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Monday 8 June 2015 – 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 2–5 of this Insert.
- This document consists of **8** pages. Any blank pages are indicated.

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Chestnut trees

For many people, the only connection they have with chestnut trees is the memory of sticky buds in school classrooms and playing conkers in autumn. Sticky buds and conkers belong to horse chestnut trees (*Aesculus hippocastanum*). There are also sweet chestnut trees (*Castanea sativa*) but these belong to a completely different family. Sweet chestnut trees are the source of the chestnuts that can be used for roasting in winter.

Horse chestnut trees – Originally these trees were found in South-East Europe but they are now widely cultivated throughout countries with temperate climates. In spring the trees flower and following pollination, large shiny brown seeds, known as conkers, develop inside green, spine-covered fruits. Despite their attractiveness, conkers are poisonous when eaten by humans. They are also poisonous to horses despite the name of their parent tree – it was once thought that they cured horses of chest complaints! Conkers are poisonous because they contain toxic saponins and glucosides.

Conkers do also have their uses. During the two World Wars, when crude oil was not readily available, conkers were collected and used as a source of starch, which could then be fermented under anaerobic conditions to give a mixture of products including propanone (acetone). Propanone was used as a solvent during the production of explosives. In the past, conkers were also used on the continent for whitening textiles. The conkers were peeled, dried and ground to a powder. Water was added to the powder and this mixture was stirred vigorously to produce a milky-white fluid, which was then filtered. Washing textiles in this solution produced a blue/white colour.

Saponins from horse chestnut trees are naturally-occurring substances that can be used as foaming agents. Heys, in his 1954 book 'Chemistry experiments at home for boys and girls', describes the extraction of saponins from conkers and goes on to show how their foaming effect with carbon dioxide can be used to extinguish fires. Sixty years on, there is much more emphasis on the health and safety aspects of using such materials at home. The Italian company 'Indena' has published the results of tests on the foaming properties and the safety of saponins obtained from horse chestnuts for use in detergents. These tests involve both *in vitro* and *in vivo* experiments.

The extraction of saponins from conkers (and also chickpeas) is a labour intensive exercise and some research has been carried out to see if the extraction process can be speeded up by the use of microwave technology. The initial results are promising and may lead to a more economical and safer method of saponin extraction.

The horse chestnut leaf miner moth is a pest that has been spreading throughout continental Europe and is now spreading northwards in the UK. The larvae of this moth burrow into the horse chestnut leaves causing them to shrivel, develop brown blotches and drop off the tree early. The trees do not die from the attack but ongoing research is being conducted to find out more about the origin and further spread of this problem, and the damage caused to the trees. There is an urgent need to find a treatment that is both effective and economically viable.

Sweet chestnut trees – These trees have been established in the UK for over 1000 years. They are seen throughout the country and are very common in parkland. Sweet chestnuts are sold in the winter and are traditionally roasted before being eaten. These are quite nutritious and have a relatively high Vitamin C content but this is reduced by heating. Some of the nutrient content of raw peeled sweet chestnuts when they are ripe is shown in Table 1a.

Nutritional value/100g	
Carbohydrates	44 g
of which sugars	11 g
Vitamin C	40 mg

Table 1a

Ripe sweet chestnuts contain around 11% sugars and it has been suggested that they could be harvested commercially to provide a source of sugars.

Sweet chestnut trees are susceptible to attack by a number of pests. One of these is the oak aphid, which sucks the sap from young shoots and leaves. Commercial growers spray the trees with appropriate pesticides to fight the attack by these insects.

Both horse chestnut and sweet chestnut trees can provide a wide variety of everyday products with comparatively little outlay in terms of time and money.

Glycol and glycerine

These two odourless, colourless, syrupy liquids are widely used in industry with tens of thousands of tonnes being produced annually. They are examples of polyols, which are organic compounds containing two or more hydroxyl (OH) groups.

Glycol – This is the traditional name for ethane-1,2-diol (or ethylene glycol). The rate of its commercial manufacture increased during the First World War when it was used as a substitute for glycerine in the explosives industry. At present, glycol is produced from epoxyethane by one of two processes. Some details of these processes are summarised in Table 2a.

	Traditional process	OMEGA process
Number of stages	One	Two
Yield	Approximately 90%	Greater than 90%
Removal of other products	Complex	Straightforward
Final purification method	Vacuum distillation	Vacuum distillation
Uses of other products	Making polymers and lubricants	Recycled back into the process

Table 2a

The major use for glycol is in the manufacture of the polyester PET, which is used as a plastic material and also as a textile under the name 'Terylene'®. A smaller proportion of the annual production of glycol is used to make antifreeze for the coolant in motor vehicles. A mixture of 60% glycol and 40% water does not freeze until around -45°C . It is important during cold weather that the radiators in vehicles contain enough glycol so that freezing of the coolant does not occur. Shops sell small devices that will give a rough idea of the concentration of glycol in the coolant. Large quantities of glycol are used for de-icing aeroplanes and runways. This may lead to run-off of this liquid but fortunately, glycol will break down in the environment in about ten days.

Although glycol is a very useful material, it has a serious disadvantage in that it is toxic. Unfortunately, it has a sweet taste and problems have arisen where people have been poisoned both unintentionally and intentionally. In 2007, there were 1000 reported cases of glycol poisoning in the United States and these resulted in six deaths. Luckily, there is an effective antidote for glycol poisoning.

Glycerine – This is the traditional name for propane-1,2,3-triol (glycerol). For many years it has been made as a co-product in the soap industry. Soaps are produced by reacting animal or vegetable fats and oils with a strongly alkaline solution, such as sodium hydroxide. The process of making soap can be a continuous process, where the reactants are being continually added as the products are being removed. The smaller scale production of specialist soaps still uses batch processes. These can be run at room temperature or at higher temperatures (up to 100°C), often with retention of the glycerine rather than its removal. In the cold process, an excess of the fat or oil is used so that the alkali is not left in the soap. The glycerine is not removed and the soap is left to 'finish' and set in moulds. In the hot process the ingredients are mixed together and heated at around $80\text{--}100^{\circ}\text{C}$. After saponification (soap-making) is complete, salt is added to precipitate the soap. The remaining aqueous solution can then be processed to remove the glycerine. The manufacture of soap by a batch process is one that can be tried, using adequate precautions, in a school or college laboratory.

In recent years, glycerine has been produced as a co-product during the manufacture of biodiesel. Unfortunately this has now led to over-production of glycerine and there is research being carried out to remove the glycerine by reacting it with a suitable enzyme. About 600 000 tonnes of glycerine are produced annually in the EC. With a move to the use of more biofuels, there is likely to be a huge surplus of glycerine in the future.

Unlike glycol, glycerine is non-toxic and therefore it can be used safely in the food industry and is found in cough medicines. It has been used in antifreeze and there is renewed interest in this use as it would be safer than using glycol.

It may be possible to devise simple experiments that relate the concentration of aqueous glycerine solutions to their viscosity. One idea would be to drop a ball bearing into a tall vessel containing the glycerine solution and to time how long it takes to fall a certain distance. Another idea would be to allow the glycerine solution to drip slowly through a small hole in a vessel and to measure the volume collected in a certain time.

Both glycol and glycerine are very important materials that have many uses, despite striking differences in their toxicity.

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