SPECIMEN

Advanced GCE

Applied Science

Sampling, Testing and Processing

Specimen Paper

INSERT

G628

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 6 pages. Any blank pages are indicated.

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LANDFILL SITES AS A MEANS OF WASTE DISPOSAL

Over the last one hundred years, economic progress in the United Kingdom has led to an increase in the amount of waste produced per person. Waste can be looked upon from two viewpoints – firstly, as a threat to human health and the environment and secondly, as a rich source of useful materials such as glass, plastic and paper, as well as valuable metals such as copper, zinc and aluminium.

As part of a project, a group of students explored the problems of waste disposal. They found that in 1995 domestic waste in the United Kingdom totalled 20 million tonnes. Of this quantity, 90% was disposed of in landfill sites and only 5% was recycled or reused. The remainder was burnt. Much of this waste material was organic in origin. Tests show that the burning of this material releases large quantities of carbon dioxide gas. In addition, incomplete combustion may release carbon monoxide gas and smoke. The production of all these substances causes environmental problems.

When waste reaches a landfill it is:

- compacted so that 1 tonne occupies 1 m^3 – this minimises air spaces
- placed in an area of the landfill site and sealed with clay – this helps prevent rain entering or liquid leaving, and the loss of heavy metals as aqueous ions.

The filled section of the site is then capped so that any oxygen present is quickly used up in the oxidation of organic materials. The gaseous substances produced are then lost. Some of these compounds, although harmless, give offensive odours and this is a cause for concern. This aerobic stage is then succeeded by the anaerobic stage where oxygen is absent. Under these conditions, organic materials are broken down by bacteria to contribute to landfill gas. Each tonne of domestic waste is capable of producing 400 m^3 of landfill gas. The composition of typical landfill gas changes with time but the gas is largely a mixture of carbon dioxide and methane as shown in Fig. 1a.

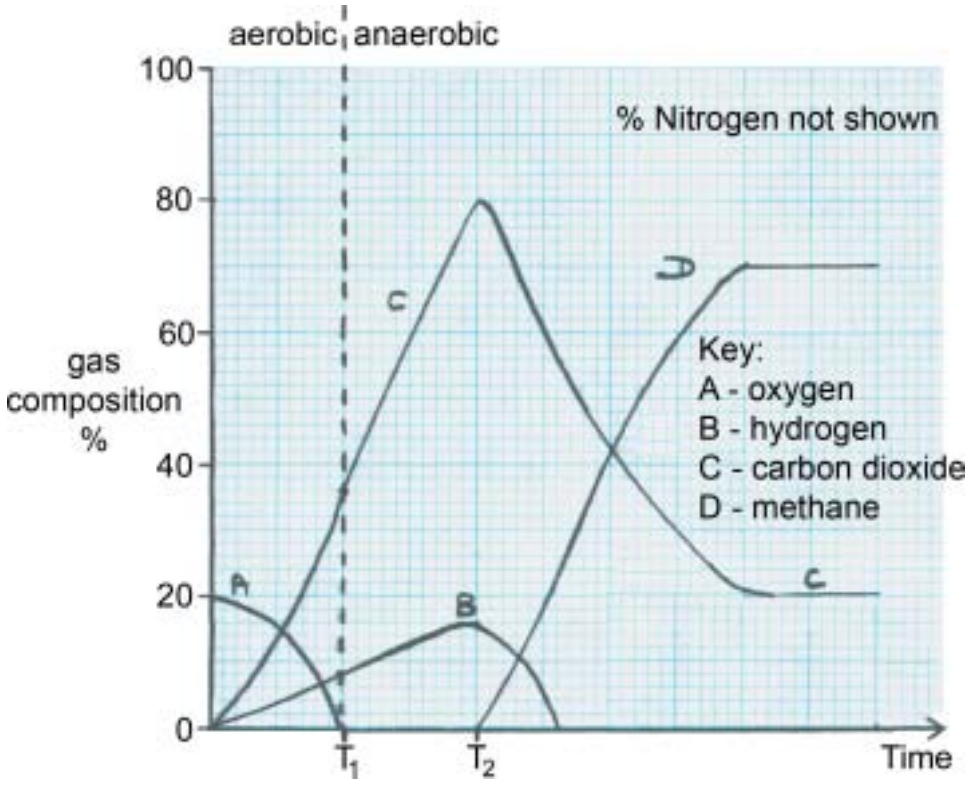

Fig. 1a

Landfill gas can be produced in the site for 25 years. This can pose an environmental threat, but increasingly this gas is being used as a source of energy and companies are selling it commercially. If the gas is not extracted it can slowly escape from the site causing damage to vegetation. Extraction of the gas has a wider economic impact, as methane is a 'greenhouse' gas with a warming potential much greater than carbon dioxide.

Water run off from landfill sites (leachates) may contain major pollutants and these can be analysed. The organic pollutants can, however, be oxidised to carbon dioxide and water or they can be converted to methane.

BITUMINOUS MATERIALS

Bitumen and tar have been used as bonding and waterproofing materials for nearly 6000 years.

Bitumen is a very viscous brown or black liquid or solid that is comprised mainly of hydrocarbons. It occurs naturally by itself, or mixed with solid mineral material when it is described as asphalt. On heating, bitumen softens and its viscosity becomes less as the temperature rises.

Asphalt was discovered in the West Indies by both Christopher Columbus and Sir Walter Raleigh. The asphalt they discovered contained 55% of soluble bitumen and 5% of insoluble organic material and a remainder of inorganic material such as calcium carbonate.

In some places rock asphalt is found. This is fine-grained limestone that is impregnated by about 10% of bitumen.

Bitumen can also be made by the distillation of crude oil, when it remains at the bottom of the distillation tower as a thick viscous liquid.

Once bitumen has been obtained it can be modified for the purpose required. It is used on roads, as sealants or in paints. It can be made less viscous and softer by adding a suitable solvent such as a thin oil.

Bitumen is used extensively on roads but suffers from aging, caused by both changes in temperature and from the effects of ultraviolet radiation. At higher altitudes the intensity of ultraviolet radiation can be as much as five times the intensity at sea level. This increase in intensity causes serious aging of the bitumen. However, one difficulty when investigating this effect is the difficulty of carrying out experiments in the field. As a result, technicians use special laboratory methods to simulate field conditions. In one experiment, samples were exposed to ultraviolet radiation (UV) for nine hours at a particular temperature. This radiation was similar to that received over a period of several months on a high mountain road in Tibet. The bitumen samples were then tested to determine the distance that a needle could penetrate and any changes that occurred in the softening point. Table 2a shows the results obtained from two different bitumen samples, **A** and **B**.

Table 2a

	Penetration/mm		Softening point/^{o}C	
Bitumen sample	Before UV	After UV	Before UV	After UV
A	79	46	46	57
B	81	49	46	54

Bitumen is a complicated mixture of chemical compounds and it is difficult to understand the changes that occur as a result of this long-term exposure to ultraviolet radiation. However, a study of the infrared absorption spectra of bitumen samples, before and after exposure to ultraviolet radiation, shows that the intensity of absorption of certain infrared frequencies increase as the exposure time to ultraviolet radiation increases.

Tar is often confused with bitumen since it too is a viscous liquid. However, tar is obtained from coal rather than from oil. Chemically it differs in that it contains aromatic hydrocarbons rather than the straight or branched chain hydrocarbons found in bitumen. Pitch is similar to tar but is a solid at room temperature.

Bitumen and tar have many different uses. It is important to know both the chemical composition and the properties of each sample that is to be used. These vary between samples according to their source or method of production. The assessment of two of these properties is outlined overleaf.

1 Flow properties

Most bitumen is handled as a liquid and it is important to know its flow rate. This can be found by measuring its softness and its viscosity.

Fig 2a shows a simple piece of equipment for testing the softness of bituminous materials.

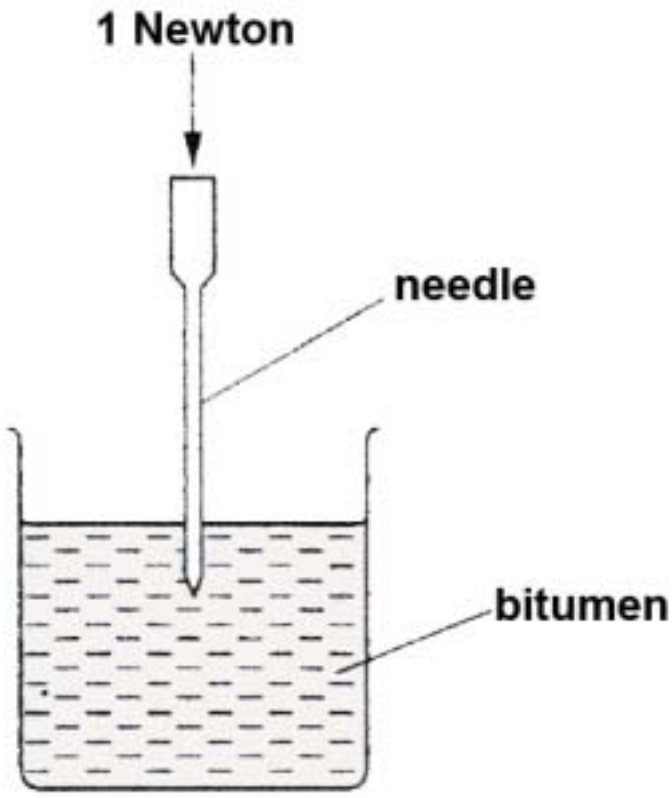

Fig. 2a

The penetration of a needle into the sample is measured using a load of 1 Newton at 25^{o}C over a period of five seconds.

2 Composition

(a) A bitumen sample of a known mass is heated for a set time at a known temperature. Volatile compounds are lost by evaporation and the resulting loss in mass is found.

(b) A known mass of bitumen is heated in air to 775^{o}C and burnt in air until no carbon remains in the ash produced.

The % of ash produced from the sample is then found.

(c) A known mass of the bituminous material is dissolved in carbon disulphide or in methylbenzene and the mass of the insoluble residue is found.

Although bituminous materials have been known for thousands of years, they still have many important uses, particularly in the road and building industries.