(0)). This is then heated to produce the pure metal, releasing carbon monoxide.

Nickel has an increasing number of important uses but unfortunately it presents some health hazards. The metal itself and its compounds can cause dermatitis. Breathing in nickel dust or many of its compounds can cause cellular changes that may lead to cancer.

Nickel has limited use in living systems. Humans only require a daily intake of 6 micrograms, although most people take in 150 micrograms every day. Nickel is contained in trace quantities in many plants. Typically, tea contains 7.6 mg per kilogram of dried leaves. Too much nickel can cause plants to die but a few plants, such as the shrub violet, can absorb considerable quantities without ill effects.

Nickel is very useful mainly because it forms many alloys, some of which have unique properties.

- Stainless steel contains iron together with chromium and nickel.
- Most modern 'silver' coins, such as 10p, are made of 25% nickel and 75% copper.
- Nickel aluminide is a compound that becomes stronger as the temperature rises. It is six times stronger than stainless steel and has been used in jet engines. It may be used in vehicle engines in the future.
- Nichrome contains nickel together with 15 to 20% of chromium. It does not oxidise, even at red heat, and is used in toasters and electric ovens.
- Smart alloys contain around equal amounts of nickel and titanium. They have remarkable properties, such as changing their shape when heated. They then return to their original shape when cooled or when a force is applied.
- Superelastic alloys are also alloys of nickel and titanium, but are not affected by changes in temperature. They need an applied force to change their shape but change back to their original shape when the force is removed. A use for these alloys is to make spectacle frames, which recover their shape after being damaged, Fig. 2.1.

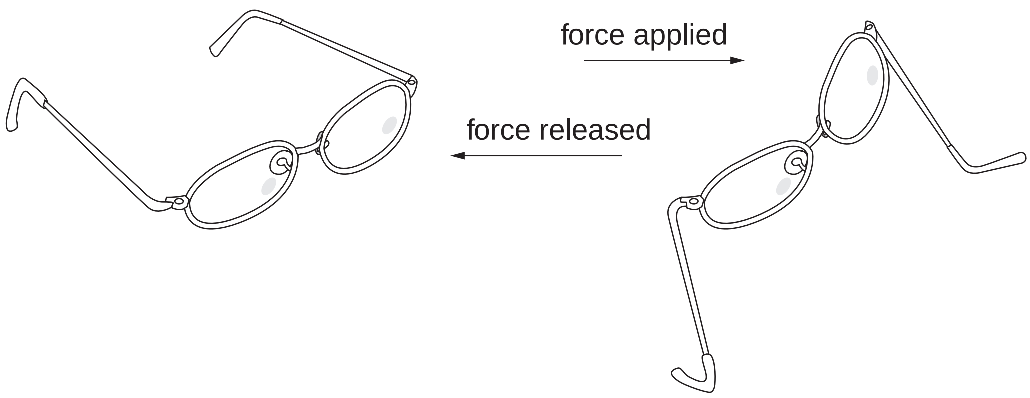

Fig. 2.1

Nickel, first discovered 250 years ago, had little use until the development of silver-plated articles. The use of stainless steel has superseded silver-plated cutlery but the development of smart alloys has demonstrated how modern technology can find new and exciting uses for a metal whose uses were once limited.