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A LEVEL

Examiners' report

GEOLOGY

H414
For first teaching in 2017

H414/01 Summer 2019 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 1 series overview

This is the very first examined component for the new style geology A Level. This Fundamentals of Geology paper is worth 110 marks and is in two sections which assess content across all the teaching modules 1 to 7. Candidates are expected to answer all the questions. Section A contains 25 multiple choice questions worth 25 marks. Section B includes short answer questions and 6 mark level of response extended response questions. In addition there are problem solving, calculations and practical skills.

Key point

It is suggested that candidates spend a maximum of 35 minutes on the 25 mark multiple choice section A. The remaining 85 marks in section B require 100 minutes.

The most successful candidates	*Less successful candidates*

• had a broad knowledge of the 7 modules
• had strong mathematical skills
• could write coherent prose
• understood the command words within the questions and therefore gave full responses that covered all aspects of each question
	• had gaps in their understanding of some areas of the specification, including
	  ○ anorthite / albite phase diagram
	  ○ the formation of casts and moulds during fossilisation
	• unsure of the definitions of stress and strain and therefore could not link stress regimes to geological structure

Note

From this series students have been provided with a fixed number of answer lines and an additional answer space. The additional answer space will be clearly labelled as additional, and is only to be used when required. Teachers are encouraged to keep reminding students about the importance of conciseness in their answers. Please follow this link to our SIU (https://www.ocr.org.uk/administration/support-and-tools/siu/alevel-science-538595/)

Section A overview

Key point

Candidates are advised to spend no more than 35 minutes on these multiple choice questions. Some questions take more time than others including those requiring some calculations before the correct answer can be chosen.

Question 1

1 A mineral is defined in geology as a solid, naturally occurring, inorganic, crystalline substance which has a fixed structure and a chemical composition which is either fixed or which may vary within certain defined limits.

Which of the following is **not** a mineral?

A olivine

B gabbro

C kyanite

D quartz

Your answer ☐ **[1]**

Most candidates knew that olivine, kyanite and quartz were the minerals. More generally candidates are sometimes confused when asked to name the rock, mineral or composition and will give a rock name when asked for a mineral and vice versa.

Question 3

3 Naturally occurring radioactive isotopes in rocks are unstable and break down (decay) at a statistically constant rate. An igneous rock has been dated using the ^{40}K to ^{40}Ar method and is found to contain $1/8^{th}$ of its original radioactive material. The ^{40}K to ^{40}Ar half-life is 1260 Ma.

What is the age of the original rock?

A 2520 Ma

B 3780 Ma

C 5040 Ma

D 10 080 Ma

Your answer ☐ **[1]**

Just under half of all candidates selected the correct answer, option B. Candidates are expected to be aware of how radiometric dating works and half-life curves (for example, ⅛ = 2^{-3}, so 3 half-lives, 3 x 1260 = 3780). Many candidates who worked out the correct answer used the space to the right of the answers to calculate the number of half-lives and then worked out the age.

Question 4

4 A sample of sedimentary rock is thought to be Cambrian in age.

Which of the following isotopes would **not** be suitable to use to determine the age of this rock?

A ^{14}C

B ^{40}K

C ^{87}Rb

D ^{235}U

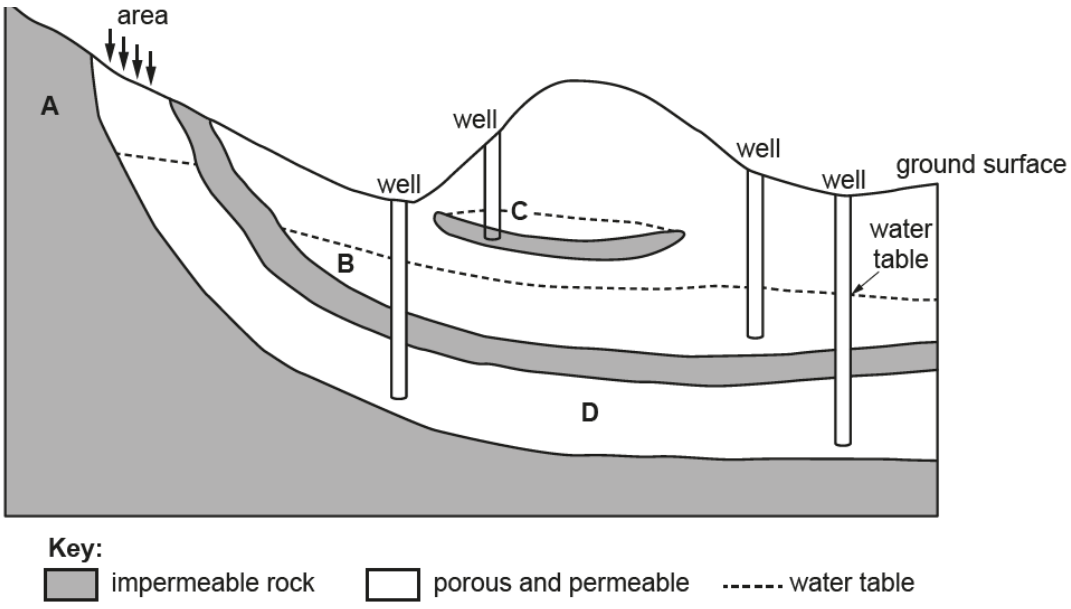
Your answer ☐ **[1]**

Although candidates are not required to know the standard parent/daughter isotope pairs used in geology, two thirds of candidates selected the correct answer A. This is an example of a synoptic question as candidates will have recognised some of these isotopes as they are a source for the geothermal flux (3.1.3c) and know that these isotopes have very long half-lives. From their prior knowledge from GCSE Science/Physics they will also know that the half-life of ^{14}C is too short to determine the age of a rock even if it does contain carbon (e.g. limestone or coal).

Question 6

6 Which letter on the diagram, **A** to **D**, represents the confined aquifer?

Your answer ☐ **[1]**



The majority of candidates selected the correct response, option D. Candidates should be able to identify all the components of confined and unconfined aquifer systems. Indeed candidates may be expected to draw labelled diagrams illustrating them.

Question 7

7 Which letter on the diagram, **A** to **D**, represents an aquiclude?

Your answer [ ] **[1]**

Every candidate attempted this question, but only a two fifths of candidates identified D as the aquiclude. There are other aquicludes between B and D, and below C, but these have no letter attached.

	**AfL**	Students will meet a lot of technical vocabulary when studying geology. It can be helpful to candidates to keep a glossary of definitions of new words. Practicing using technical vocabulary will help candidates to become more familiar with these new terms. The number of specialist words has been reduced from the legacy specification and those that have been retained give candidates a good geological working vocabulary.

Question 8

8 White smokers are cooler vents which can occur at a distance from volcanic activity. Metal sulphides precipitate below the seabed in the zone of metasomatism.

Which of the following does **not** cause the white smokers' colour?

A anhydrite

B calcite

C silica

D zinc

Your answer [ ] **[1]**

Two fifths of candidates correctly identified option D (zinc) as not causing the white smokers' colour. A detailed understanding of hydrothermal systems at Mid Ocean Ridges is new content in this specification and candidates should know the difference between black and white smokers (5.3.2d). Some candidates may have known that anhydrite, calcite and silica are all precipitated from the warm brines as they mix with sea water, others will have applied knowledge from 3.1.2 and know that zinc is a chalcophile and therefore will have precipitated as zinc sulphide (ZnS) below the seabed in the zone of metasomatism.

Question 9

9 New metamorphic minerals can grow as the temperature increases during mountain building. Higher temperatures increase the rate at which ions diffuse between minerals however the mineral growth still occurs over a long period of time.

Which of the following enables faster growth of these new metamorphic minerals?

A oxygen

B hydrogen

C water

D silica

Your answer ☐ **[1]**

Over a half of all candidates were aware of the role of water (option C) in enabling faster growth of metamorphic minerals. Many candidates have found metamorphic processes a challenging area in the past. It was encouraging to see that the new course structure which emphasises the role of water as a geological agent, rather than just learning about water supply, has helped candidates to develop their understanding of metamorphic processes.

Question 11

11 A borehole can be drilled into an ore deposit and opened up by hydraulic fracturing. Leaching solution can then be pumped down into the ore before being pumped back to the surface.

Which of the following products is **not** extracted using this method?

A copper

B evaporites

C hematite

D uranium

Your answer ☐ **[1]**

Only the highest ability candidates correctly chose option C (hematite). Candidates were expected to apply their knowledge of hematite cements (2.1.4e) and BIFs (5.1.1e) to know that hematite would not be a suitable mineral for solution mining. In situ leaching (5.5.2b) and hydraulic fracturing (7.2.2d) are techniques that are new to the specification. Although candidates are not expected to be familiar with a list of mineral products which can be extracted by these methods, (such as copper, evaporites and uranium) they are expected to understand the principles of how the methods work and what characteristics make minerals suitable to be extracted.

Question 13

13 The diagram below represents a fossil used in correlation studies.

Which of the time spans is divided into biozones based on this fossil group?

A Mesozoic

B Permian and Triassic

C Lower Palaeozoic

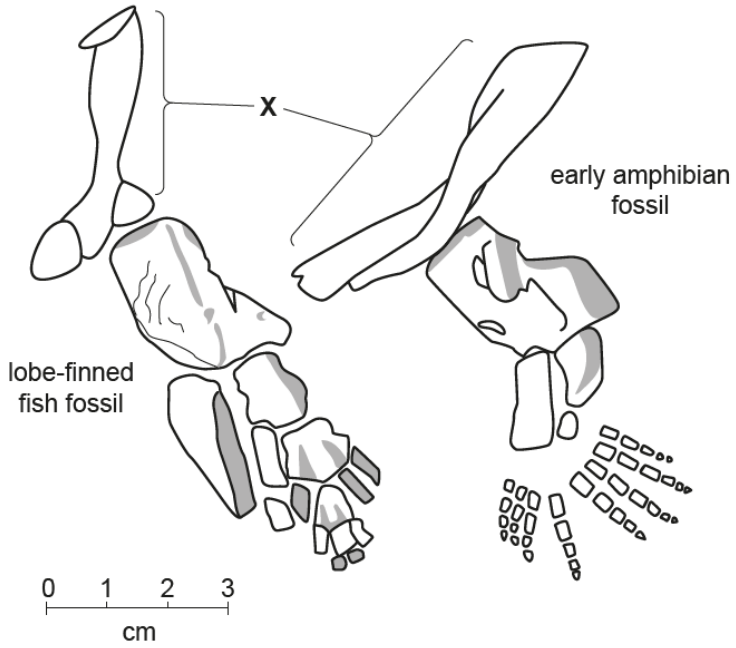
D Precambrian

Your answer ☐ **[1]**

Half of all candidates were aware that graptolites are used as zone fossils in the Lower Palaeozoic (7.2.3a). A common misconception was to choose option A, the Mesozoic, where candidates are expected to be familiar with the use of ammonites and belemnites as zone fossils (7.2.3b).

Question 14

The diagram below shows two fossils observed by a palaeontologist in the field. Questions 14, 15 and 16 refer to this diagram.



14 The terrestrial fossil record can be used as evidence to investigate long-term evolutionary change.

During which geological period did amphibians begin to evolve from marine animals?

A Cambrian

B Devonian

C Jurassic

D Ordovician

Your answer ☐ **[1]**

Over half of all candidates were aware that the transition from fish to amphibians occurred in the Devonian (7.1.2b), and chose option B.

Question 15

15 What is the feature labelled **X** on the diagram above which provides evidence for adaptation to life on land?

A humerus

B radius

C shoulder girdle

D ulna

Your answer ☐ **[1]**

This was intended as a high demand question and it was encouraging to see that over a half of all candidates knew the location of the humerus, radius, shoulder girdle and ulna. These candidates correctly identified C as the shoulder girdle in lobe finned fish and early amphibians.

Question 16

16 What is the actual length of the lobe-finned fish fossil observed in the field?

A 35 mm

B 75 mm

C 100 mm

D 135 mm

Your answer ☐ **[1]**

Two thirds of candidates selected the correct answer, option C. This is an example of a practical skills question and all candidates are expected to take measurements to the appropriate resolution (half the smallest scale division = 5 mm) and as accurately as possible. Candidates could be expected to measure the dimensions of geological features across a range of scales (e.g. minerals, bones, fossils or geological structures) using scales, scale bars or magnification. Some candidates chose option C, which was closest to the length of fossil image in the question paper.

Question 17

17 Radioactive waste can be disposed of in sealed chambers, deep underground.

Which of the following is **not** needed for the viability of an underground geological repository for radioactive waste?

A expels water when heated

B free from the potential effects of natural hazards

C sited in a tectonically stable area

D within dry, impermeable rocks with a low water table

Your answer ☐ **[1]**

Candidates often find negative questions quite challenging, but the majority of candidates had clearly understood the question asked, and chose the correct response, option A. Other candidates who chose options B, C or D should have been aware that these are very important geological factors in selecting a site for the safe disposal of radioactive waste underground.

Question 18

18 A mafic rock contains:

- 60% plagioclase, density 2620 kg m^{-3}
- 40% pyroxene, density 3260 kg m^{-3}.

The rock density is 2732 kg m^{-3}.

What is the porosity of the rock?

A 3%

B 5%

C 7%

D 10%

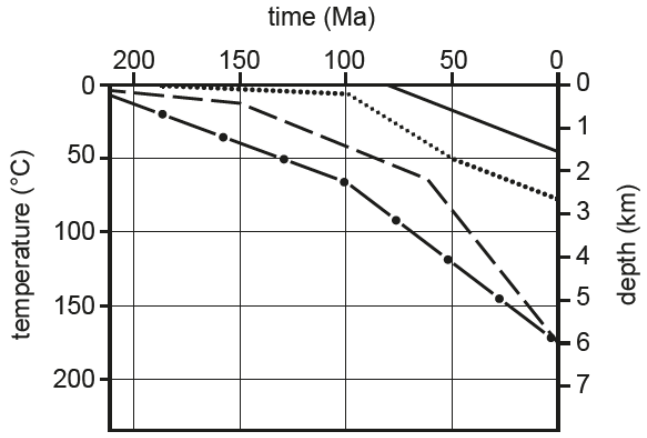
Your answer ☐ **[1]**

Half of all the candidates selected the correct response option B. To work this out they calculated what the density should be without pore spaces and then linked the missing mass to the percentage of air in the pore space.

Question 19

19 Burial history curves show the relationship between time, temperature and depth of a sedimentary deposit.

Which of the burial history curves shows a slow rate of sediment accumulation followed by a rapid rate until 50 Ma before present, and is still currently forming oil?



A ——•——

B — — —

C ••••••••••••••••

D ————

Your answer ☐ **[1]**

Almost all candidates selected option C, by correctly interpreting the information on the burial curves plot (7.2.2a). Understanding geothermal gradients and how they vary in different geological situations is important and can be linked to diagenesis, partial melting and the maturation of hydrocarbons.

Question 21

21 The diagram below represents a faulted cross-section of rock.

Which of the following describes the type of fault shown?

A horst

B strike-slip

C dip-slip normal

D dip-slip thrust

Your answer ☐ **[1]**

Three quarters of candidates correctly recognised the dip-slip thrust fault (option D) on the cross-section. The most common misconception was option B strike slip, which indicates that these candidates had not read the information in the stem of the question and assumed that the diagram was a map rather than a side view.

Question 22

22 Onshore hydrocarbon deposits continue to be extracted. Advanced drilling techniques can allow for the extraction of more oil from one well.

Which of the following is **not** an improvement made to drilling techniques?

A oil shale drilling

B multilateral drilling

C horizontal drilling

D complex drilling path

Your answer ☐ **[1]**

Over a half of all candidates knew that that multilateral, horizontal and complex drilling paths are all examples of directional drilling (7.2.2d) and so improvements to standard drilling techniques. Option A (oil shale drilling) is not a drilling technique, but rather an alternative name for 'fracking.'.

Question 24

24 Porosity is the volume of pore space in a rock. There are a number of factors which affect porosity in a rock.

Which of the following combinations of factors **decreases** porosity?

A poorly sorted and angular grains

B well sorted and angular grains

C poorly sorted and rounded grains

D well sorted and rounded grains

Your answer ☐ **[1]**

This question required very careful application of knowledge from across the specification. The correct response, selected by half the candidates, was option A, because it has two factors both of which will decrease porosity. Options B and C were common misconceptions but in both cases only one of the factors would decrease porosity while the other factor would increase the porosity of the rock.

Question 25

25 Groundwater can be extracted to be used as drinking water after suitable treatment. Depending on the environmental legislation in the country, controls may be placed on extraction to limit the amount of water that can be removed.

Which of the following is **not** a problem caused by groundwater extraction?

A connate water

B lowering of the water table

C saltwater encroachment

D subsidence

Your answer ☐ **[1]**

Three quarters of all candidates selected the correct response, option A. Connate water is water trapped in pore spaces during burial of sediments and is not itself a problem. Understanding why options B, C and D are problems associated with over extraction of groundwater comes from the application of the candidate's knowledge and understanding of module 6 (Geohazards and Engineering geology) rather than from module 5 (5.1.1). Topics such as cone of depression and saltwater encroachment in coastal areas are no longer required specification knowledge learnt in isolation. Instead candidates are expected to apply their knowledge to why the removal of groundwater would, for example, change the strength of rocks and sediments (6.2.1c) giving less support to the surface rocks or causing clays to shrink.

Section B overview

Key point

There are a wide range of question types in this section some of which do provide a significant amount of information that must be read and understood before answering the question. There are also two 6 mark level of response questions which require more extended and organised writing.

Candidates should spend approximately 100 minutes on this section.

Question 26 (a) (i)

26 The atomic structure of minerals influences many of the physical properties. In the simplest silicate structures, single tetrahedra are bonded to cations. They have a silicon to oxygen ratio of 1:4.

(a) (i) Draw and label the simplest silicate structure.

[1]

The detailed structure of silicate minerals is new to the specification and candidates should know the basic single tetrahedra with 1 silicon to 4 oxygen atoms. Most candidates knew the structure with a roughly pyramidal shape. Some candidates had not understood the question and so combining more than one tetraherdra in their drawings to show a more complicated mineral structure.

?	**Misconception**	The most common misconception was to draw 4 silicon atoms around 1 oxygen atom.

Question 26 (a) (ii)

(ii) Fig. 26 shows the chain structures, **A** and **B**, of two common groups of silicate minerals.

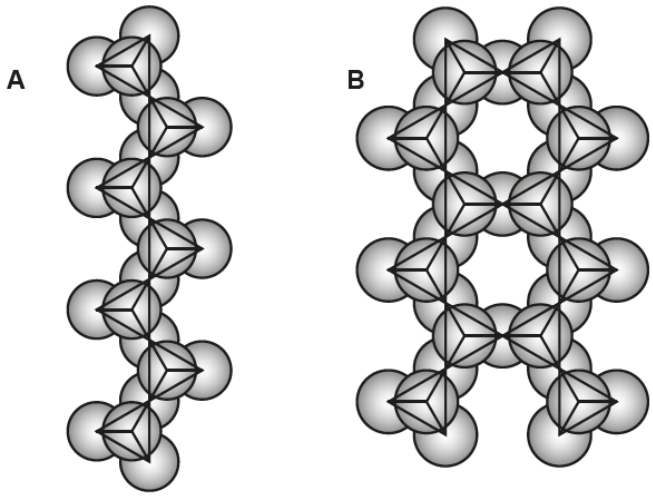


Fig. 26

Identify the groups of common silicates which have chains **A** and **B**.

A = ... **B** = ... **[1]**

Only a few higher achieving candidates answered this question successfully. Candidates should know one representative mineral for each type of silicate structure (2.1.1b).

i	**OCR support**	Teacher resource 2 – Ball and stick models contains some clear diagrams and simple activities to help candidates understand silicate mineral structures.

Question 26 (a) (iii)

(iii) Explain why the cleavage will be different in each group of minerals.

.....

..... **[1]**

Very few candidates could give and explanation of why the two minerals would have the different cleavages. Candidates are expected to understand the science behind the diagnostic physical properties of rock-forming minerals (2.1.1c), in this case the relatively weak bonds between the chains causing the cleavage. Detailed knowledge, such as that the double chains are wider molecules than the single chains and so the cleavage in the double chains is 120°/60° while the narrower single chains are 90°, is beyond the requirements of the specification. There were a small number of candidates who did have this detailed knowledge and were credited the mark for correct geology.

Question 26 (b) (i)

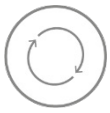
(b) Victor Goldschmidt grouped the Periodic Table elements according to where they occur in the Earth.

(i) Complete the table below.

Goldschmidt's classification	Description	Example elements
lithophile	....	Metals: aluminium, barium, calcium Non-metals: chlorine, fluorine
.....	High density transition elements which combine more easily with iron than oxygen to form dense compounds. These descend to the deeper layers of the Earth.	cobalt, gold, iron
chalcophile	....	silver, arsenic, copper
.....	Occur as liquids or gases at the temperature and pressure conditions found on or above the Earth's surface.	nitrogen, hydrogen

[4]

Most candidates knew the names of the Goldschmidt classes but not what they meant. The Goldschmidt classification is a new topic in the specification and candidates need to know about the application of Goldschmidt to the geochemistry of elements based on a qualitative understanding of the preferred formation of states of substances (oxides and sulfides). The stem of the question uses density as a proxy for ideas that are beyond the specification (such as ionic radius and ionic potential). What is important for candidates to know is how elements tended to combine / are found in association with other elements in the Earth.

	**AfL**	Candidates need to be able to spell the technical terms in the specification correctly. The term atmophile was often written as 'atmosphile' and numerous alternative spellings of siderophile were seen.

Question 26 (b) (ii)

(ii) Describe how Goldschmidt's classification may help to explain the layered structure of the Earth.

.....

.....

.....

..... **[2]**

Most higher ability candidates made the general link of atmophile with the atmosphere and hydrosphere, lithophile to the crust, chalcophile to the mantle and siderophile to the core for one mark. The best answers linked the density of siderophile associations (such as iron nickel mixtures) to differentiating under gravity to the core while less dense lithophile associations (such as silicon and oxygen, but including dense elements like uranium) differentiated upwards to the crust.

	OCR support	Learner resource 2 – Goldschmidt Classification of the Elements gives clear explanations of the Goldschmidt classification system and a number of learner activities that can help candidates to integrate this knowledge with their existing understanding from GCSE Chemistry.

Question 27 (a) (i)

27 A sequence of processes which link all three rock classes is shown in Fig. 27.1.

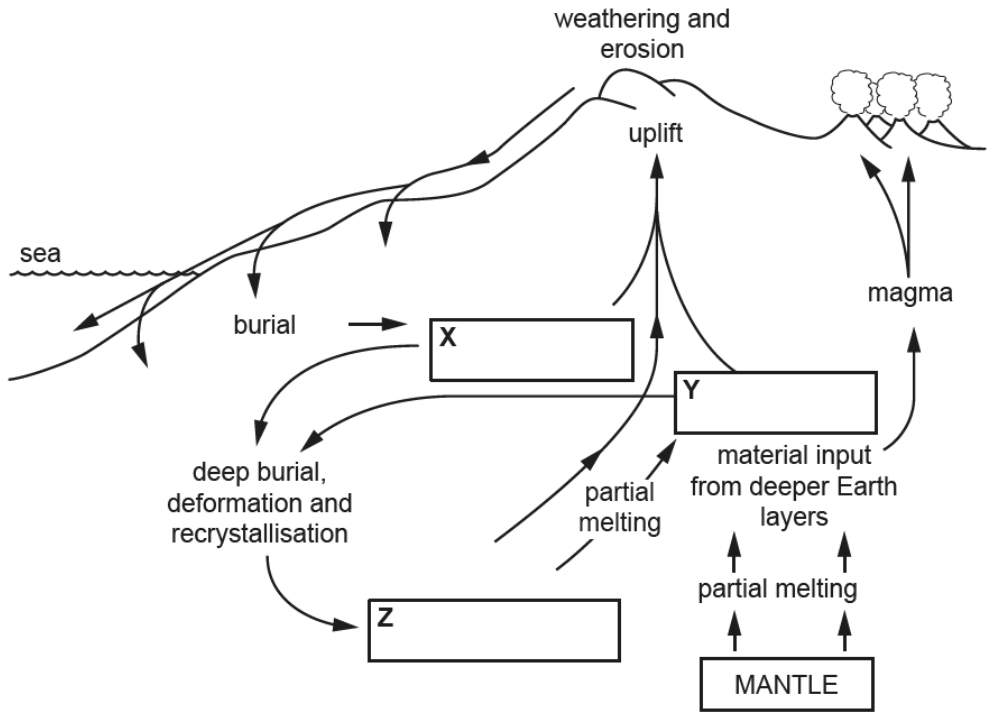


Fig. 27.1

(a) (i) On Fig. 27.1, label **X**, **Y** and **Z** with the missing products. **[1]**

Most candidates know the rock cycle diagram and so completed the rock types correctly. The question asked for products, so candidates need to be able to differentiate between processes and products and also to read the question carefully and fully. A common misconception was to put processes in place of rock types such as metamorphism instead of metamorphic rocks or intrusion instead of igneous rocks.

Question 27 (a) (ii)

(ii) Complete the table below by entering the name of each process described. Choose from the following processes:

burial, **crystallisation**, **diagenesis**, **recrystallisation**, **partial melting**.

Description of process	Name of process
Occurs when sediment is covered by younger layers of sediment	
The solid state process that changes minerals into new crystalline metamorphic minerals	
Occurs during the cooling of magma so that solid mineral crystals form	
All processes that occur in sediments at low temperature and pressure at or near the Earth's surface	

[2]

Candidates found this question straightforward with most gaining full marks.

Question 27 (b)

(b) The conditions in the rock cycle produce the three classes of rock. As the temperature and/or pressure increases in a body of rock, it undergoes a range of changes. Fig. 27.2 shows the pressure, temperature and classes of rock.

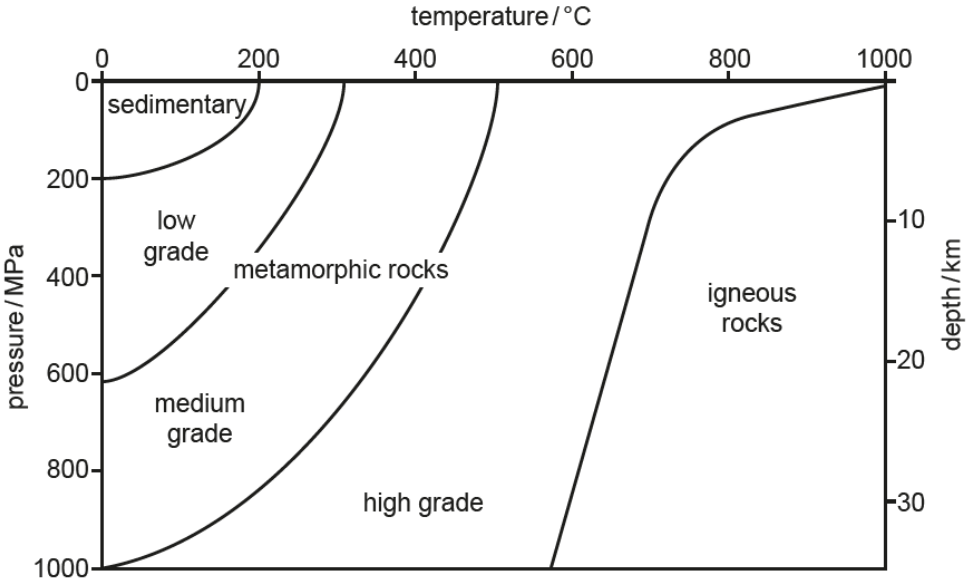


Fig. 27.2

The boundary between igneous and metamorphic rocks is where partial melting occurs.

Using Fig. 27.2, calculate the rate of change of partial melting between 10 km and 30 km.

rate of change = ... unit = ... **[2]**

Most higher ability candidates were able to calculate the rate of change (the gradient of the solidus between 10 km and 30 km). The main misconception was candidates not using the correct units which should be °C km^{-1}. The change of temperature was 700 − 600 = 100 °C, the change in depth was 30 − 10 = 20km therefore rate of change was 100 ÷ 20 = 5.0°C km^{-1}

Question 27 (c) (i)

(c) Fig. 27.3 is a diagram showing the compositional range between the plagioclase end-members albite (Ab) and anorthite (An), also known as a solid solution series.

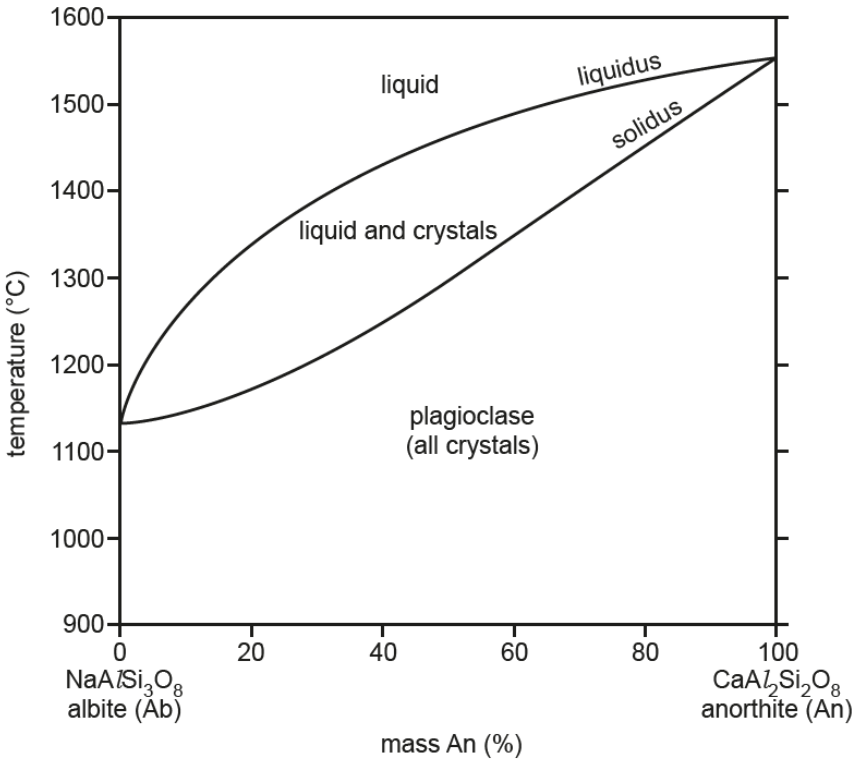


Fig. 27.3

(i) Describe and explain the continuous series and the processes that occur as a plagioclase melt cools.

.....

.....

.....

.....

.....

.....

..... **[3]**

Phase diagrams are an area that has been reintroduced to the specification and candidates are expected to understand what is happening in both the anorthite–albite and anorthite–diopside phase diagrams. Candidates should be able to describe the cooling history of a magma being able to state the initial composition of the magma, the temperature at which it will start to crystallise, the composition of the first crystals, what happens to these crystals and melt as the temperature drops, lowest temperature required for total crystallisation and the composition of the final solid.

	AfL	Candidates should practice describing the cooling of a range of starting magma compositions. The Does salt make ice melt? Teaching activity is a simple practical way for candidates to gain an understanding of the behaviour of a two phase mixture and a eutectic.

Question 27 (c) (ii)

(ii) If a melt of 40% An (60% Ab) cools, what is the composition of the first crystals to form?

..... **[1]**

	AfL	Candidates should use vertical and horizontal lines to locate an 80% anorthite composition precisely. Firstly a vertical line is dropped down from the starting magma to intercept the liquidus. Then a horizontal line is drawn across to intercept the solidus. Finally a vertical line is drawn down to intercept the x-axis. Activity 7 in the Checkpoint Task KS4 Science – KS5 Geology is very similar but considers the anorthite–diopside system

Question 27 (c) (iii)

(iii) Draw a diagram and annotate this with suitable explanations to account for the formation of **zoned** crystals which will form if the melt cools quickly.

[3]

Most candidates knew about these zoned crystals and could annotate with anorthite rich in the centre and anorthite poor at the rim. Many higher ability candidates described how the early formed high temperature anorthite rich crystals formed in the centre and the later low temperature anorthite poor crystals formed the rim. The best answers discussed the zoning occurring because the crystal could not equilibrate with the magma due to the quick cooling. The most common misconception was to have this the wrong way around with albite rich centre and anorthite rich rims.

Question 28 (a) (i)

28 Sandstones are an important group of silicate rocks. Fig. 28.1 is a diagram showing the environment of deposition of three samples.

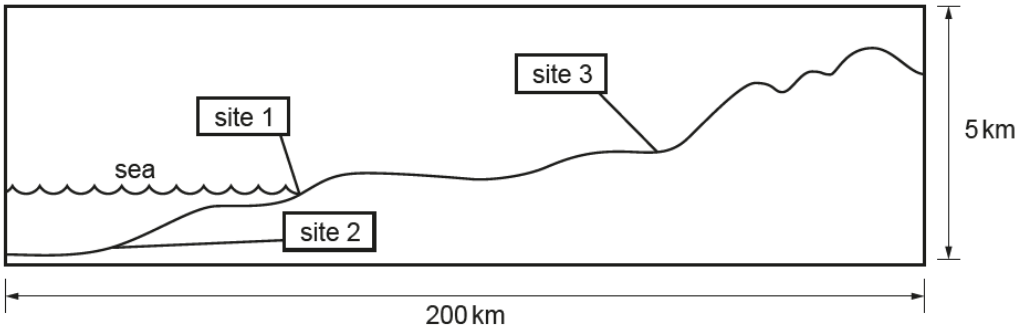


Fig. 28.1

(a) (i) Fig. 28.2 represents a thin-section of rock commonly formed in beach and shallow marine environments at sample site 1.

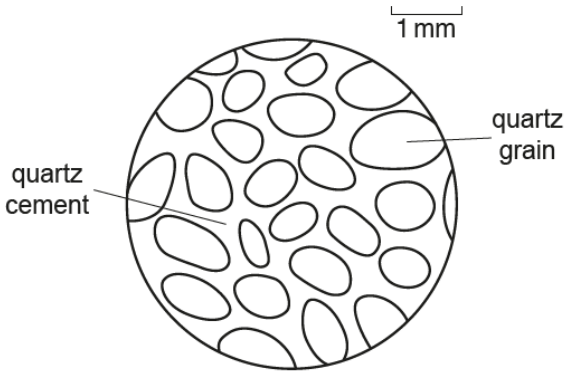


Fig. 28.2

Identify and fully describe the rock.

rock .....

description .....

.....

.....

[2]

Candidates were generally confident with all of these sedimentary rock questions. Many recognised that this was an orthoquartzite and observed that the quartz grains were well sorted and well rounded. The best answers stated that it was mature and had >90% quartz. The most common misconception, seen in nearly a fifth of responses, was to restate information from the stem of the question and identify the rock as a sandstone. Candidates are expected to have specific knowledge of the characteristics of different sandstones, for example 2.1.3d.

Question 28 (a) (ii)

(ii) A sample of sandstone from site 3 has a total volume 4.5 cm^3 and a total volume of pore space of 0.7 cm^3.

Calculate the percentage porosity of the sandstone.

percentage = ... **[1]**

The majority of candidates carried out this simple calculation. However only a third of candidates were credited with the mark because they had rounded the final result appropriately. The most common error was to round 15.555 to 15.5%. Because this was the first time that geology candidates were expected to apply rules about significant figures the mark scheme allowed up to three s.g. in candidate answers, this allowance may not be available in future series.

i	**OCR support**	The Practical Skills Handbook provides guidance on how many significant figures should be used, and also how to round numbers. If the last figure is between 5 and 9 inclusive round up; if it is between 0 and 4 inclusive round down. As a general rule the result should contain the same number of significant figures as the measurement that has the smallest number of significant figures, in this case two, so 16%.

Question 28 (a) (iii)

(iii) The rock shown in Fig. 28.3 is from sample site 2.

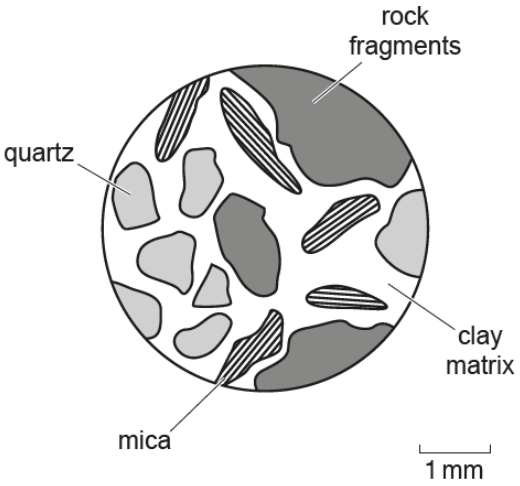


Fig. 28.3

Name and describe the rock type and the environment of deposition.

rock type .....

.....

.....

.....

environment of deposition .....

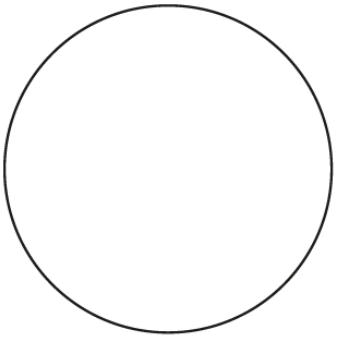
.....

[3]

Most candidates could describe the rock (typically that it was poorly sorted or it had angular clasts) and many of those correctly recognised the rock sample as a greywacke. Higher ability candidates also noted that the sample was immature or had >15% clay matrix. The most commonly suggested environment was that it had been deposited by a turbidity flow. However only the most able candidates identified the rock, wrote a complete description of the rock and suggested the correct depositional environment. The two most common misconceptions were to identify the rock as a breccia (grains are too rounded and not coarse enough) or as an arkose (although it does not contain any feldspar).

Question 28 (a) (iv)

(iv) Draw a fully labelled diagram of a sandstone commonly found in sample site 3 in Fig. 28.1, which is an arid area. Describe the characteristics of this rock type.



.....

.....

[3]

Over half of all candidates realised that the most likely sandstone was a desert sandstone and then drew well rounded, well sorted quartz grains with a hematite cement. Although the majority of candidates are confident in describing desert sandstones, many candidates need to take more care with their drawings to make sure that the clasts are < 2mm and that the drawing shows a sandstone that is clearly well sorted.

?	**Misconception**	The most common error was where candidates had drawn the grains suspended in a large area of space, repeating the error shown in Figure 14b of the Drawing Skills Handbook. The sediment grains in a rock touch, unless it is a matrix supported rock such as a greywacke, so when drawing them they do need to be close together with few gaps between.

Question 29 (a) (i)

29 The graph in Fig. 29.1 shows the stability fields of the three polymorphs of Al_2SiO_5.

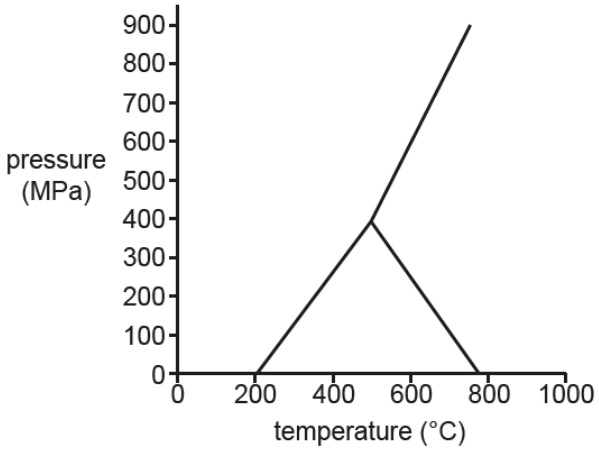


Fig. 29.1

(a) (i) On Fig. 29.1, label the triple point. **[1]**

Almost all candidates correctly labelled the triple point. Candidates who did not get the mark were often not precise in labelling the triple point, and labelled a general region close to but not the exact intersection of the three stability fields.

Question 29 (a) (ii)

(ii) On Fig. 29.1, name and label the three Al_2SiO_5 polymorph stability fields. **[1]**

Only a third of candidates correctly labelled the diagram. The aluminosilicate polymorph phase diagram is in the specification (5.4.1a) and so candidates should know where andalusite, kyanite and sillimanite are on the diagram.

Question 29 (a) (iii)

(iii) At 400 MPa and 200 °C, state which of the Al_2SiO_5 polymorphs form.

..... **[1]**

Error carried forward was applied from (a)(ii) and this allowed two thirds of candidates to gain the mark.

Question 29 (a) (iv)

(iv) Three geothermal gradients, **A**, **B** and **C**, have been drawn as dashed lines which correspond to regional, burial and contact metamorphism in Fig. 29.2 below.

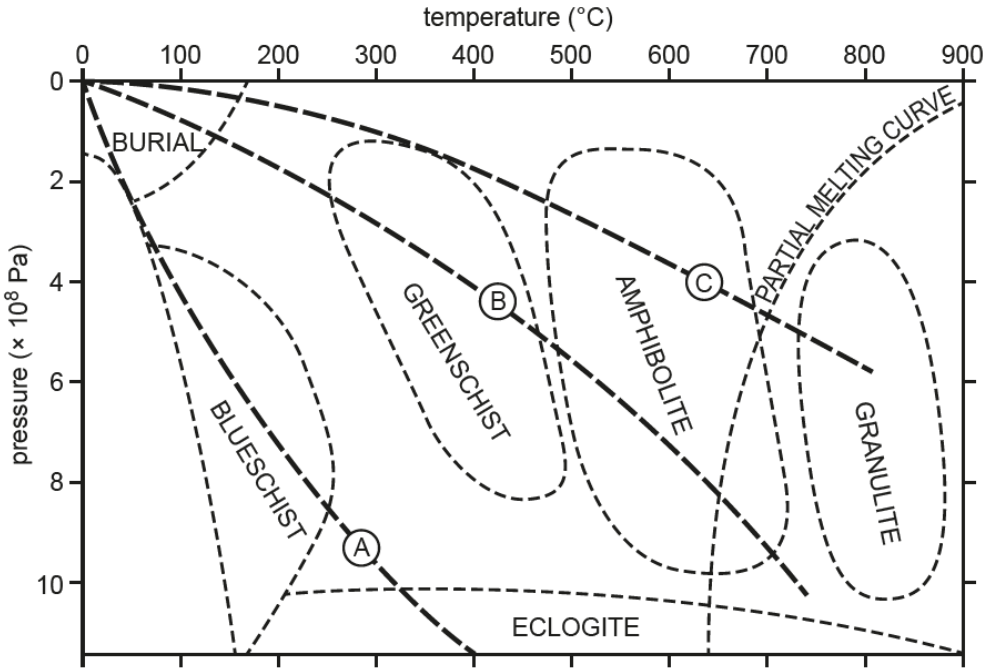


Fig. 29.2

State the most appropriate gradients for contact metamorphism and for regional metamorphism.

contact ..... regional ..... **[1]**

Most candidates applied their knowledge to work out that C was contact and B was regional.

Question 29 (a) (v)

(v) Using information from Fig. 29.1 and Fig. 29.2, describe the changes in mineralogy **and** texture as fine-grained, clay-rich mudstones experience increasing temperature and pressure with burial.

.....

..... **[4]**

Half of all candidates were credited with some marks, although very few gained all 4 marks. Good candidate responses were organised from low grade to high grade and started by discussing low grade slates or phylites, linking them to the correct mineralogy and slaty cleavage. They then discussed medium grade schists with minerals such as garnet and schistosity or porphyroblasts. At high grade they discussed gneisses with gneissose banding and appropriate minerals such as sillimanite. The highest ability candidates who gained full marks added annotated diagrams of representative rocks and textures.

Question 29 (a) (vi)

(vi) Explain the difference between prograde and retrograde metamorphism.

.....

.....

.....

.....

..... **[2]**

Although the majority of high ability students knew about prograde and retrograde metamorphism, only a third of all candidates gained any mark. The best answers linked these metamorphic processes to the loss or gain of water and other volatiles. A common misconception was failing to link the terms with processes such as increasing or decreasing grade / temperatures and pressures.

Question 30 (a) (i)

30 A fossil is any preserved remains, impression, or trace of any once-living organism from a past geological age.

(a) (i)* Describe and explain the factors which can affect the preservation potential of organisms.

..... **[6]**

This is a level of response question, with the candidate's mark based on their use of appropriate geological content and the quality of their explanation and discussion of the factors. The mark scheme indicates over 10 potential factors that could be used by candidates in their explanation. It is important to note that it is the quality of the candidate's response and not the quantity of their writing that is important. The position within the level depends on how well the candidate develops their reasoning. Three quarter of all candidates were credited with at least 4 marks and a quarter of candidates gained full marks. Most candidates were confident with factors affecting preservation potential and the best answers were well structured with subheadings and clear links made between the factor and the preservation potential.

Exemplar 1

Diagenesis – If it has undergone diagenesis the preservation will not be as Good due to the heat and pressure deforming the potential fossil.

Rapidity of Burial – the Speed of Burial will affect the condition of the fossil. the as faster the burial the more well preserved it will be due to it being more complete as it has been buried there will be a reduced chance of predators scavenges damaging it and the decaying process will be reduced as Soit will have more detailed Features.

Hard Parts – if the potential fossil has hard parts such as a Shell or bones, it as bones and Shells won't will be more likely to survive as soft bodies and shells would decay and breakdown as much due bacteria and they can be replaced by minerals. Hard Shells and bones are also harder so can withstand transportation.

Transportation – the degree of transportion will affect the condition and completness of the fossil and if it is articulated, if there is less transportation the fossil will remain intact and have less damage. it will also be more complete as there is less chance of parts breaking off.

Grain size – the grain size will also affect fossilisation, if the grain size is Small [6]
it will be more likely to preserve finer details like feelers and Skin, also Small grains
Additional answer space if required. would cause less damage to the fossil, if the grain size was large it would either decay or damage the fossils.

Ph – the ph of the Surrounding rock/water or environment will affect the organisms preservation, if the conditions are more acidic, there will be reduced bacterial decay as the acid would kill the bacteria and Stop decomposition.

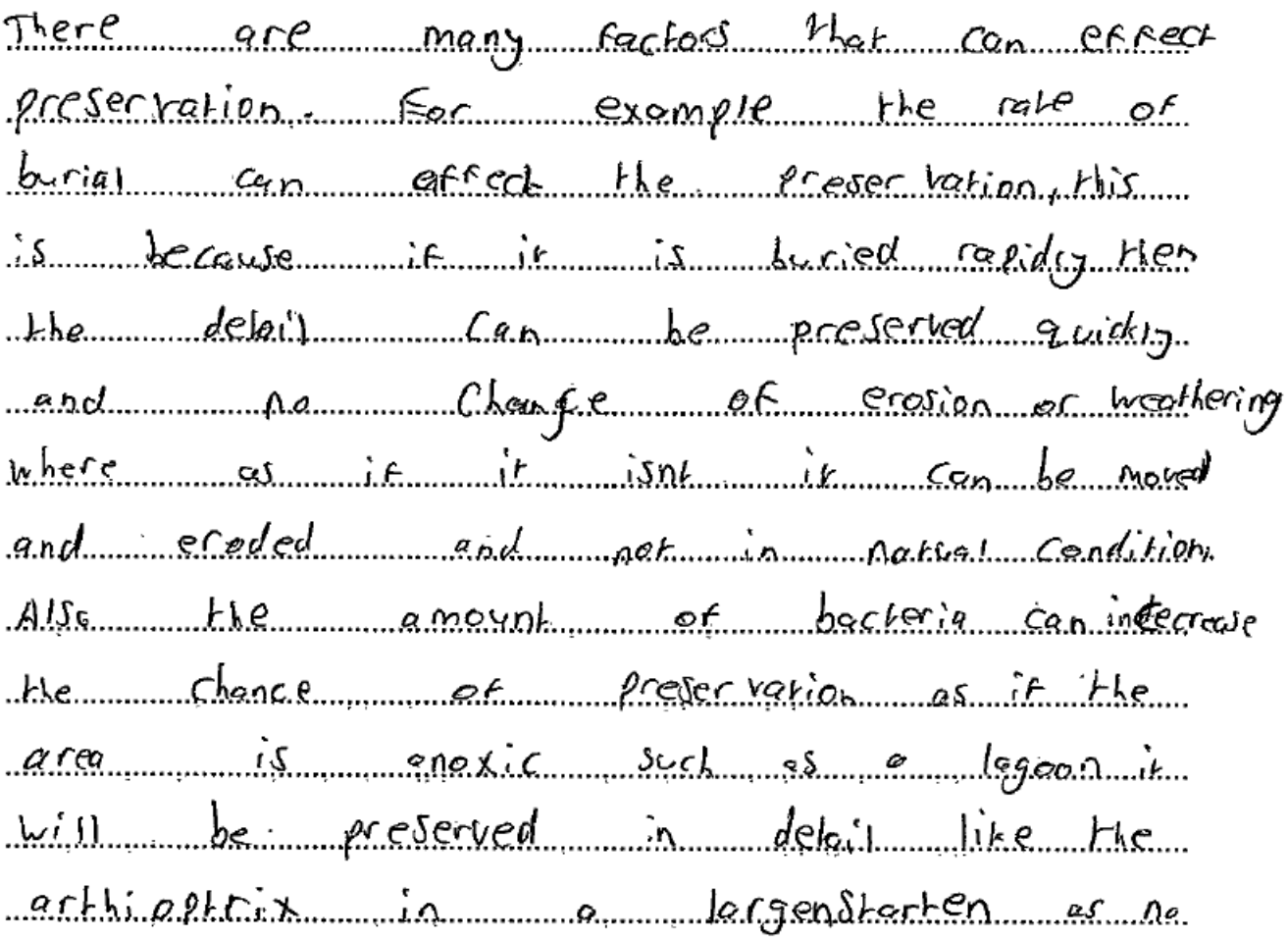
Scavengers – the degree to which Scavengers have affected the fossil will affect its articulation, quality and completness, as if there were Scavenges the Organism would not be complete and damaged.

Anaerobic conditions – if the conditions are anaerobic this would prevent Standard Bacterial decay as there is no oxygen so most bacteria cant respire. It would also allow processes like pyritisation to occur.

Sorting – the Sorting of Sediments would also affect the preservation

This candidate has discussed most of the appropriate factors and they are clearly linked to the preservation potential. The response is clearly and logically structured and so gets the top of Level 3 and was given 6 marks. The response is very comprehensive but other shorter responses of a similar quality, with fewer points could still gain full marks as long as the points are well made and detailed. It is the quality of the scientific writing that is most important rather than the number of technical points made. In this example the first point is not very detailed but many of the other points are linked to the underlying geology and are technically well written. Therefore this answer could have gained full marks with only the sections on rapidity of burial, hard parts, transportation and grain size.

Exemplar 2



bacteria could decay it.
The sediment size can also be [6]

Additional answer space if required.

a factor as if it is very fine grained it will preserve the organism in lots of detail as it can capture all the detail where as coarse grained would not. Finally the number of scavengers around will effect its preservation potential as if there are many predators and scavengers then its remains will more likely to be eaten and destroyed so little or no preservation will occur.

A good answer which is well written and linked some appropriate factors to the preservation potential. Not all the factors discussed were relevant which restricted the answer to Level 2. The overall scientific writing style was good which is why it is at the top end of Level 2.

Question 30 (a) (ii)

(ii) There are a range of methods of fossil preservation.

With the aid of labelled diagrams, explain the process of mould and cast preservation.

..... [3]

Candidates generally knew about casts and moulds but some gave confused and unclear answers. The best answers clearly labelled moulds and casts on the diagram, without these annotations the diagram mark could not be given. The best answers linked the mould to providing an impression of the organism as a void and that the cast was an infilling from precipitated minerals or sediment.

?	**Misconception**	Some candidates were unfamiliar with the taphonomic processes that form fossil (2.2.1a) These candidates described the processes used to create an artificial replica of a fossil, for example by making a mould and then taking a casts from the mould.

Question 31 (a) (i)

31 The geological column shown in Fig. 31.1, represents a biostratigraphic relative time sequence, divided into eras and periods.

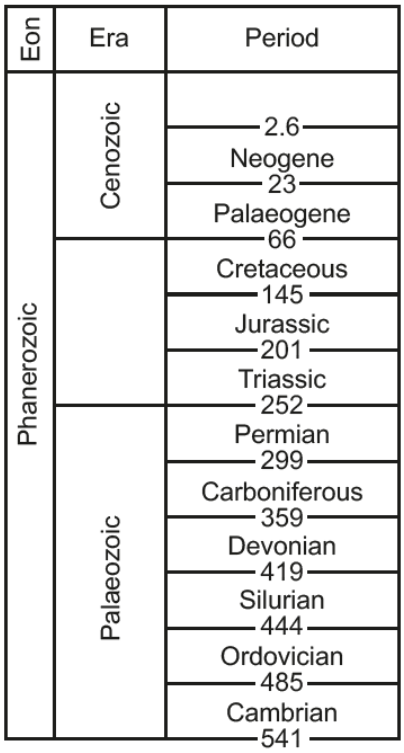


Fig. 31.1

(a) (i) Name the era and period missing from the geological column in Fig. 31.1.

era ..... period ..... **[1]**

Most candidates knew that the missing era was the Mesozoic and many also knew the missing period was the Quaternary.

	AfL	The stratigraphic column is the basic time framework that all geologists use. Having an example on the classroom wall that is used regularly in lessons is a more effect approach, than rote learning. An old favourite is the mnemonic: camels only sit down carefully, perhaps their joints creak, paracetamol neutralises queasiness

Question 31 (a) (ii)

(ii) Trilobites evolved in the Cambrian and became extinct in the Permian. Their rapid evolution allows their use as zone fossils in the Welsh Basin.

Describe and explain the main differences in morphology between benthonic epifaunal and nektonic communities of trilobites from the Welsh Basin.

.....

.....

.....

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.....

.....

.....

..... **[3]**

The majority of candidates knew one or two adaptations made by nektonic and benthonic epifaunal trilobites. The best answers made direct comparisons between the two communities and explained why the differences existed. These were mainly to do with overall size, number of pleura, nature of their compound eyes and the size of the glabella. The most common misconception was to describe burrowing trilobites which are infaunal and not epifaunal.

	**AfL**	When a question asks the candidate to 'describe and explain the difference between' it is important to make comparisons. Many candidates lacked detail in their answers and did not compare the two communities. Some candidates may find using a comparison table can help them answer this type of question.

Question 31 (b)

(b) Fig. 31.2 shows two external views of an ammonite. These fossils can be used to zone part of the Jurassic period.

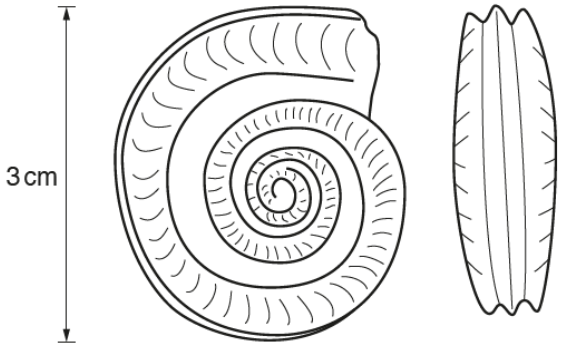

Fig. 31.2

Describe and explain why this fossil type can be used as a zone fossil.

.....

.....

.....

.....

..... **[2]**

Most candidates could state some of the characteristics of ammonites that make them excellent zone fossils such as rapid evolution, abundance, wide geographical distribution, ease of recognition and hard parts. Only a third of candidates went on to explain how these characteristics link to being a good zone fossil. For example by linking their rapid evolution to a narrow stratigraphic range providing a precise age.

Question 31 (c)

(c) Compare the use of macro fossils and micro fossils in their use as zone fossils.

.....

.....

.....

.....

..... **[2]**

Less able candidates found this question very challenging. Most candidates discussed the ease of recognition of macrofossils but very few made the more obvious point that macrofossils can be seen with the naked eye and microfossils require a microscope, so the ease of viewing varied. The best answers discussed the relative abundance of microfossils especially in drill/core samples, and that microfossils are more likely to be preserved whole.

?	**Misconception**	As with any 'compare' question the candidate must discuss both the macro and microfossils and not just focus on one.

Question 32 (a) (i)

32 From the 1700s, scientists began to consider the possible structure of the Earth.

(a) (i) Describe the nature of the asthenosphere.

.....

..... **[1]**

Most candidates knew that the asthenosphere was a rheid or was a zone of partial melting. The most common misconception was to describe the asthenosphere as semi molten which is not the case, even immediately below Mid-ocean ridges the proportion of partial melting is very low (very rarely up to 5%) and the bulk rock is solid with the melt forming tiny pockets at mineral grain boundaries.

Question 32 (a) (ii)

(ii) Describe the characteristics of the outer core.

.....

.....

.....

..... **[2]**

Most candidates knew that the outer core is liquid and mainly composed of an iron nickel. More detailed answers mentioned the convection currents in the outer core as the origin of the Earth's magnetic field and that S waves stopped but P waves slowed down/refracted at the mantle/outer core boundary.

Question 32 (a) (iii)

(iii)* Describe and explain the solar nebular disc model.

.....

..... **[6]**

This is the second of the 6 mark level of response questions and candidates found describing and explaining the solar nebula theory more difficult than preservation potential. Three quarters of higher ability candidates achieved at least a Level 2, but a third of all candidates got no marks, Level 0. The best answers brought together a number of relevant points in a logical order with a clear explanation of the various stages. Only the more detailed answers discussed the terrestrial planets, gas giants and asteroids. Most candidates had enough detail and understanding to reach Level 2 but often lacked a thorough understanding of the processes involved to reach Level 3.

Exemplar 3

The solar nebular disc model describes how the solar system formed 4.4 billion years ago. This occured when a supernova explosion of a past star created a nebular of gas (hydrogen) and dust. This then accreted due to gravity, increasing temperature and pressure. Eventually, the accreted mass began to spin due to high temperatures and pressures. This caused the mass to flatten and form a protoplanetary disc, which accreted more mass to form individual planets. This final accretion took place after the process of nuclear fission, which created the sun due to 2 hydrogen atoms reacting to produce helium. Each planet formed and accreted its own mass due to their individual gravitational fields. Thus, the solar system was formed, creating the sun, and both terrestrial rocky and gas giant planets. **[6]**

Additional answer space if required.

The moon formed when a mars sized impact (called Theia) hit molten Earth. This caused material to be dispersed and it accreted itself to form the moon, which now orbits around Earth.

This is a Level 3 answer which discusses many of the key points required to explain the solar nebular disc model. It is also written in a logical order clearly linking what the candidate has written to the question and so is achieved 6 marks at the top end of Level 3.

Exemplar 4

...the solar nebular disc model describes the formation of the solar system. It starts with the protoplanetary disc surrounding the young sun made of a dense cloud of ash and space dust as a nebular this would be moving in a rotation pattern around the sun under the Suns' gravity. Planetsimals then begin to form which are small balls of rock forming as the gravity draws more material towards the sun. the planetsimals then begin to accumulate more material and become protoplanets with a small centre of gravity. eventually the nebulas around the sun begin to clear as material... [6]

Additional answer space if required.

is taken from the surrounding space and added to the revolving protoplanets around the sun.

This candidate has written a good response that covers many of the key points but some of the mechanisms lacked sufficient detail for an A Level answer, so it is Level 2. The answer does have a logical structure and the points clearly link to the formation of the planets so this candidate's response was credited with 4 marks at the top of Level 2.

Question 33 (a) (i)

Fig. 33 is a map showing the Canary Islands and the suggested ages of volcanism.

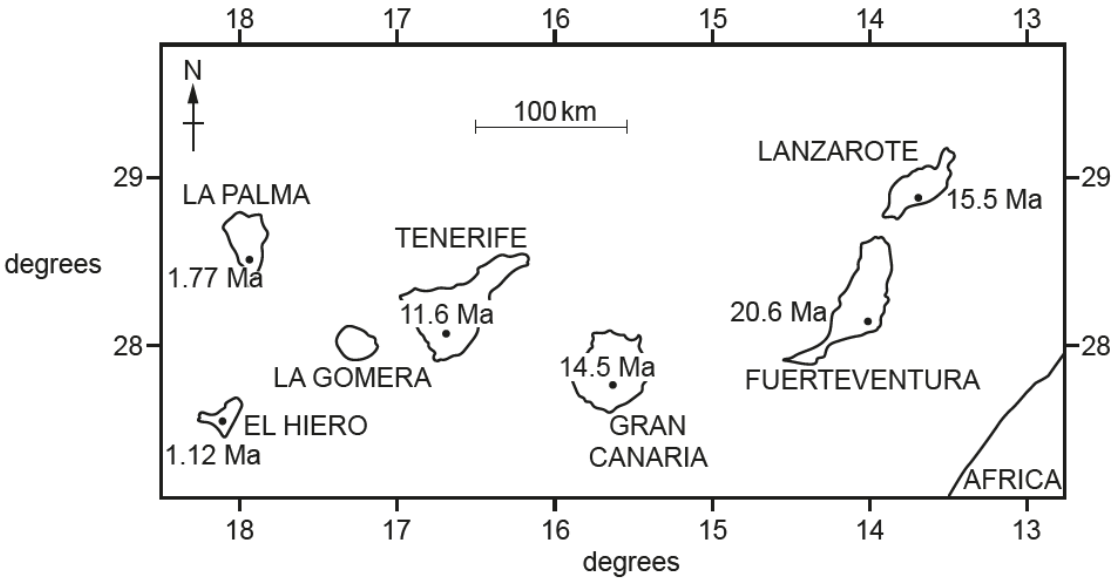

Fig. 33

(a) (i) Calculate the rate of relative plate movement between Gran Canaria and Tenerife.

rate = ... unit = ... **[2]**

This was a relatively straight forward calculation that most candidates gave their answer in the appropriate units of km Ma^{-1} or cm a^{-1} (which was also allowed). It is always advantageous for candidates to show their working because even if their answer is incorrect there may be a compensatory mark available for using a correct method.

Question 33 (a) (ii)

(ii) Describe and explain a geological theory that could account for the formation of the Canary Islands.

.....

.....

.....

..... **[2]**

Two thirds of all candidates were able to identify that a mantle plume/hotspot was responsible for the formation of the Canary Islands. A mark was available for providing a clear description of a mantle plume / hotspot but most the descriptions that most candidates wrote did not provide the specific detail needed to get the mark. Higher ability candidates stated that a hotspot is the surface expression of a mantle plume. About a third of the candidates were unable to interpret from the map that the volcanic activity created the islands or that the plate was moving over a static mantle plume/hotspot.

?	**Misconception**	A common error being that a mantle plume is rising magma in the mantle rather than rock with a high heat flow transferring heat from the core/mantle boundary to the mantle/crust boundary.

Question 33 (a) (iii)

(iii) Explain why some lavas on Tenerife show evidence of phenocryst alignment.

.....

..... **[1]**

Only a fifth of all candidates, but most of the higher ability candidates, got this mark. It was a higher demand question and that required candidates linked their understanding of igneous textures (2.1.2b) with the characteristic features of lava flows (3.2.2f). Many candidates did realise that the phenocrysts would be aligned in the direction of the flow of lava. The most common misconception was to describe how magnetism is induced in mafic minerals during crystallisation (sic) to produce permanent remnant magnetism. Note that the orientation of the minerals in an igneous rock are not linked to the direction of the permanent remnant magnetism, as the magnetism is related to the Fe outer shell unpaired electrons in the minerals.

Question 33 (a) (iv)

(iv) Explain why it is difficult to determine accurately the age of igneous rocks using radiometric data.

.....

.....

..... **[1]**

Some candidates discussed the loss of Argon from the K/Ar method but not all of these candidates linked this loss to calculating an artificially young age. Only a few candidates discussed the long time that it would take intrusive magmas to cool and in particular the different dates of crystallisation between the chilled margin and the interior of a major intrusion.

Question 34 (a) (i)

34 Stress can be defined as the force applied to a rock whereas strain is the deformation of a rock caused by applied stress.

Fig. 34.1 shows two graphs, **A** and **B**, giving the relationship between stress and strain.

Fig. 34.1

(a) (i) Which of the graphs, **A** or **B**, represents a competent rock?

rock ..... **[1]**

Most candidates were able to identify graph B as representing the behaviour of a competent rock.

Question 34 (a) (ii)

(ii) Describe the relationship between the types of forces and the geological structures they produce.

.....

.....

.....

..... **[2]**

A third of the candidates linked compressive stress to folds and reverse/thrust faults, tensional stress to normal faults and joints and tensional stress to strike slip faults. Higher ability candidates gave examples of specific folds. All candidates should be able to define stress and strain and link stress to different structures and plate margins.

?	**Misconception**	A common misconception was to link 'stress' to one to type of structure and 'strain' to another. These candidates did not mention compression, tension or shear in their answers.

Question 34 (a) (iii)

(iii) Fossils can be used to measure the amount of strain that a rock has undergone.

Fig. 34.2 shows a fossil before and after deformation.

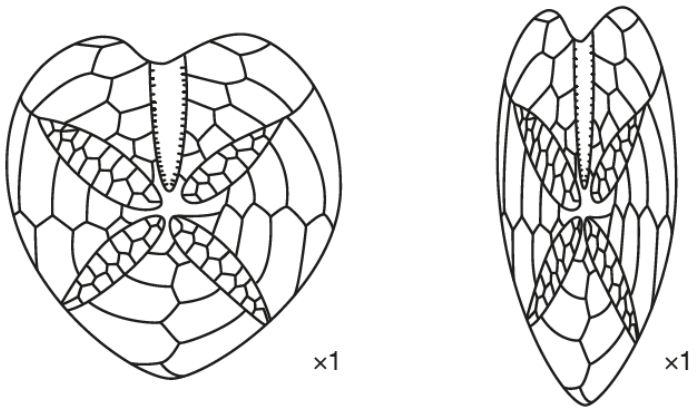

Fig. 34.2

(iii) Using the fossil evidence above, calculate the strain.

strain = ... **[2]**

A third of the candidates were able to work out the amount of strain as the change in length of the fossil as a proportion of the original length. Candidates could choose the vertical or horizontal change and could offer it as a decimal or a percentage such as 0.50 or 50% for the horizontal/width strain. Even where these candidates' final answer was incorrect they still got a compensatory mark for their method.

Question 35 (a) (i)

35 A rock salt mine is 170 m below the surface. Established in 2005, it is now an underground waste storage facility. It is a safe, secure and permanent storage site. The facility operates within 10% of the mine's total void capacity.

(a) (i) Describe and explain the geological issues which needed to be considered before using the mine as a waste storage facility.

.....

.....

.....

.....

..... **[2]**

Almost all candidates got at least one mark for this question. Most candidates understood the significance of the permeability of the surrounding rocks as a critical geological factor which some of them linked to tectonic activity and faulting. Higher ability candidates discussed how tectonic activity could create instability. Other geological issues that candidates wrote about included the stability of the overlying rocks linking it to the risk of collapse or subsidence, and the position of the water table.

Question 35 (a) (ii)

(ii) Mines can be a source of pollution.

Explain the causes of contaminated minewater.

.....

.....

.....

.....

..... **[2]**

This is new topic in the specification and two thirds of the candidates named acid mine drainage and could explain how it formed. Others discussed toxic elements including heavy metals.. Some of the highest ability candidates discussed the pollutants produced by the mining operations themselves including from the machines and leaching fluids.

Question 35 (a) (iii)

(iii) Describe the management of contaminated minewater.

.....

.....

.....

.....

..... **[2]**

The majority of candidates knew about using lime/alkalis to neutralise the acid and the best answers discussed active methods and passive methods. The use of natural wetlands was discussed by some. Many also mentioned pumping out the water and placing it into tailings ponds.

Question 35 (a) (iv)

(iv) At peak production, the salt mine produced 312.5 tonnes of salt every 30 minutes.

How much salt could it produce in three years?

salt produced = ... tonnes **[2]**

This question assessed the candidates' ability to convert units and apply an appropriate method to calculate the answer. Given the possibility that a leap year could be one of the three year 1.642×10^7 and 1.642×10^7 were both acceptable answers. Because this was the first time that geology candidates were expected to apply rules about significant figures the mark scheme allowed up to seven s.g. in candidate answers, this allowance may not be available in future series. About three quarters of all candidates successfully worked through this fairly straightforward calculation. Although this question did use some rather arbitrary values, future candidates could expect to have to make calculations to predict the production of mineral extraction operation, which could include having to make compensation for geological factors, for example percentage recovery.

i	**OCR support**	The Practical Skills Handbook provides guidance on how many significant figures should be used, and also how to round numbers. If the last figure is between 5 and 9 inclusive round up; if it is between 0 and 4 inclusive round down. As a general rule the result should contain the same number of significant figures as the measurement that has the smallest number of significant figures.

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