

**ADVANCED GCE UNIT**

**APPLIED SCIENCE**

Unit 9: Sampling, testing and processing

**INSERT**

**FRIDAY 19 JANUARY 2007**

**G628**

Afternoon

Time: 1 hour 30 minutes



**INSTRUCTIONS TO CANDIDATES**

Questions 1 and 2 are based on the articles which follow on pages 2 – 6 of this insert.

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

## Osteoporosis – A challenge for modern medicine

Osteoporosis (meaning porous bone) is a disease that results in reduced bone strength and which leads to an increased chance of a fracture. In the United States there are at least 25 million sufferers from this disease. Of these only 4 million are receiving treatment but the cost of this to the US economy is around £8 billion.

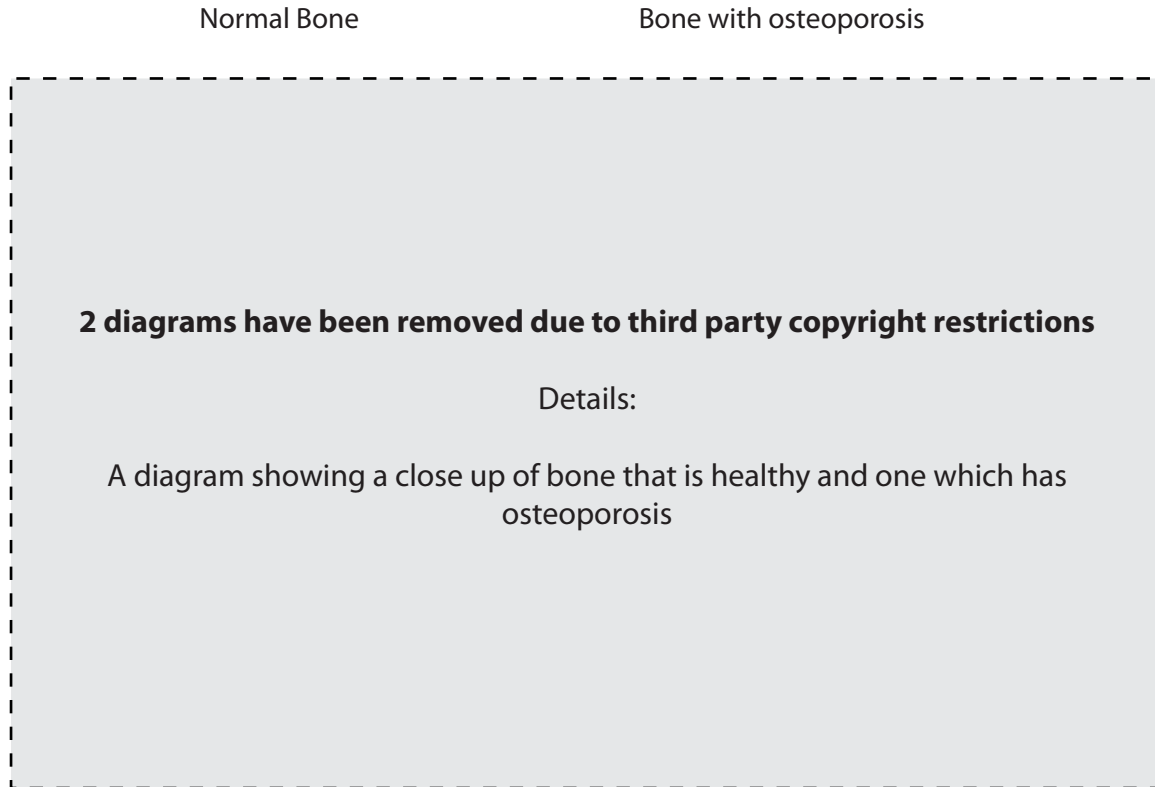


Fig. 1.1

In the United States there is a 20% risk of a hip fracture for women over 55. Statistics show that women over 55 are 5 times more likely to suffer from fractures than men of the same age.

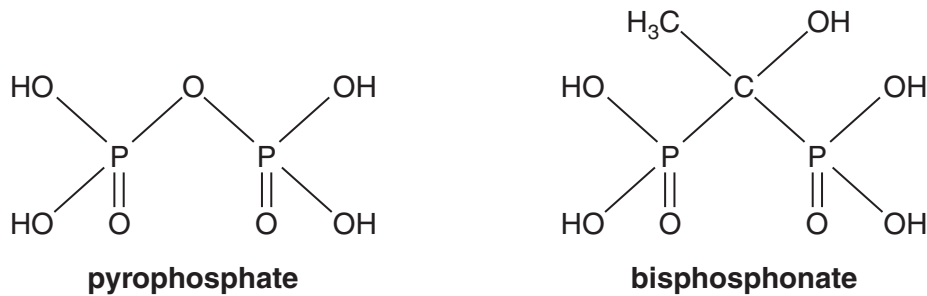
Bone is composed mainly of hydroxyapatite (a basic calcium phosphate) and the protein collagen. There are also blood vessels and two types of special cell. One of these types of cell is responsible for dissolving existing bone and the other is responsible for new bone formation. In a healthy person these two processes are balanced by controlling hormones. As people become older changes in the concentration of these hormones occur with a decrease in testosterone in men and oestrogens in women.

The control of bone removal and restoration is a complex chemical process and as a result scientists have found it difficult to provide a definitive treatment for this disease.

There are two main courses of therapy; either hormonal or non-hormonal.

The hormonal route focuses on hormone replacement therapy (HRT). This is not without risks, as maintaining hormonal levels as we grow older may cause other medical problems.

As a result non-hormonal treatment is becoming more common. One mechanism for bone removal by enzymes involves the decomposition of pyrophosphate groups in bone. Replacing the pyrophosphate group by drugs containing a bisphosphonate group (Fig. 1.2) makes the phosphorus containing groups more stable to attack by enzymes.



**Fig. 1.2**

The bone mineral density is measured at intervals during treatment so that the effect of the various drugs used is monitored.

However, the way in which these bisphosphonates work is not clearly understood by scientists and there is a risk in using any compounds that are foreign to the body. The long term risk of these bisphosphonates is therefore still to be ascertained.

Another approach is to find some way in which the action of the cells that are responsible for dissolving and replacing bone can be affected. At present a particular antibiotic shows some promise but the problem is to make this antibiotic selective in its action. Scientists are not sure how this antibiotic actually works and it is therefore difficult to know where to modify its structure so that it can be more effective in the treatment of osteoporosis.

The safe and effective treatment of osteoporosis presents a difficult scientific challenge, but it is nevertheless of great interest as there is estimated to be 200 million people worldwide who are affected by this disease.

## 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 which is impregnated by about 10% of bitumen.

Bitumen can also be made by the distillation of crude oil, where 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. For use 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 can also be used as an emulsion. Liquid bitumen is made into tiny droplets and dispersed in a liquid in which it is insoluble, such as water. The emulsion was first developed in Venezuela where there are extremely large deposits of crude oil. An emulsion of bitumen and water is sold as 'Orimulsion' and has increasingly important uses in electrical power generation. Some properties of 'Orimulsion' and related properties are shown in Table 2.1.

**Table 2.1**

properties of orimulsion	value / comment
density / g cm <sup>-3</sup>	1.01
flammability for transportation	non flammable
minimum storage temperature / °C	13
comparative energy generation	greater than coal but less than fuel oil
ecological disaster hazard	relatively low risk
sulphur / %	2.8

properties for comparative purposes	value / comment
density of pure water / g cm <sup>-3</sup>	1.00
sulphur in coal %	1.0

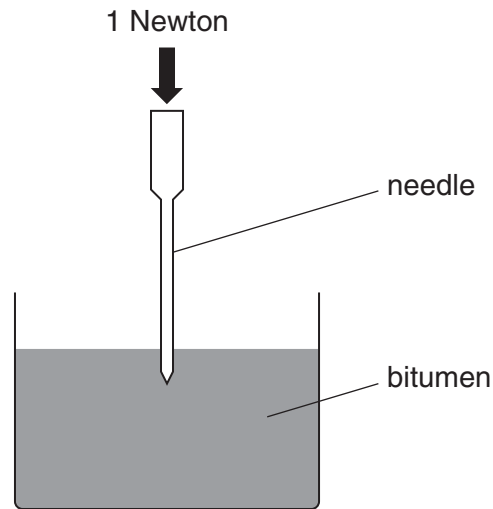
Tar is often confused with bitumen since it too is a viscous liquid. However tar is obtained from coal rather than from oil. Chemically it differs in that it contains aromatic hydrocarbons rather than the straight or branched chain hydrocarbons found in bitumen. Pitch is similar to tar but is a solid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

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

### 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.

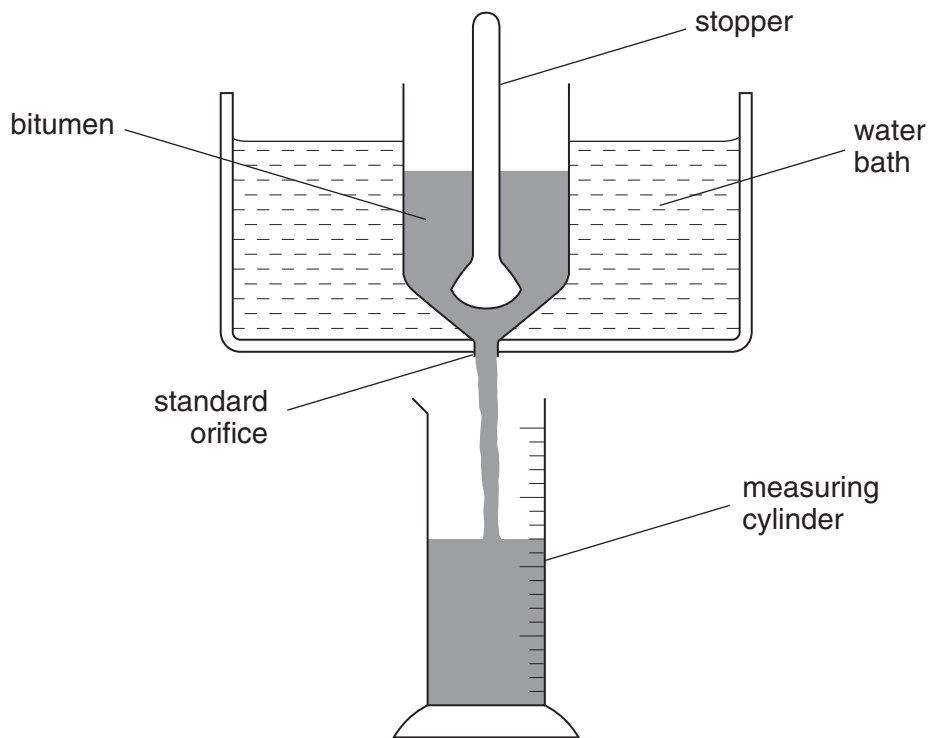
(a) Fig. 2.1 shows a simple piece of equipment for testing the softness of bituminous materials.



**Fig. 2.1**

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

(b) A standard tar viscometer is shown in Fig. 2.2.



**Fig. 2.2**

The time taken for  $50\text{cm}^3$  of the sample, at a certain temperature, to flow through into a measuring cylinder is recorded.

## 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  $775^\circ\text{C}$  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.



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