Exemplar Materials: Unit 9 Sampling, Testing and Processing

[A2 level, mandatory, externally assessed]

ABOUT THIS UNIT

This A2 level unit is an optional part of the single award and a mandatory part of the double award and is externally assessed.

This unit complements Unit 1: *Science at Work*, Unit 2: *Analysis at Work* and Unit 3: *Medical Imaging*, and requires greater detail about the needs for sampling, testing and processing across several different areas of activity. It also supports investigative work in Unit 8: *Investigating the Scientist's Work*.

This unit draws together skills developed in both the AS and A2 units that have been already studied and give opportunities for synoptic assessment.

This unit is assessed externally through pre-released case study material and a 1 hour question paper with 90 marks.

The written paper has **three** questions of short-answer style with some parts giving candidates the opportunity to present their response by means of continuous prose.

Two of the questions will be based on the pre-released case study material.

This unit requires little specific-subject matter to be learned and assessed, although candidates will be expected to understand and apply basic scientific terms and the use of apparatus. Where questions are set in unfamiliar situations candidates will be able to apply knowledge gained in other units or use the detailed information given in the question.

This external assessment will necessarily explore topics from a wide vocational perspective.

Guidance is given in the specification as to the type of information needed to achieve success in this unit. The specification is divided into the three areas of sampling, testing and processing with possible practical approaches to be used with the candidates. This practical experience could be gained through other units and it may not, therefore, be appropriate to prepare candidates for this unit using a traditional 60 hour model.

Centres are advised that questions will not simply explore the practical topics outlined in the specification but will explore areas from a wider vocational perspective. This is particularly true of the two questions based on case study material. Experience with a similar unit in the previous AVCE (Science) specification has shown that candidates could apply their knowledge to new situations without problems.

Case study material will draw from a wide range of scientific disciplines including the medical testing of new drugs and candidates should be familiar with this area as well as the more traditional testing of, for example, foods and materials. In the testing of possible new drugs, placebos are used and candidates should be aware of the need for this type of testing. Candidates should also be familiar with the sampling techniques as outlined in the specification. In addition they should be familiar with the small scale processing of substances and the problems that are likely to be encountered when such processes are scaled up.

The case study material will often be concerned with current real life situations and explore, with the candidates, how they would approach the problems encountered, using their knowledge from other units and from details presented in the case study itself.

Candidates will be expected to display a reasonable ability in basic arithmetic and Centres are encouraged to make sure that their candidates are confident in the use of graphs, in calculating percentages and in the rearrangement of mathematical equations. Experience with similar units in the past has shown that many marks are lost in this area. When arriving at numerical answers candidates should be encouraged to assess whether their answer is realistic. Purities of much greater than 100% need further attention!

Experience has shown that a number of candidates produce responses at too trivial a level. This is a paper at A2 level and simple responses such as ‘so it’s a fair test’ are generally not appropriate, particularly if mentioned several times in the paper.

Using case study material means that a number of questions are necessarily very open ended and the mark scheme has to try and accommodate a wide range of acceptable responses. A line has to be drawn somewhere in this type of question and candidates should therefore consider whether what they have written constitutes an answer at Level 3.

The nature of the paper means that detailed scenarios have to be used and candidates should be encouraged to read through the material with great care. Questions based on a case study should generally reflect material given in the case study and not irrelevant material drawn from other sources.

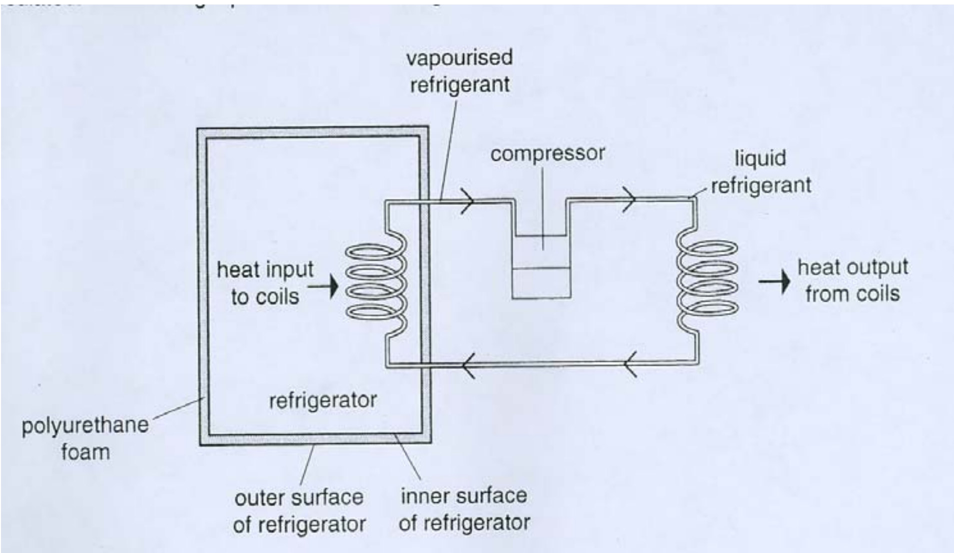
The material that follows uses case study materials in two cases and considers acceptable and unacceptable responses to the questions that follow.

CASE STUDY ONE

The use of Insulation and Refrigerants in Refrigerators

Refrigerators work on the principle of removing heat from inside an insulated box and releasing it outside. The result is that the temperature inside the box drops, keeping food at a safe low temperature. If a thermostat is used then the refrigerator will switch on when the temperature inside rises to a certain level.

A volatile liquid is present in coils inside the refrigerator and this liquid evaporates to a vapour by using the heat of the food and air inside the refrigerator. When this vapour is compressed back to a liquid, outside the refrigerator, the heat previously absorbed is given out to the surroundings and the liquid is recirculated. This cooling liquid is called the refrigerant.



The refrigerant must have a low enough boiling point so that it evaporates easily and a low enough freezing point so that it does not turn to a solid at the operating temperature of the refrigerator.

A number of substances have been used as refrigerants since domestic refrigerators became available around 75 years ago. None of these proved ideal, however, until the use of chlorofluorocarbons, CFCs, and related compounds.

Chlorofluorocarbons are also used to make the polyurethane foams, which form the insulating material in refrigerators. The low thermal conductivity of these foams means the walls of the refrigerators containing these foams can be much thinner than previously, when air was the insulating material.

By the mid 1970s the production of CFCs had reached a peak but concern was beginning to be expressed about the problems that these compounds caused by destroying ozone in the atmosphere. The thinning of the ozone layer results in an increase in the intensity of dangerous ultraviolet radiation reaching the Earth's surface, with serious consequences for plant and animal life. Subsequent legislation has resulted in the use of many CFCs being severely curtailed. This has led to problems for refrigerator manufacturers whose products have been designed both to use CFCs in the manufacture of the polyurethane foams and as refrigerants.

Manufacturers have been forced to seek alternatives to CFCs for refrigerants and for synthesising polyurethane foams. A major problem they have encountered is the lack of suitable compounds to use for this purpose. Hydrofluorocarbons, HFCs, which do not destroy ozone are now being used as refrigerants, and in Europe, butane is being considered as a possible refrigerant. Instead of using CFCs for synthesising polyurethane foams, manufacturers have started using cyclopentane despite its flammability. These foams have been used in vacuum panels which contain an open mesh of the polyurethane foam sandwiched between the inner and outer surfaces of the refrigerator wall. Initial tests with this system have proved promising.

Refrigeration is an essential part of everyday life and, if suitable long-term replacements for CFCs can be found, the advantages will far outweigh any disadvantages.

SAMPLE QUESTIONS

(a) Most modern refrigerators use a refrigerant.

State what is meant by the term 'refrigerant'.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

[1]

(b) A group of students has designed a piece of apparatus to test the effectiveness of insulating materials in the walls of refrigerators, Fig.1.1.

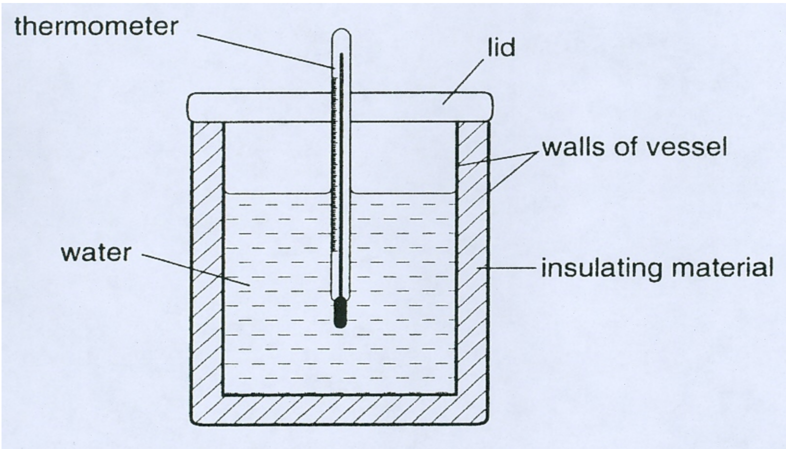


Fig. 1.1

The walls of the vessel are tightly-packed with the insulating material which is being tested.

Hot water is placed in the vessel and the temperature measured at intervals. The experiment is then repeated using different insulating materials.

(i) The students want to make this a fair test. What needs to be kept the same?

1. ……………………………………………………………………………………

2. ……………………………………………………………………………………

3. ……………………………………………………………………………………

[3]

(ii) Explain why the results will not be comparable if loosely-packed material is used.

....

.... [1]

(c) Some of the students' results for insulating materials **A**, **B** and **C** are shown as a graph Fig. 1.2.

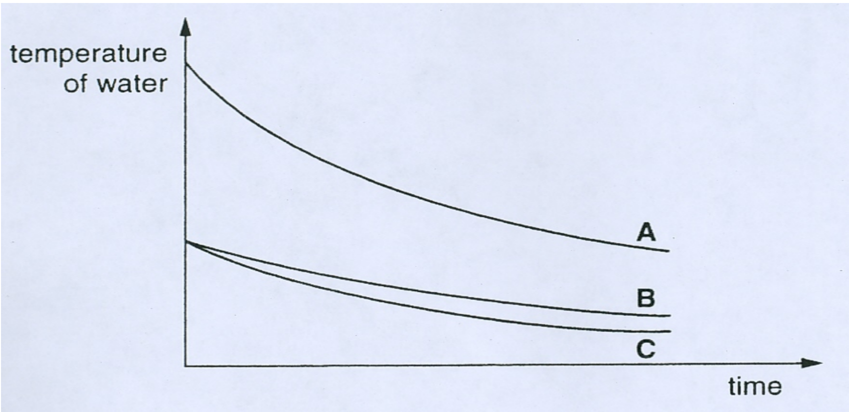


Fig. 1.2

(i) State and explain which of the insulation materials, **B** or **C**, is the more effective.

....

.... [2]

(ii) Explain why the results obtained by using material **A** should not be compared with those of **B** and **C**.

....

.... [1]

(iii) Suggest a modification to this experiment so that the insulating properties of the apparatus could be increased.

....

.... [1]

(d) The students repeated the experiment by placing water at 5 °C in the vessel. The outside temperature remained constant at 20 °C. The experiment started at time, t = 0 minutes.

After two hours the temperature reached a constant value.

On the axes below, Fig. 1.3, sketch the line which would be obtained if the experiment continued for 2 hours and 30 minutes.

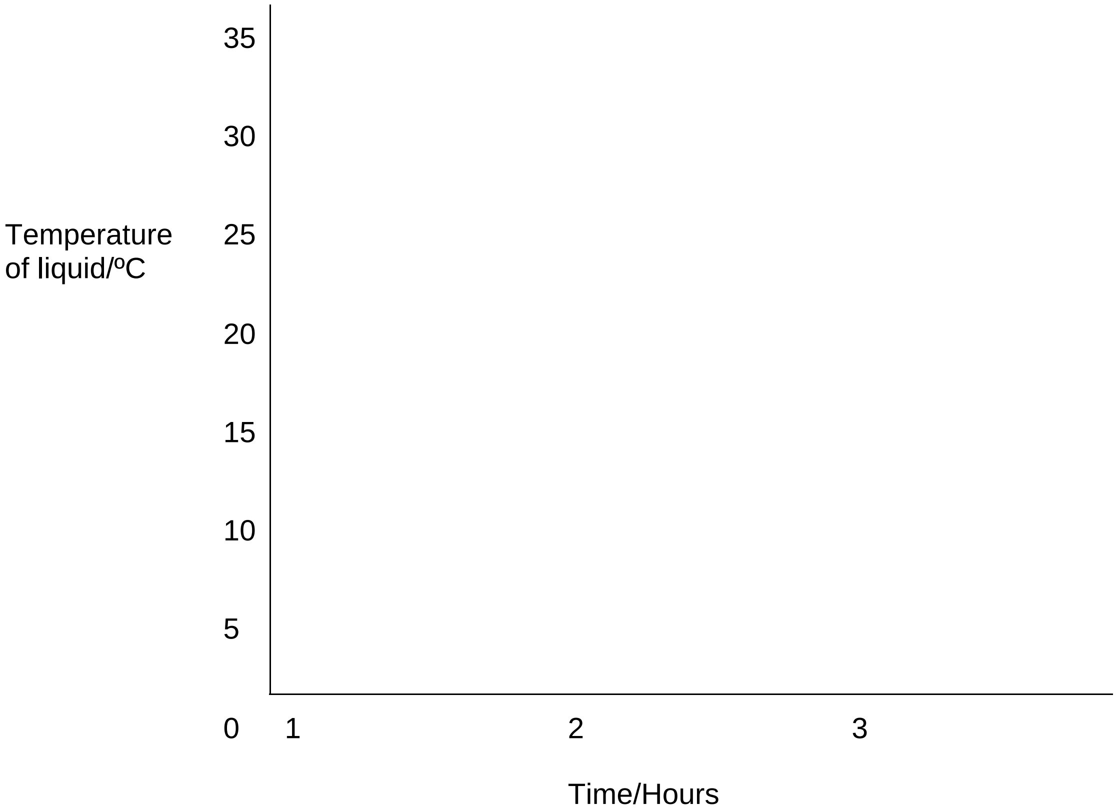


Fig 1.3

[3]

CASE STUDY ONE

The Use of Insulation and Refrigerants in Refrigerators

(Answers and comments to the sample questions)

(a) Most modern refrigerators use a refrigerant.

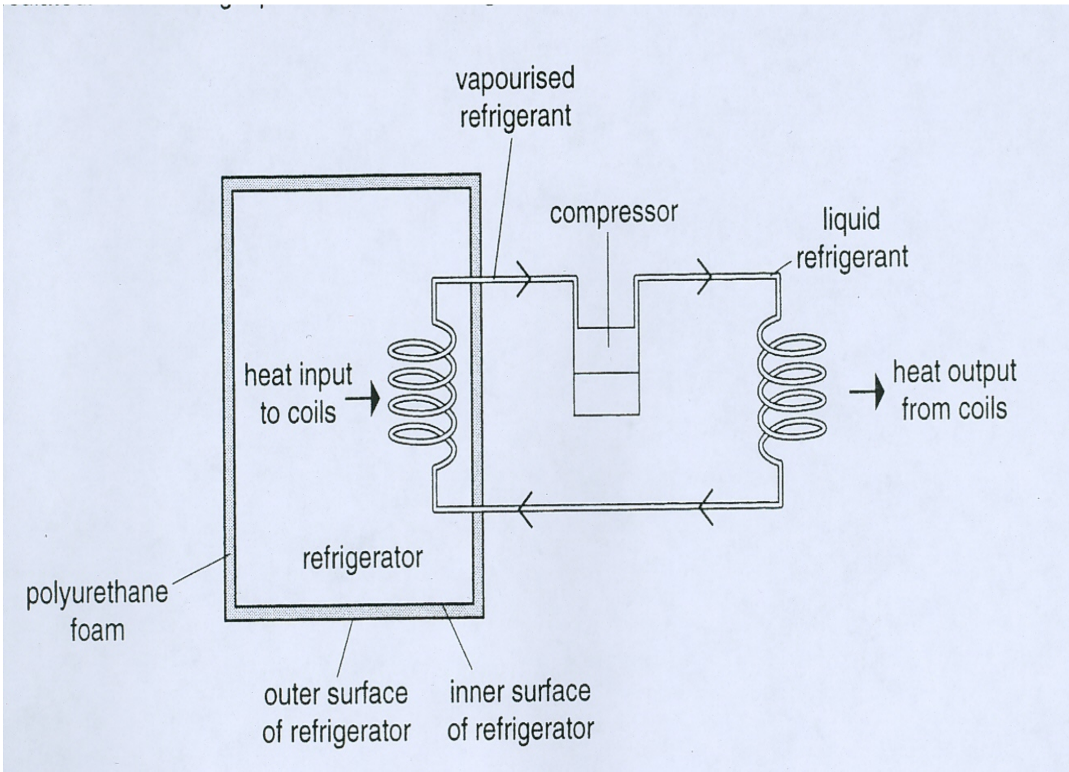
State what is meant by the term refrigerant.

'A liquid that is used to transfer the heat inside the refrigerator to the outside'

[1]

The response 'a cooling liquid' would be seen as insufficient as the answer needs to be linked to the case study.

(b) A group of students has designed a piece of apparatus to test the effectiveness of insulating materials in the walls of refrigerators, Fig 1.1.



The walls of the vessel are tightly-packed with the insulating material which is being tested.

Hot water is placed in the vessel and the temperature measured at intervals. The experiment is then repeated using different insulating materials.

(i) The students want to make this a fair test. What needs to be kept the same?

1. 'the starting temperature'
2. 'the volume of the water'
3. 'the external temperature'

[3]

These would be the expected answers. There are other acceptable responses, for example – use the same thermometer or probe. Responses such as the thickness of the walls would not be accepted.

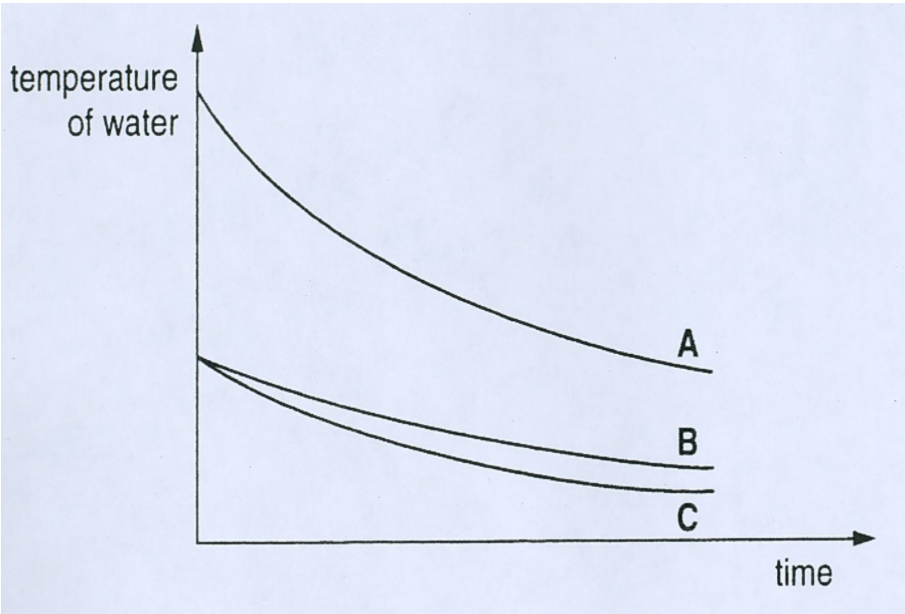
(ii) Explain why the results will not be comparable if loosely-packed material is used.

'Inadequate packing leads to heat losses / different materials could be packed to different degrees'

[1]

The response required here is of a higher level and simplistic answers such as 'you cannot compare them' are seen as inadequate in this A2 paper.

(c) Some of the students results for insulating materials **A**, **B** and **C** are shown as a graph Fig. 1.2.



(i) State and explain which of the insulation materials, **B** or **C** is the more effective.

'**B**, because the temperature drop over a period of time is less than for ***C***'

An adequate explanation must be given here for the letter mark. Any references to material **A** render the response invalid.

[2]

(ii) Explain why the results obtained by using material **A** should not be compared with those of **B** and **C**.

'**A** starts at a higher temperature'

[1]

(iii) Suggest a modification to this experiment so that the insulating properties of the apparatus could be increased.

'use more tightly packed insulating material in the walls'

[1]

This response is more open-ended and responses such as use a larger gap between the Walls would be acceptable. An answer such as 'use thicker walls' is less clear.

(d) The students repeated the experiment by placing water at 5 ^{o}C in the vessel. The outside temperature remained constant at 20 ^{o}C. The experiment started at time, t = 0 minutes.

After two hours the temperature reached a constant value.

On the axes below, Fig. 1.3, sketch the line which would be obtained if the experiment continued for 2 hours and 30 minutes.

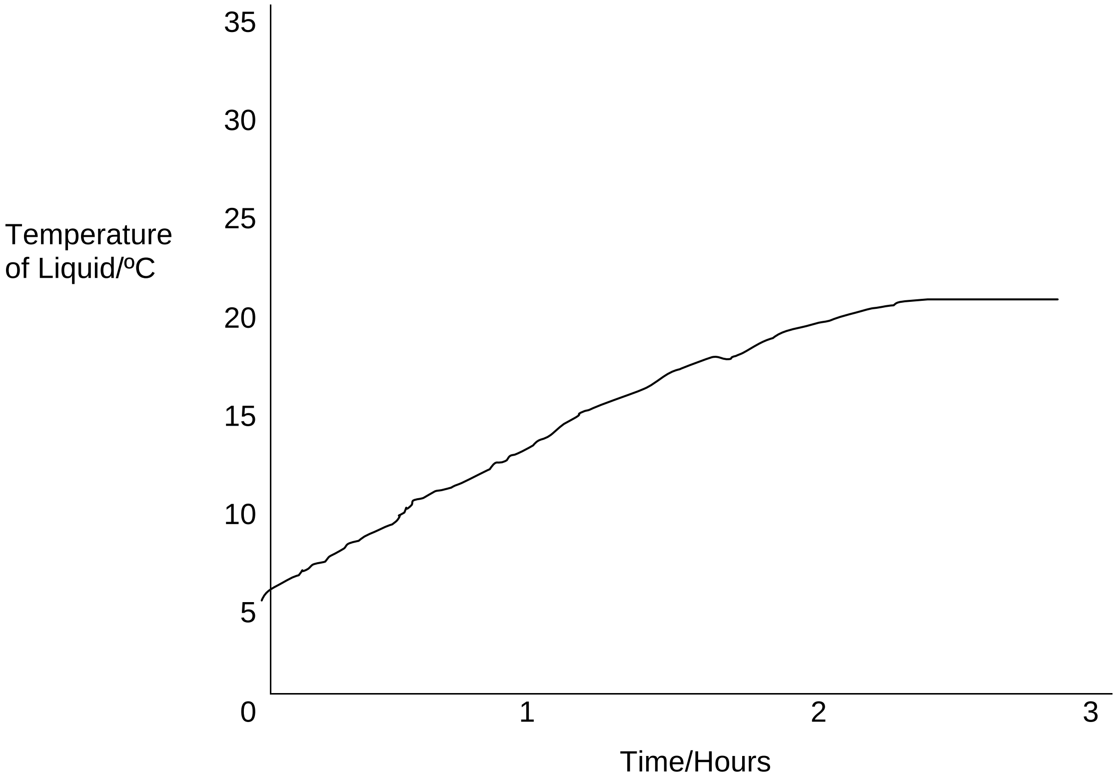


Fig 1.3

[3]

The graph needs to start at 5^{o}C and finish at 20^{o}C after 2 hours, after which there is a straight line for a further 30 minutes. The curve drawn by the student is not smooth but has the correct profile. The graph would probably gain all three marks.

CASE STUDY TWO

A Student Geologist at Work

Brian is a geology student at university. As part of the practical work for his degree he has to produce a geological map of the local region.

The region is made up mainly of sedimentary rocks (clays, shales and limestones). In some parts of the region there are igneous rocks that have produced lead/zinc mineralisation. The lead was once mined, but the mines have now closed.

The first thing that Brian did was to find out if any information about the area was readily available. Then he went and studied the region for himself – the field work part of the project. Finally, he used his results to produce a report and a geological map.

As part of his field work he examined rock exposures and he measured the dip of the rock strata. He collected samples of rocks, fossils and minerals. He put a label with each sample showing where it was found and whether it was a piece from the original rock face or a piece of fallen material. At the lead mine he took samples from the spoil heaps for analysis later.

At the end of each day he cleaned and identified all the samples which he had collected, and filled in a diary of what he had done. He used all the information he had gathered to produce his final report and map.

[This is a very short case study but is used to focus candidates on the sampling part of this module and would lead candidates to expect questions on sampling, on the testing of samples, deducing results from measurements and forming conclusions.]

CASE STUDY TWO

A Student Geologist at Work

Sample Questions

(a) Suggest one hazard when collecting rock samples and what Brian should do to reduce the risk to himself.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

[2]

(b) When Brian collected samples from the spoil heap he collected samples from a number of different places.

Explain why he did not choose samples all from the same place.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

[1]

(c) State why it is important that when analysing samples the equipment should be cleaned between samples.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

[1]

(d) Samples from the lead mine consist of galena (lead sulphide) contaminated with barytes. Brian analyses his samples and constructs a graph, Fig.2.1, which shows how the density of his sample is related to the percentage of galena present.

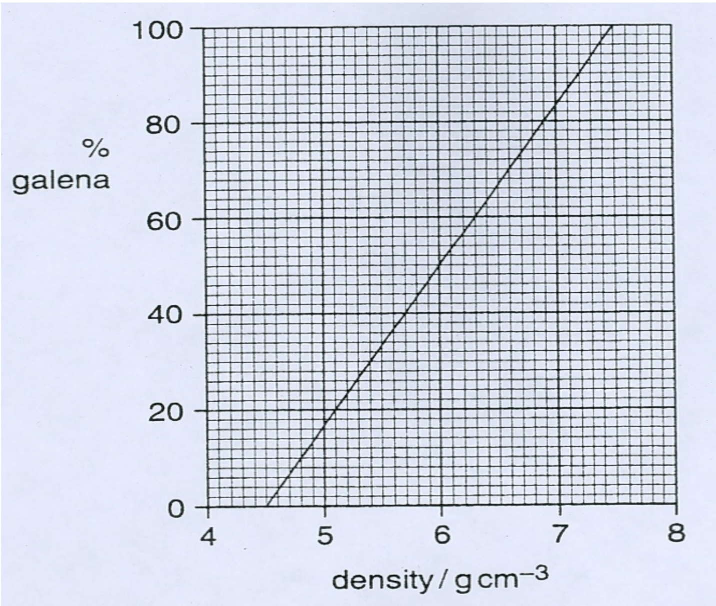


Fig. 2.1

(i) The density of a piece of rock from the spoil heap is 5.5 g cm^{-3}.

Use the graph, Fig.2.1 to find the % of both galena and barytes in this rock.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

[2]

(ii) The maximum mass of lead obtainable from pure galena is given by the formula

$$\text{mass of lead} = \frac{\text{mass of galena} \times 207}{239}$$

A 20g sample from the mine has a density of 7.0 g cm^{-3}.

Use the graph and the formula above to calculate the mass of **lead** in this 20g sample.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

[3]

CASE STUDY TWO: A STUDENT GEOLOGIST AT WORK

Answers and comments to the sample questions

(a) Suggest one hazard when collecting rock samples and what Brian should do to reduce the risk to himself.

'Beware of overhanging rocks and wear a hard hat to minimise injury from falling material.'

[2]

An easy starter question but very open-ended; there are a number of other valid acceptable answers.

(b) When Brian collected samples from the spoil heap he collected samples from a number of different places.

Explain why he did not choose samples all from the same place.

'If collected from the same place the samples may not be representative and an overall picture of the percentage of lead on the spoil heap may not have been obtained.'

[1]

The candidate has given an adequate basic reason of the need for representative sampling.

(c) State why it is important that when analysing samples the equipment should be cleaned between samples.

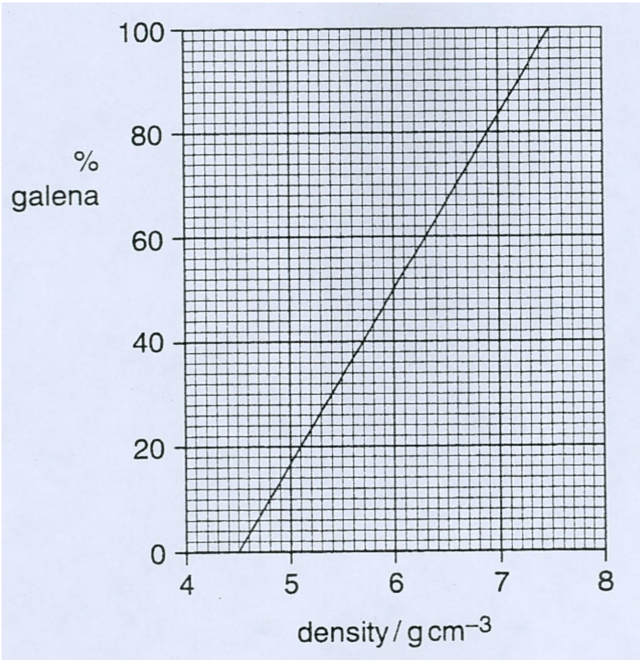
'To avoid the contamination of a sample by others or by material from other sources.'

[1]

A basic question that all candidates should get correct but an essential part of any analysing procedure.

(d) Samples from the lead mine consist of galena (lead sulphide) contaminated with barytes.

Brian analyses his samples and constructs a graph, Fig.2.1, that shows how the density of his sample is related to the percentage of galena present.



(i) The density of a piece of rock from the spoil heap is 5.5 g cm^{-3}.

Use the graph, Fig.2.1 to find the % of both galena and barytes in this rock.

'Using the graph the % of galena is 37.
The % of barytes is 100 – 37 = 63.'

[2]

Accept 36 to 38 for the % of galena. The % of barytes is marked consequentially.

(ii) The maximum mass of lead obtainable from pure galena is given by the formula.

$$\text{mass of lead} = \frac{\text{mass of galena} \times 207}{239}$$

A 20g sample from the mine has a density of 7.0 g cm^{-3}.

Use the graph and the formula above to calculate the mass of **lead** in this 20g sample.

'Using the graph, % of galena is 83, (accept 82-84). 83% of 20 g = 16.6 g

Mass of lead = 16.6 x 207/239 = 14.4 g'.

[3]

There is one mark for each stage, consequential marking applies to the last two marks.

QUESTION THREE

You work in a quality control laboratory for a company that manufactures aspirin tablets.

An important part of your work is to ensure that the tablets contain the correct quantity of pure aspirin as described on the box. One method of analyzing the tablets for aspirin is as follows.

Twenty aspirin tablets from a batch weigh a total of 7.400 g. The tablets are ground to a powder, mixed well with and a 0.370 g sample taken. The aspirin is converted to salicylic acid, and then precipitated as compound **Q** which is purified, dried and weighed. The sample of compound **Q** has a mass of 0.535 g.

Each 1.000 g of **pure** aspirin will give 3.620 g of compound **Q**.

(a) Calculate the % of aspirin in each tablet. Show **all** the steps in your calculation.

Answer:………………………….. %

[4]

(b) The analysis of aspirin requires the following steps from the powdered sample.

- Dissolve in a suitable solvent
- Boil with strong alkali solution
- Acidify the product to produce a solid
- React the solid with iodine solution
- Filter and dry compound **Q.**

Suggest three points at which inaccuracies are most likely to occur in this analysis.

1. ……………………………………………………………………………………………

2. ……………………………………………………………………………………………

3. ……………………………………………………………………………………………

[3]

There is a report in a scientific journal that compound **Q** may have important uses in the pharmaceutical industry and it has been decided to manufacture it from aspirin by the method given in **(b)** above, on a large scale.

In your response to the questions below you should consider the method of heating, separation of solid materials and drying the solid, as appropriate.

Suggest how, on a large scale, you would:

(i) Boil the aspirin solution with a strong corrosive alkali solution

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

[2]

(ii) Filter off the precipitated solid

……………………………………………………………………………………………

……………………………………………………………………………………………

[1]

(iii) Dry compound **Q**.

……………………………………………………………………………………………

……………………………………………………………………………………………

[1]

QUESTION THREE

Answers and comments

(a) Calculate the % of aspirin in each tablet. Show **all** the steps in your calculation.

'3.620 g of **Q** from 1.000 g aspirin

$\therefore$ 1 g of **Q** from 1.000/3.620 g aspirin (1)

$\therefore$ 0.535 g of **Q** from $\frac{1.000 \times 0.535}{3.620}$ aspirin = 0.148 g (1)

Each tablet has a mass of 7.40/20 = 0.370 g (1)

$\therefore$ % aspirin in each tablet = $\frac{0.148 \times 100}{0.370}$ = 40.0' (1)

answer ......40.0...... %

[4]

The working has been asked for as this question has nor been subdivided (an A2 question) and if steps are shown it is easier for candidate and marker to spot errors. The question is marked consequentially.

(b) The analysis of aspirin requires the following steps from the powdered sample.

- Dissolve in a suitable solvent
- Boil with strong alkali solution
- Acidify the product to produce a solid
- React the solid with iodine solution
- Filter and dry compound **Q.**

Suggest three points at which inaccuracies are most likely to occur in this analysis.

'not precipitating all the solid; loss of solid when filtering; incorrect drying'

[3]

Candidates should be aware of the various points in a weighing exercise where material can be lost or incorrect yields being obtained through inadequate drying.

(c) There is a report in a scientific journal that compound **Q** may have important uses in the pharmaceutical industry and it has been decided to manufacture it from aspirin by the method given in **(b)** above, on a large scale.

In your response to the questions below you should consider the method of heating, separation of solid materials and drying the solid, as appropriate.

Suggest how, on a large scale, you would:

(i) Boil the aspirin solution with a strong corrosive alkali solution.

'mention of appropriate heating method, e.g. steam piping.
consideration given to corrosive nature of alkali e.g. vented vessel, not open to the atmosphere'.

[2]

(ii) Filter off the precipitated solid.

'mention appropriate method of filtration e.g. settling tanks / use of fine mesh'

[1]

(iii) Dry compound **Q**.

'appropriate method given for drying e.g. heated rollers, hot air driers'

[1]

This is an open ended question and a variety of correct responses are acceptable. Answers using labelled diagrams are equally valid.