



**Monday 9 June 2014 – Afternoon**

**A2 GCE APPLIED SCIENCE**

**G628/01** Sampling, Testing and Processing

**INSERT**

**Duration:** 1 hour 30 minutes



**INFORMATION FOR CANDIDATES**

- Questions 1 and 2 are based on the articles which follow on pages 2–6 of this Insert.
- This document consists of **8** pages. Any blank pages are indicated.

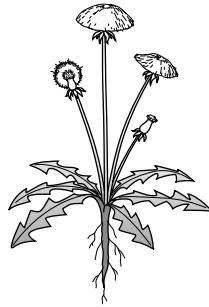
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## Rubber

Rubber trees that produce latex sap, a sticky milk-coloured liquid, may have originated in the Amazon rainforest. There is evidence that ancient peoples made primitive rubber from these trees about 3600 years ago.

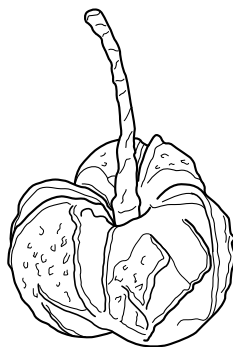
It is now known that a number of different plants (including the dandelion plant, Fig. 1a) produce latex.



**Fig. 1a**

However, the tree that is grown commercially today to produce natural rubber is the Para rubber tree (*Hevea brasiliensis*). These trees need a climate that has heavy rainfall and no frost. Most rubber tree plantations are to be found in South and South-East Asia, but some are also found in West Africa. Attempts to cultivate *H. brasiliensis* on a large scale in the Amazon region have been severely hampered by fungal attack. The leaf blight caused by this fungus has led to strict quarantine measures being imposed in South-East Asia to prevent its spread from other areas. In the past, this type of fungal disease was kept in check by the use of spraying or dusting using contact fungicides such as copper arsenate, sulfur, arsenic trioxide and mercury-containing materials. The dangers of using these toxic materials have led to the development and use of more modern organic fungicides, particularly those that act systemically. However, there are also dangers in using these new materials and the way forward seems to be the development of disease-resistant varieties of rubber trees.

The natural rubber industry is principally concerned with the production of latex but there is increasing interest in other products from the rubber tree, including the seeds. The seed-pod of the rubber tree, Fig. 1b, contains three seeds.



**Fig. 1b**

The outer cover of the pods dries out and the seed-pod then bursts, scattering the seeds up to 25m away from the tree. These seeds can be collected and used to feed animals. The oil from the seeds is rich in fatty acids or their derivatives, but glycosides are also present that can release highly toxic hydrogen cyanide under certain conditions.

Table 1a shows the relative percentage of each fatty acid that can be produced from the oil.

Fatty acid	Type of acid	Percentage
Palmitic acid	saturated	10.3
Stearic acid	saturated	8.7
Oleic acid	unsaturated	24.8
Linoleic acid	polyunsaturated	39.8
Linolenic acid	polyunsaturated	16.4

**Table 1a**

A typical rubber plantation contains 400 trees per hectare. When the trees are about five years old they can be 'tapped' to collect latex. When the tree is tapped, an incision is cut in the outer layers of the trunk and the latex flows out and is collected in a bowl. About 50g of latex is obtained each time a tree is tapped. Latex contains 62% water, 35% rubber particles and 3% other compounds. Liquid latex looks like milk but is actually a suspension of tiny rubber particles in water. The size of each particle is between 0.1 and 1 micron ( $1 \times 10^{-7}$  to  $1 \times 10^{-6}$  m). One cubic centimetre of latex contains about  $8 \times 10^{12}$  particles of rubber. These particles are negatively charged and this prevents them from coagulating. However, on standing in air, the particles will coagulate by enzyme action. This produces natural rubber. In industry, acetic acid (ethanoic acid) or formic acid (methanoic acid) can be added to encourage coagulation. If liquid latex is to be transported from place to place then ammonia solution is added, which inhibits coagulation.

Much of this raw natural rubber is then vulcanised. This is a process by which the polymer chains are restricted in their movement by cross-linking them with sulfur. The more sulfur that is added, the harder and less flexible the rubber becomes. Hard vulcanised rubber can be used to make bowls (for use on a bowling green) and for the mouthpieces of clarinets and saxophones. We are all familiar with softer rubber that is used in erasers and rubber bands.

The properties of rubber can be investigated in the laboratory. Masses can be added to elastic bands to investigate elasticity, and the density of different types of rubber can be investigated. It is also possible to investigate the coefficient of static friction for a hard rubber and compare the relatively high value obtained to that of other materials.

Although there is still an enormous demand for natural rubber, the decrease in its supply during World War 2 emphasised the need for synthetic rubber materials. In 2005, about 21 million tonnes of rubber were produced, of which 58% was synthetic rubber. Many different types of synthetic rubber have been developed.

Table 1b lists two types of synthetic rubber and compares their properties with natural rubber.

Each property is given a score of 1 to 8 with 1 being the lowest and 8 being the highest score.

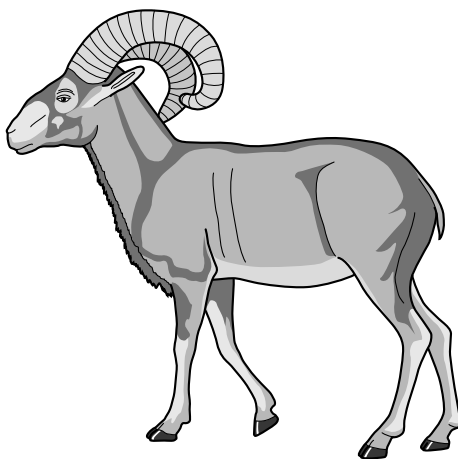
Property	Natural rubber	Synthetic rubber	
		Butyl rubber	Silicone rubber
Ease of stretching	8	2	3
Resistance to atmospheric ageing	5	8	8
Resistance to sunlight	2	7	8
Resistance to mineral oil	2	2	2
Resistance to dilute acid	8	7	8

**Table 1b**

Rubber has been an important commodity for nearly 4000 years. Natural rubber and its synthetic variants have unique properties that form an important part of everyday life. Researchers continually test different types of rubber to ensure that they are fit for purpose.

## Wool

Wool is a textile fibre obtained mainly from sheep but other animals including goats and rabbits also produce wool. Sheep were first domesticated around 10 000 years ago in the Middle East. Sheep rearing for wool was established around 8000 years ago and the first woollen clothes were made about 5000 years ago. Fig. 2a shows a probable ancestor of our domestic sheep.



**Fig. 2a**

We are all familiar with wool that is used for clothes but a fleece recently shorn from a sheep needs processing before it can be used as the textile we know as wool. After shearing, the fleece is soaked in cold water. This removes dried perspiration from the fibres. The perspiration is largely a soluble potassium compound and makes up about 5% of the total mass of the fleece. In addition, the fleece contains wool wax (lanolin) and this may make up between 5% and 25% of the mass of the fleece.

Wool is graded according to its fibre diameter, strength and crimp (curliness). Of these, the most important is the fibre diameter, which can vary from about 12 micrometres (microns) ( $1.2 \times 10^{-5}$  m) to about 45 micrometres. Sizes of 25 micrometres or less can be used for clothes whilst coarser wool is used for rugs and carpets.

Wool is composed of a protein in the keratin group. Proteins are denatured or destroyed by alkalis. When a textile mixture of wool and cotton is boiled with a 5% sodium hydroxide solution, the wool is destroyed but the cotton, being made of cellulose, is not. This can form a method for analysing the amount of cotton in wool-cotton mixtures. By contrast, if a wool-cotton mixture is treated for some hours with sulfuric acid, the cotton is destroyed and the wool remains. This is also a quantitative reaction that can be used for the analysis of textile mixtures.

Wool is hydrolysed when it is treated with hydrochloric acid, and the protein is denatured. A mixture of amino acids is produced, of which glutamic acid and leucine are present in the greatest amounts. The different amino acids produced can be identified by thin layer chromatography, using ninhydrin as the locating agent.

Both wool and nylon can be made into suitably-sized yarn for knitting. Both these materials (often called 'knitting wools') contain peptide linkages, but they may react differently when treated with bleach. The strength of the resulting products can be tested using a spring balance. Loops of these knitting 'wools' are boiled with a soap solution for 20 minutes. Then, their lengths before and after boiling can be compared to see if any shrinkage occurs during washing. These experiments may form the basis for laboratory investigations.

Wool wax (lanolin) may make up to 25% of the mass of a fleece. Lanolin is extracted by washing the fleece in hot water that contains a detergent. The lanolin is then further extracted by using a centrifuge. The lanolin is seen as a waxy solid with a melting point of about 38°C. It is a complex mixture of substances with a variable composition. Purified lanolin may contain about 97% of waxy esters. This large number of components is not normally separated and can be used as it is, or chemically modified to be used in a wide range of cosmetic and skin treatment products.

Wool is one of our oldest naturally-occurring materials and it continues to have many varied and extensive uses even in our modern technological society.



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