OCR
RECOGNISING ACHIEVEMENT

**GCE ADVANCED UNIT** **G628**

**APPLIED SCIENCE**

Unit 9: Sampling, testing and processing

**TUESDAY 3 JUNE 2008** Afternoon

Time: 1 hour 30 minutes

Candidates answer on the question paper
**Additional materials (enclosed):** Insert

**Additional materials (required):**
Electronic calculator
Ruler (cm/mm)

Candidates may not bring the Pre-release Case Study into the examination room. An insert is provided.

*CUP/T43700*

| Candidate Forename | | Candidate Surname | |
|---|---|---|---|
| Centre Number | | Candidate Number | |

**INSTRUCTIONS TO CANDIDATES**

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

**INFORMATION FOR CANDIDATES**

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You are advised to show all steps in any calculations.
- You may use an electronic calculator.
- The total number of marks for this paper is **90**.

| FOR EXAMINER'S USE | | |
|---|---|---|
| **Qu.** | **Max.** | **Mark** |
| **1** | **31** | |
| **2** | **29** | |
| **3** | **30** | |
| **TOTAL** | **90** | |

This document consists of **17** printed pages, **3** blank pages and an insert.



**[Turn over**

Answer **all** the questions.

The questions in this section refer to the materials supplied to your Centre in the Pre-release Case Study. You are supplied with fresh copies in the insert.

This question is based on the article 'Acid rain – a soluble problem?'.

**1** Samples of water from Swedish lakes have been taken for a number of years.

**(a) (i)** What is the purpose of collecting these samples?

.....[1]

**(ii)** Why should several water samples be collected from different areas of the same lake?

.....[1]

**(iii)** The samples collected may be contaminated by biological toxins.
Suggest a precaution that should be taken when collecting these samples.

.....

.....[1]

**(iv)** Suggest **two** other hazards connected with the collection of samples from a lake.

1. .....

2. .....[2]

**(v)** Suggest a safe method that would allow a technician to collect a 1 $dm^3$ sample from the lake.

.....

.....

.....

.....[3]

**(vi)** At each location the technician collects **two** samples.
State **one** reason why two samples are collected.

.....

.....[1]

**(vii)** The technician collects several samples from each site in the lake.
What should be written on the label of each sample container?

.....

.....[2]

**(viii)** The same collecting equipment is used more than once.
What should be done to the equipment before using it each time?

.....[1]

**(ix)** The acidity of each sample is measured at the lake by using a portable pH meter.
The accuracy of the meter is ± 5%.
If the pH of a sample is 5.00, calculate the lowest possible value for the pH reading according to the accuracy of the meter.

.....[2]

**(b)** The acidity of a lake is measured every three months over several years.
The pH in summer is 5.00.
Suggest a reason why the pH in winter could be

**(i)** lower .....

.....[1]

**(ii)** higher .....

.....[1]

**(c)** If a pH meter is not available to measure the pH, an alternative method has to be used.
State **two** factors that should be considered when choosing an alternative method.

1. .....

2. .....[2]

**(d)** The acidic water in lakes due to sulphuric acid is treated so that a coloured solution is obtained.
The intensity of the colour can be measured using a colorimeter, which measures the amount of light absorbed by the colour.
The concentration of sulphuric acid can then be calculated using the equation

$$absorption = 0.120 \times \text{concentration of sulphuric acid in mg dm}^{-3}.$$

A sample of lake water gave an absorption of 1.50.
Calculate the concentration of sulphuric acid in the water sample, in mg $dm^{-3}$.

..... mg $dm^{-3}$ [1]

**(e)** Scientists in Sweden have tried to reduce the acidity of lakes by adding 'liming agents'.
A number of different liming agents have been used.

**(i)** State **three** factors, apart from cost, the scientists should consider before recommending a liming agent for use on a large scale.

1. .....

2. .....

3. .....[3]

**(ii)** State **two** factors the scientists need to keep constant when comparing the effectiveness of the liming agents in reducing the acidity of the water.

1. .....

2. .....[2]

**(iii)** The pH of a sample of lake water is 4.50.
Devise a simple experiment to find out how much calcium hydroxide (a liming agent) needs to be added to raise the pH of 1 $dm^3$ of lake water to 6.50.
The acidity is measured by a pH meter, which is suspended in the water.

.....

.....

.....

.....[3]

**(iv)** Your laboratory method described in **(iii)** is then tried on a pilot scale in a tank holding 36 $m^3$ of lake water.
You find that 180 g of calcium hydroxide is needed to raise the pH of the water from 4.50 to 6.50.

Use the experimental results to calculate how much calcium hydroxide is required to raise the pH of lake water from 4.50 to 6.50 if the lake contains $2.4 \times 10^5$ $m^3$ (240 000 $m^3$) of water. Include the unit in your answer.

..... unit ..... [2]

**(f)** One method for reducing acid rain is to remove sulphur dioxide from the flue gases at power stations, by using limestone.
Laboratory calculations show that 1000 g of limestone is needed to react with 640 g of sulphur dioxide.

At the power station, 340 000 tonnes of limestone was needed to remove 155 000 tonnes of sulphur dioxide from the flue gases.

*[1 tonne = $1 \times 10^6$ g]*

**(i)** Use the **laboratory results** to calculate how much sulphur dioxide should be removed by 340 000 tonnes of limestone.

[1]

**(ii)** Calculate the percentage efficiency of the power station process for removing sulphur dioxide, based on your answer to **(i)**.

[1]

[Total: 31]

This question is based on the article 'Nickel – the devil's copper'.

**2** **(a)** Metallic meteorites are found scattered widely in the Australian outback.
Suggest a simple technique for showing that some meteorites contain nickel.

.....[1]

**(b)** Suggest why you would advise the geologist to wear gloves when collecting meteorite samples.

.....

.....[1]

**(c)** A group of students are examining samples of rock to see if they are meteorites.
They found the following vague information on the internet.

- If the sample contains metal fragments and the nickel content of the **metal fragments** is less than 5% it is not a meteorite, but if it contains greater than 5% of nickel then it is a meteorite.
- If the **powdered** sample contains between 1 and 2% of nickel and may or may not have metal fragments, it might be a meteorite. If it contains less than 1% of nickel it is not a meteorite.

Draw a flow chart to present this information in a clearer way.

[3]

**(d)** **(i)** A student correctly identified a rock as a meteorite. Its volume was found by immersing the rock in water in a measuring cylinder. The following results were obtained.

| | | |
|---|---|---|
| Mass of meteorite | = | 27.9 g |
| Volume of water + meteorite | = | 21.5 $cm^3$ |
| Volume of water only | = | 17.0 $cm^3$ |

Calculate the density, $\rho$, of the meteorite using the formula

$$\rho = \frac{m}{V}$$ *where m is the mass of the meteorite and V is its volume.*

State the unit of your answer.

..... unit ..... [2]

**(ii)** The density of the same meteorite was determined by another student using the same equipment.
She reported that the density had a numerical value of 6.2178.
Explain why this is **not** a valid answer.

.....

.....[1]

**(iii)** Explain why the calculated value for the density of a very small meteorite sample is not very accurate.

.....

.....[1]

**(e)** Metallic nickel is purified by decomposing nickel tetracarbonyl.
State **two** reasons why this is done in apparatus that is not open to the atmosphere.

1. .....

2. .....[2]

**(f)** A plant, the shrub violet, could be used to remove nickel from contaminated soil.
The plant can absorb large quantities of nickel from the soil.
In an experiment, shrub violets were planted on land highly contaminated with nickel.
The area of the land chosen was 80 $m^2$.
At the end of the growing season 200 kg of dried shrub violet was obtained.
Analysis of the dried material showed that it contained 0.6% of nickel.

**(i)** Calculate the total mass of nickel removed by the plants.

.....[1]

**(ii)** How much nickel had been removed from each square metre of soil?

.....[1]

**(g)** A student used the following method to find the percentage of nickel in a coin which contained only copper and nickel.

- the mass of the coin was obtained
- it was placed in an acid
- the nickel slowly dissolved in the acid, leaving the copper behind
- the copper was filtered off, dried and weighed
- the green nickel containing solution was made up to 500 $cm^3$ with water
- this green solution was analysed for nickel by atomic absorption spectroscopy

The following results were obtained

| | | |
|---|---|---|
| mass of coin | = | 9.48 g |
| mass of copper obtained | = | 7.11 g |
| concentration of nickel | = | 4.74 g $dm^{-3}$ |

**(i)** State **two** things that the student could do to make the coin 'dissolve' more quickly.

1. .....

2. .....[2]

**(ii)** The student wrote down any modifications that he made to the method provided. Why did he do this?

.....[1]

**(iii)** Use the results from the atomic absorption spectroscopy to calculate the mass of nickel present in the 500 $cm^3$ of green solution.

..... g [1]

**(iv)** Calculate the percentage by mass of nickel present in the coin.

[1]

**(v)** Use the information given to state and explain why it was not really necessary to find the percentage of nickel.

.....

.....[2]

**(h)** A student visited a metallurgy department at a university to find the ultimate tensile stress of nichrome wire of original cross sectional area 0.520 $mm^2$.
The wire was supported and increasing loads were applied to the wire and the resulting extension was recorded. The applied load was increased until the wire broke.
The results are shown in the graph Fig. 2.2.

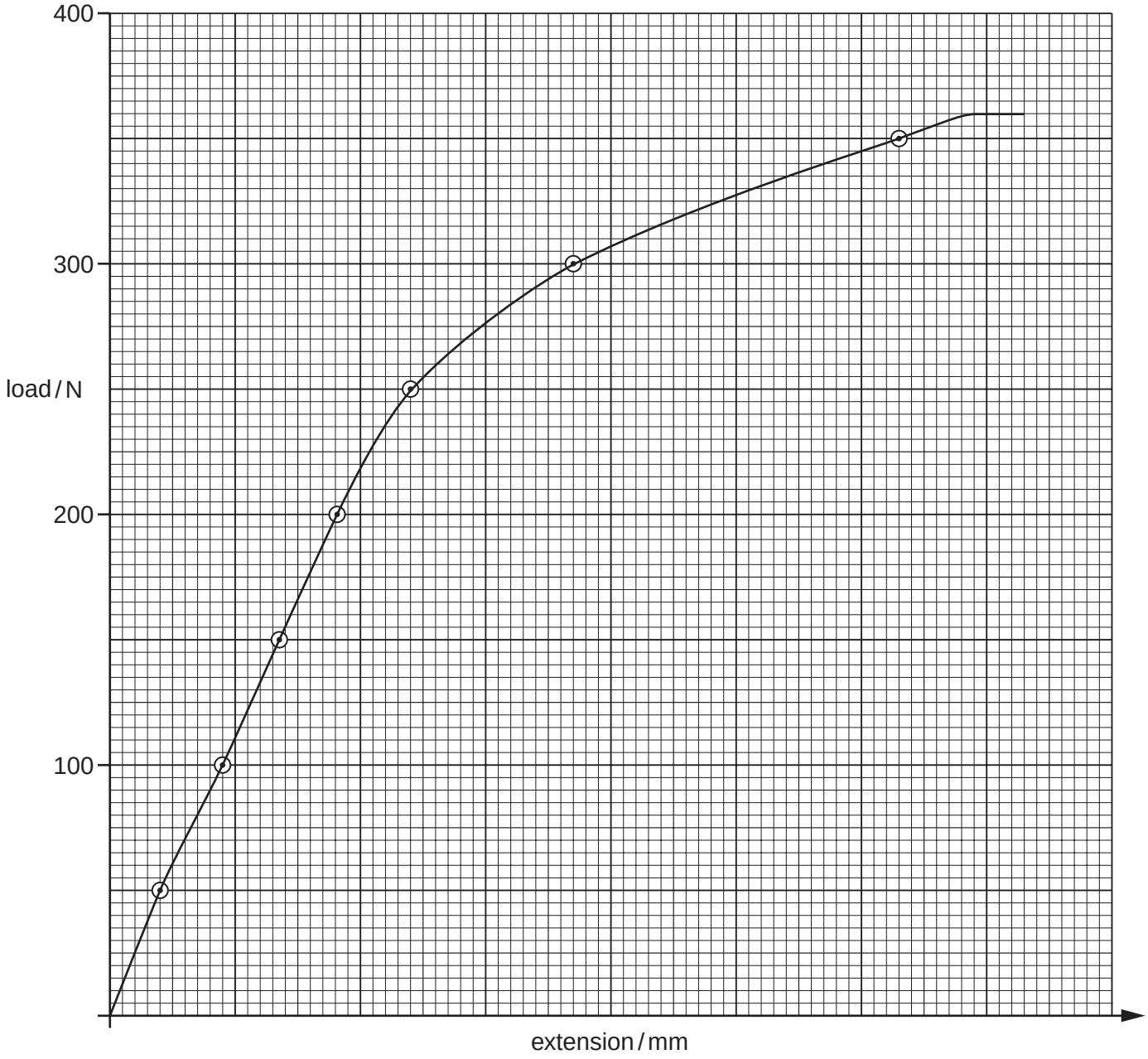


**Fig. 2.2**

Use the graph and the formula below to find the ultimate tensile stress of the nichrome wire in N $mm^{-2}$.

$$\text{ultimate tensile stress} = \frac{\text{maximum load}}{\text{original cross sectional area}}$$

..... N $mm^{-2}$ [2]

**(i)** When an electric current passes through a spring made of a smart alloy it gets hot and contracts.

You are given the following equipment

- smart spring
- 1 kg mass and hook
- electrical leads and connectors
- low voltage D.C. power supply
- stand and clamp
- usual laboratory apparatus as necessary

Design an experiment to show how the spring can be used to raise and lower the 1 kg mass, explaining how your method works.

You are advised to use a diagram in your answer.

In this question two marks are awarded for organising relevant information, and for spelling, punctuation and grammar.

.....

.....

.....

.....[5]

Quality of Written Communication [2]

[Total: 29]

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**3** Goldenseal is an American plant that has been used for over 200 years as a source of a yellow dye and as a herbal remedy.

**(a)** To obtain the dye, the root system is removed, washed and dried.
It is then cut into small pieces and warmed with water to extract the dye.

**(i)** State why the roots are cut into small pieces.

.....[1]

**(ii)** A student had not used goldenseal before. What should she do before commencing work with it?

.....[1]

**(b)** The student tested the yellow dye solution with different fabrics, by placing them in the hot dye solution.
Before testing, some fabrics were treated with aluminium sulphate (a mordant).
Mordants are chemical compounds used to make the dye remain on the fabric after washing.
The results are shown in Table 3.1.

**Table 3.1**

| fabric | aluminium sulphate mordant used | colour fades after several washes |
|---|---|---|
| wool | no | no |
| wool | yes | no |
| cotton | no | yes |
| cotton | yes | no |
| linen | yes | yes |

**(i)** Deduce from Table 3.1 the difference between the dyeing of wool and cotton with the yellow dye.

.....

.....[1]

**(ii)** Suggest what the student should do to obtain dyed linen that does not fade after several washes.

.....

.....[1]

**(iii)** Suggest **two** ways in which the cotton could be made a deeper yellow colour when using goldenseal.

1. .....

2. .....[2]

**(iv)** Some wool that had been dyed yellow was removed from the dyeing solution.

How could the student ensure that all traces of yellow dye solution had been removed from the wool?

.....

.....[2]

**(v)** Give **two** ways in which the dyeing experiment could be extended to give a wider range of conclusions.

1. .....

2. .....[2]

**(vi)** Commercially, fabrics are dyed in batches. The colour from one batch is not always identical to that in another batch.

Suggest **two** reasons for this.

1. .....

2. .....[2]

**(vii)** Despite the success of this dyeing experiment, the student felt that she could **not** recommend it for use on a larger scale.

Apart from cost, suggest **three** reasons why she could **not** recommend it for production on a larger scale in this way.

1. .....

.....

2. .....

.....

3. .....

.....[3]

**(c)** Goldenseal is also used as a herbal remedy. Berberine is one of the pharmacologically active compounds present.
A book gave the following method for extracting berberine from goldenseal.

- a risk assessment
- finely powdered root is stirred with alcohol
- the mixture is filtered
- most of the alcohol is evaporated off
- excess dilute sulphuric acid is added to the remaining alcoholic solution, giving a yellow precipitate of berberine sulphate
- after filtration, berberine is produced by adding alkali to berberine sulphate
- further treatment of the remaining alcoholic solution gives another active compound, hydrastine

**(i)** Suggest what is missing from the second step in the method.

.....

.....[2]

**(ii)** Describe a safe method to remove most of the flammable alcohol from the solution.
You may use a diagram to illustrate your answer.

.....

.....

.....[3]

**(iii)** The method does not say how much dilute sulphuric acid to add.
Describe how you can tell when no more berberine sulphate is being produced.

.....

.....[1]

**(d)** The percentage of berberine in goldenseal roots is around 4.0%.

**(i)** A student follows the method given and finds the percentage of berberine to be 1.8%. Suggest **two** reasons why the student has obtained this lower value, apart from errors in calculation.

1. .....

2. .....[2]

**(ii)** Another student claimed to have obtained a value of 7.5%.
Suggest a reason, apart from calculation error, for this apparently high result.

.....[1]

**(iii)** Another obtained the results shown in Table 3.2.

Calculate the missing values and enter them in Table 3.2. [2]

**Table 3.2**

| | | |
|---|---|---|
| mass of goldenseal roots | = | .....g |
| mass of berberine obtained | = | 0.720 g |
| % of berberine obtained | = | 4.80% |
| mass of hydrastine obtained | = | 0.420 g |
| % of hydrastine obtained | = | .....% |

**(e)** Commercially, the root extract of goldenseal is analysed for berberine and hydrastine by quantitative chromatography.
A typical chromatogram is shown in Fig. 3.1.

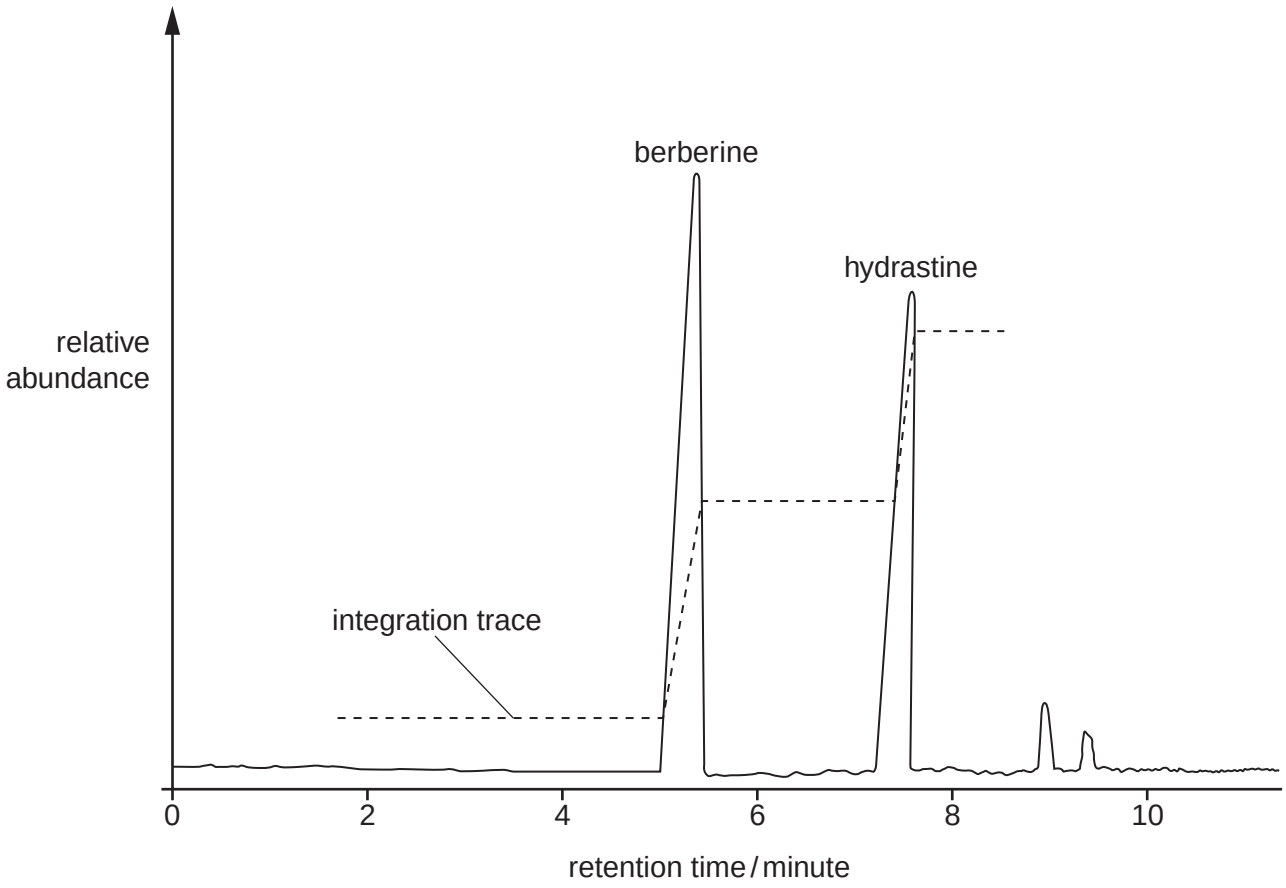


**Fig. 3.1**

**(i)** An integration trace is used to find the relative amount of the two compounds present. The height of the vertical section of the integration trace for each compound is used to find the percentages of the compounds present.

Calculate the percentage of berberine in the mixture shown in Fig. 3.1.

..... % [2]

**(ii)** Use the chromatogram to explain why the root extract containing berberine and hydrastine needs further treatment before it can be used safely as a herbal remedy.

.....

.....

.....[2]

[Total: 30]

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