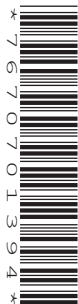


## Tuesday 4 June 2019 – Afternoon

### A Level Geology

#### H414/01 Fundamentals of Geology

Time allowed: 2 hours 15 minutes



**You must have:**

- a ruler (cm/mm)
- a pencil

**You may use:**

- a scientific or graphical calculator



Please write clearly in black ink. **Do not write in the barcodes.**

Centre number

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Candidate number

--	--	--	--

First name(s)

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Last name

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### INSTRUCTIONS

- Use black ink.
- Answer **all** the questions.
- Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

### INFORMATION

- The total mark for this paper is **110**.
- The marks for each question are shown in brackets [ ].
- Quality of written communication will be assessed in this paper.
- This document consists of **40** pages.

2  
SECTION A

You should spend a maximum of 35 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

- 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]

- 2 The mineral calcite can be scratched by a 2p coin but not by a finger nail.

Which of the following is the hardness of calcite on the Mohs scale?

- A 2
- B 3
- C 4
- D 5

Your answer

[1]

- 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  $^{40}\text{K}$  to  $^{40}\text{Ar}$  method and is found to contain  $1/8^{\text{th}}$  of its original radioactive material. The  $^{40}\text{K}$  to  $^{40}\text{Ar}$  half-life is 1260 Ma.

What is the age of the original rock?

- A 2520 Ma
- B 3780 Ma
- C 5040 Ma
- D 10080 Ma

Your answer

[1]

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

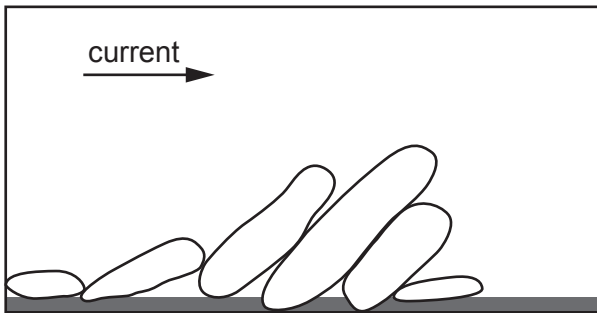
Which of the following isotopes would **not** be suitable to use to determine the age of this rock?

- A  $^{14}\text{C}$
- B  $^{40}\text{K}$
- C  $^{87}\text{Rb}$
- D  $^{235}\text{U}$

Your answer

[1]

5 Way-up indicators and palaeocurrent indicators are useful to geologists.



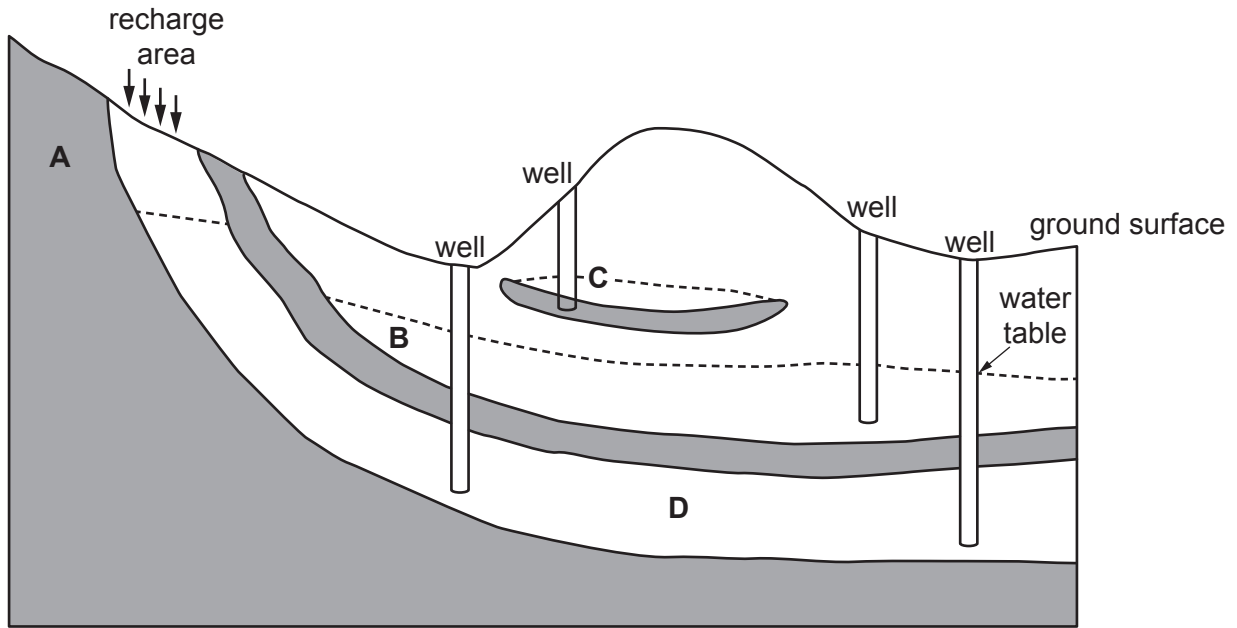
Which of the following is shown in the diagram above?

- A cross-bedding
- B desiccation cracks
- C graded bedding
- D imbricate structure

Your answer

[1]

The diagram below is a cross-section showing the main components of aquifers. Questions 6 and 7 refer to this diagram.



**Key:**

- impermeable rock
- porous and permeable
- water table

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

Your answer

[1]

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

Your answer

[1]

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]

- 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.

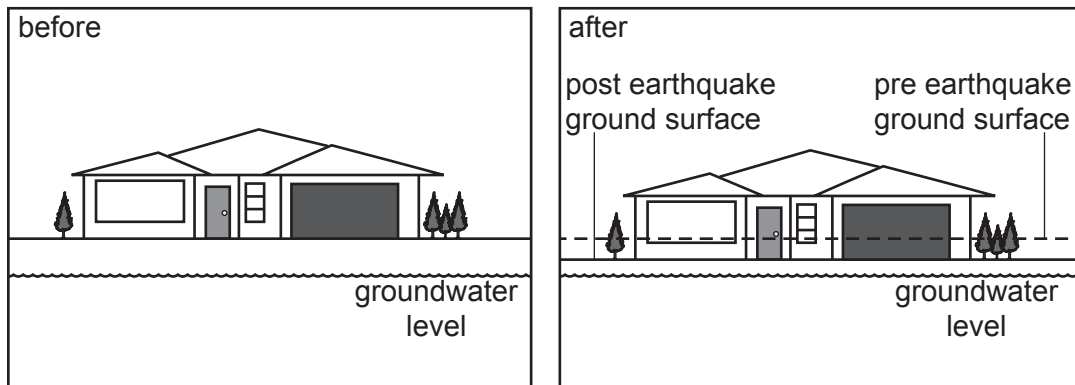
Which of the following enables faster growth of these new metamorphic minerals?

- A oxygen
- B hydrogen
- C water
- D silica

Your answer

[1]

- 10 The diagram below represents what can occur when a building is subjected to liquefaction. Liquefaction results from seismic vibrations in bedrock passing into overlying deposits.



Which of the following materials in the building's foundations is most likely to lead to this geological issue?

- A granite
- B shale
- C limestone
- D sands

Your answer

[1]

- 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]

- 12 What is the main source rock for oil and gas in the Northern Basin of the North Sea?

- A fractured chalk
- B marine sandstone
- C Kimmeridge clay
- D oolitic limestone

Your answer

[1]

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



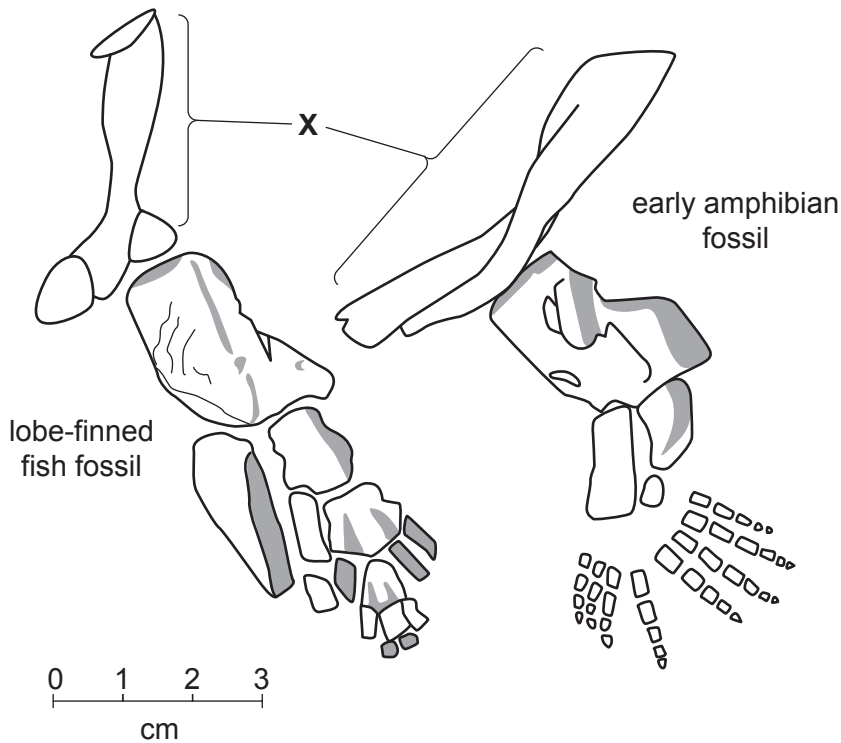
Which of the time spans is divided into biozones based on this fossil group?

- A Mesozoic
- B Permian and Triassic
- C Lower Palaeozoic
- D Precambrian

Your answer

[1]

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]

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]



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]

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]

18 A mafic rock contains:

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

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

What is the porosity of the rock?

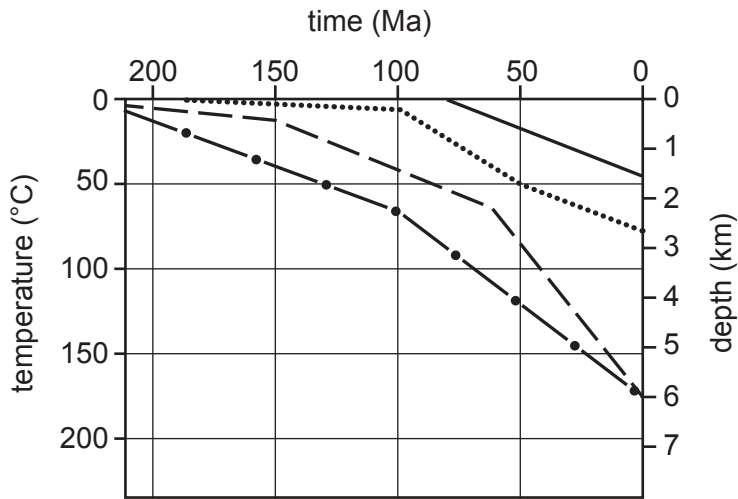
- A 3%
- B 5%
- C 7%
- D 10%

Your answer

[1]

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?

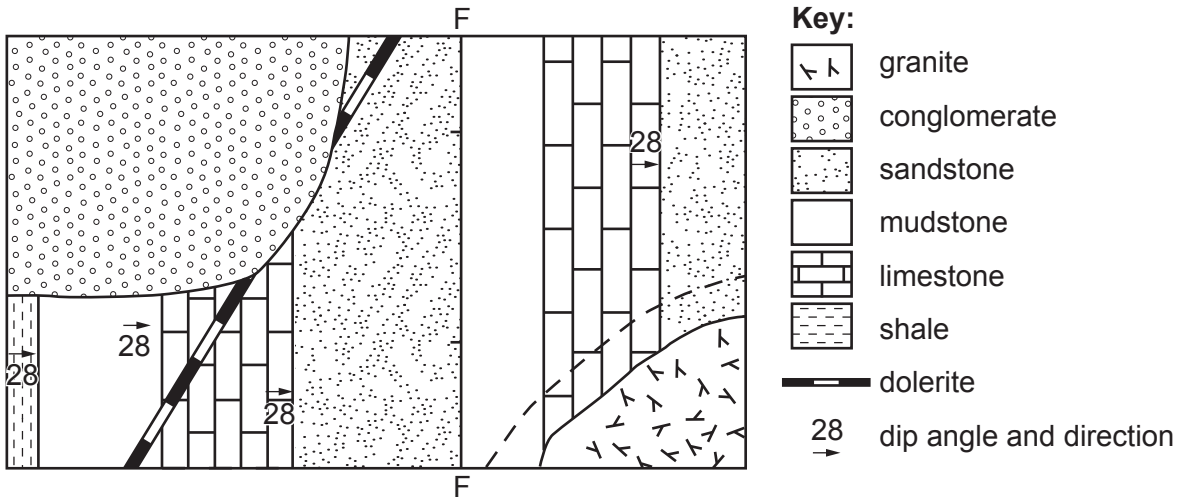


- A —●—
- B - - -
- C .....
- D \_\_\_\_\_

Your answer

[1]

20 A sequence of sedimentary and igneous rocks is shown in the map below.



Which statement identifies feature(s) visible in the map?

- A there are two faults present
- B there are two intrusions present
- C a plunging syncline is present
- D a plunging anticline is present

Your answer

[1]

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]

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]

23 An oil field has a reserve of 650 million barrels. The rate of oil production is 150 000 barrels a day.

How long will the reserve last?

- A 1.19 years
- B 11.9 years
- C 119 years
- D 1990 years

Your answer

[1]

- 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]

- 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

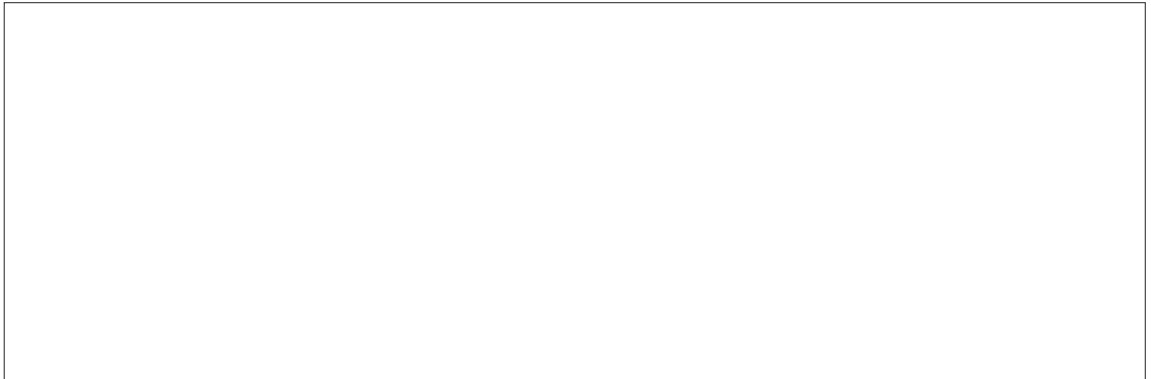
[1]

SECTION B

Answer **all** the questions.

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]

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

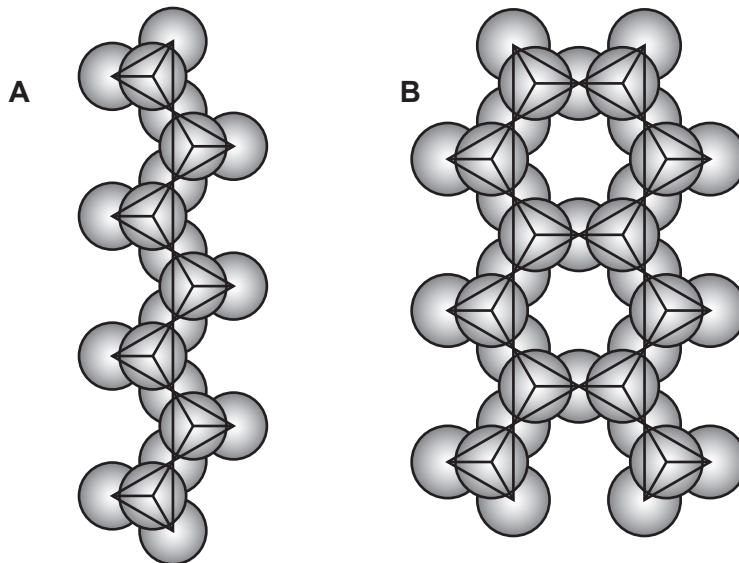


Fig. 26

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

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

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

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

(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	<p>.....</p> <p>.....</p> <p>.....</p>	<p>Metals: aluminium, barium, calcium</p> <p>Non-metals: chlorine, fluorine</p>
.....	<p>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.</p>	cobalt, gold, iron
chalcophile	<p>.....</p> <p>.....</p> <p>.....</p>	silver, arsenic, copper
.....	<p>Occur as liquids or gases at the temperature and pressure conditions found on or above the Earth's surface.</p>	nitrogen, hydrogen

[4]

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

.....

.....

.....

..... [2]

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

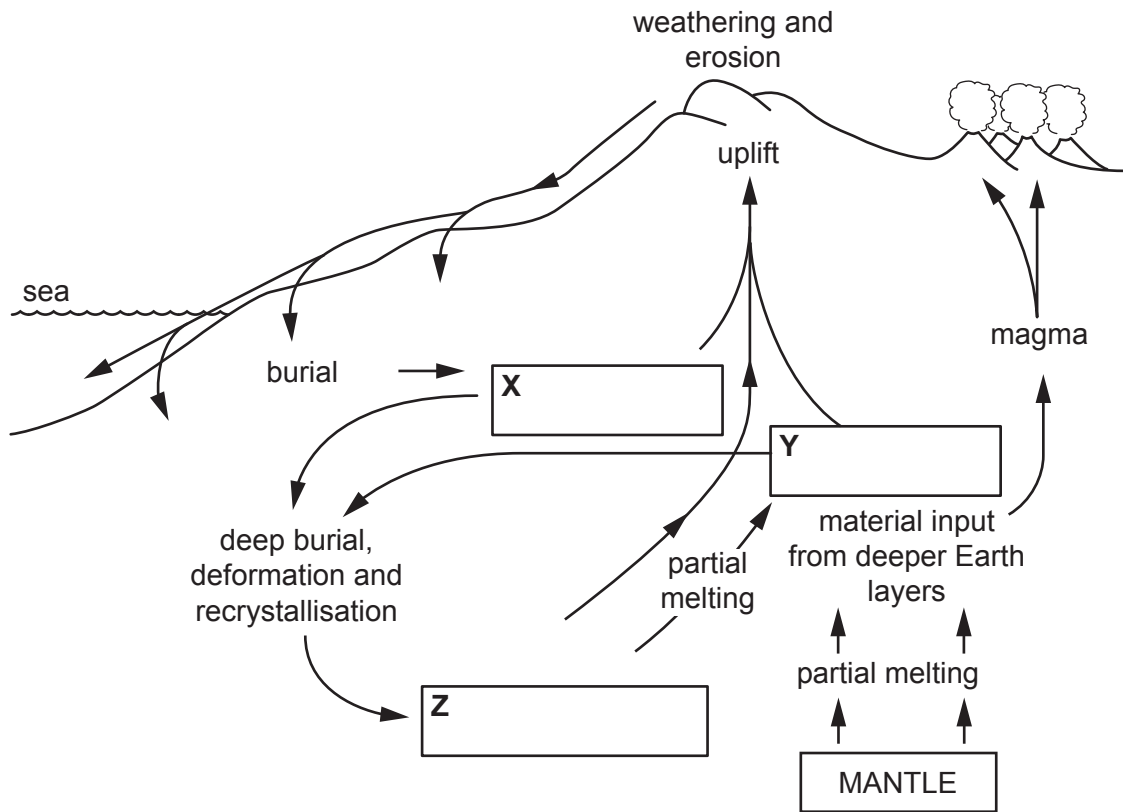


Fig. 27.1

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

(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]



(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.

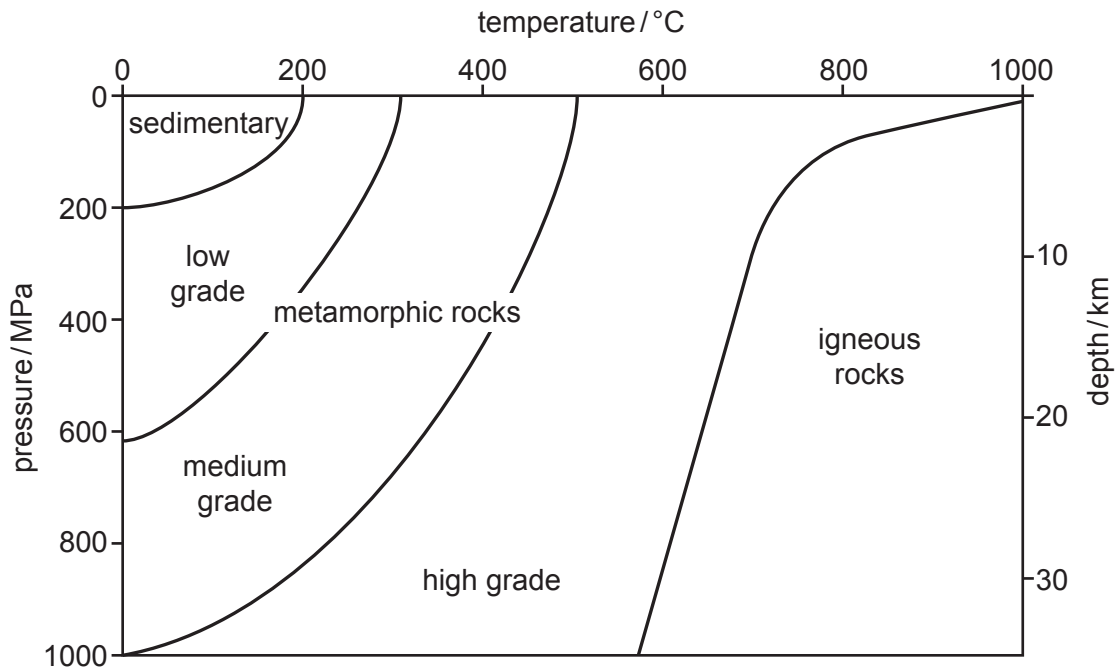


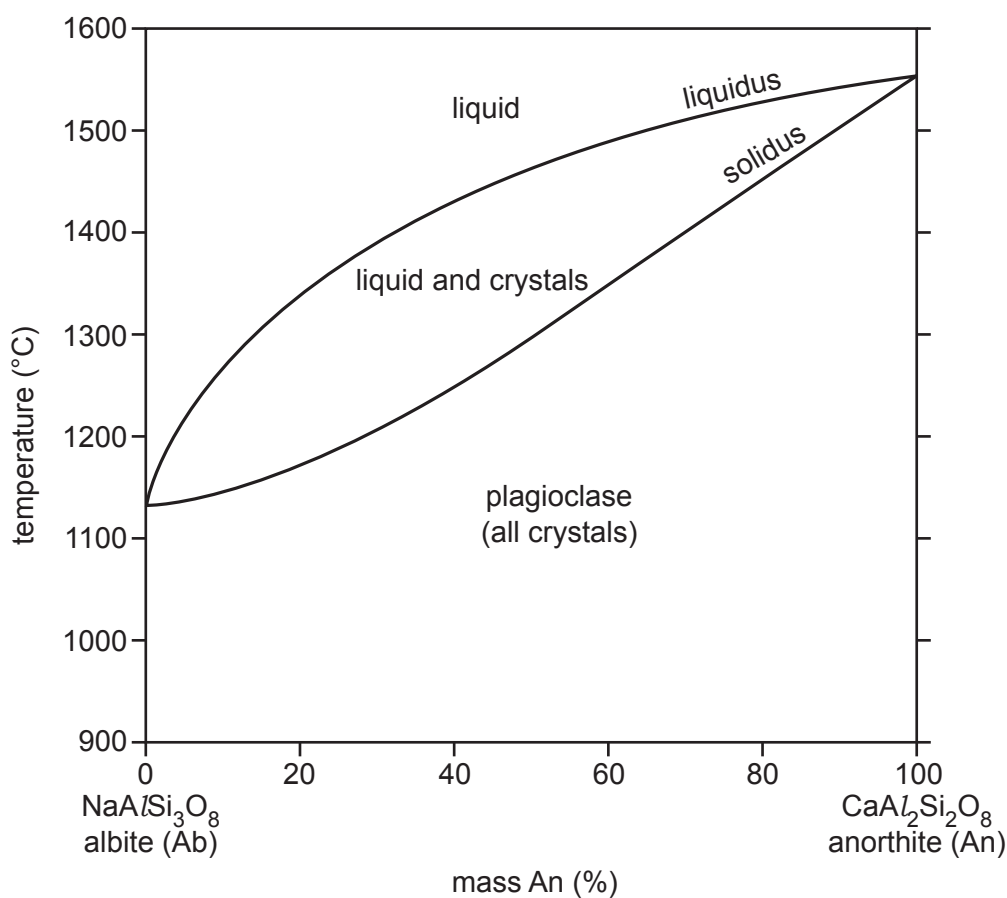
Fig. 27.2

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]

- (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**

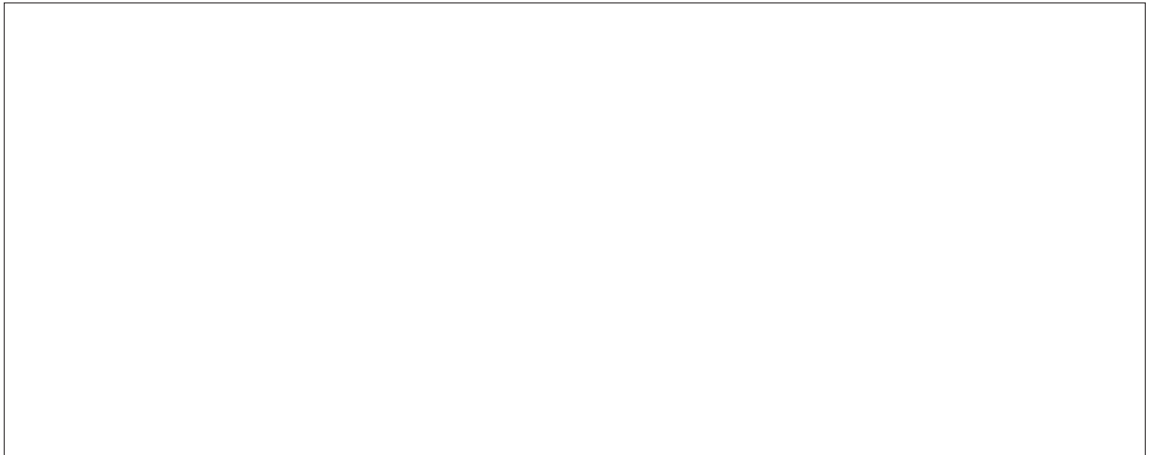
- (i) Describe and explain the continuous series and the processes that occur as a plagioclase melt cools.

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

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

..... [1]

- (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]

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

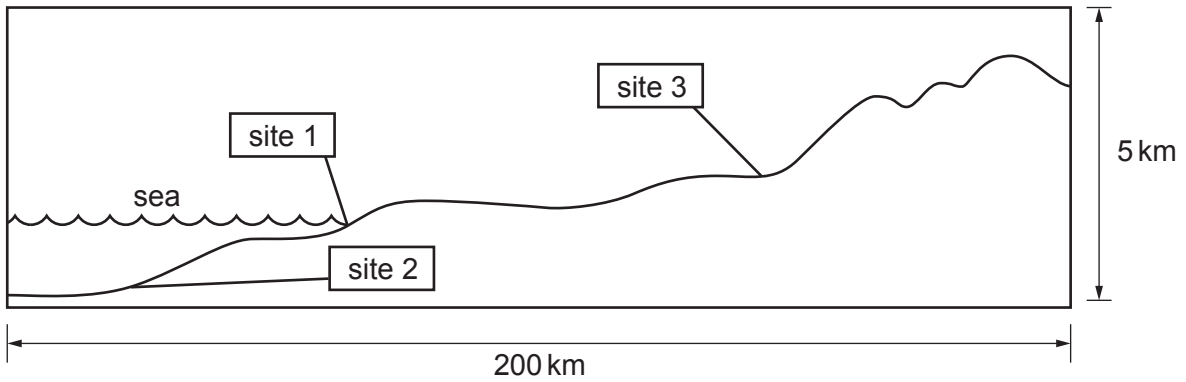


Fig. 28.1

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

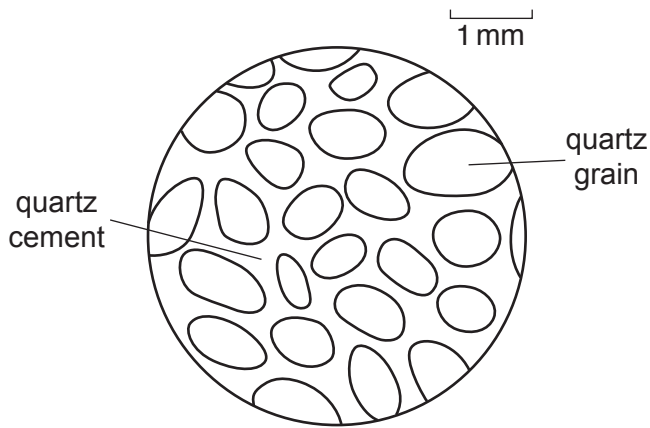


Fig. 28.2

Identify and fully describe the rock.

rock .....

description .....

.....

.....

[2]

- (ii) A sample of sandstone from site 3 has a total volume  $4.5 \text{ cm}^3$  and a total volume of pore space of  $0.7 \text{ cm}^3$ .

Calculate the percentage porosity of the sandstone.

percentage = ..... [1]

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

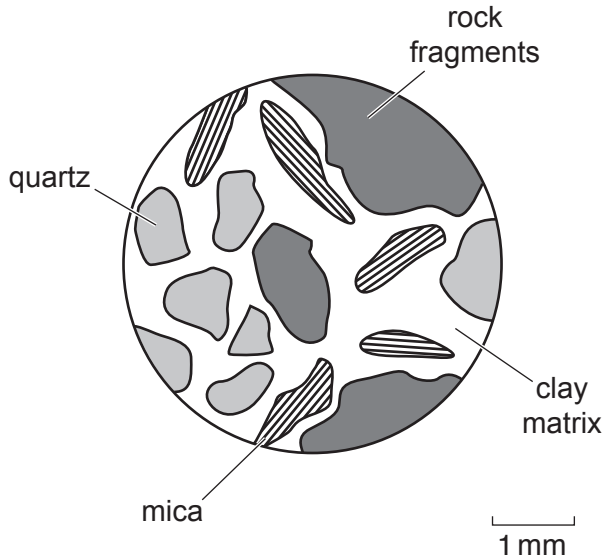


Fig. 28.3

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

rock type .....

.....

.....

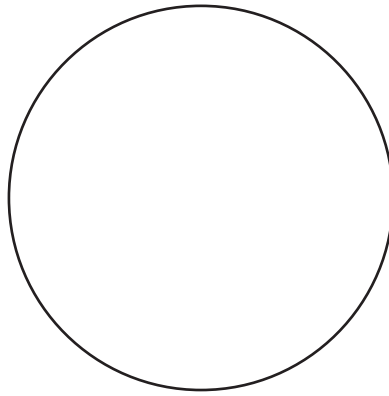
.....

environment of deposition .....

.....

[3]

- (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.



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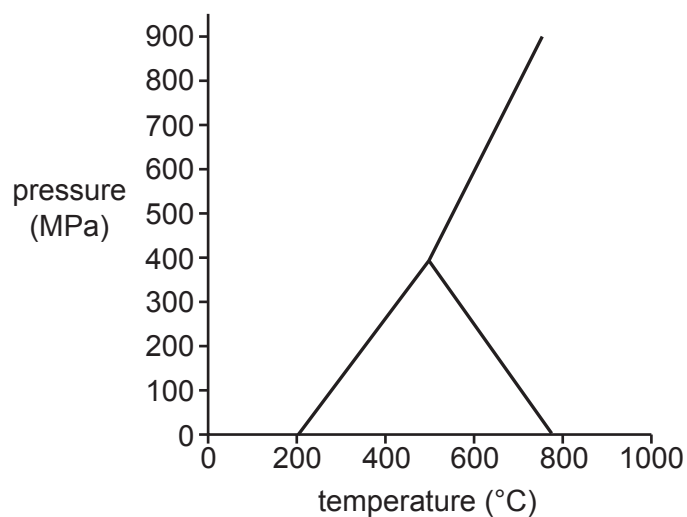
[3]

**23**  
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**Turn over for the next question**

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]
- (ii) On Fig. 29.1, name and label the three  $Al_2SiO_5$  polymorph stability fields. [1]
- (iii) At 400 MPa and 200 °C, state which of the  $Al_2SiO_5$  polymorphs form.

..... [1]



- (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.

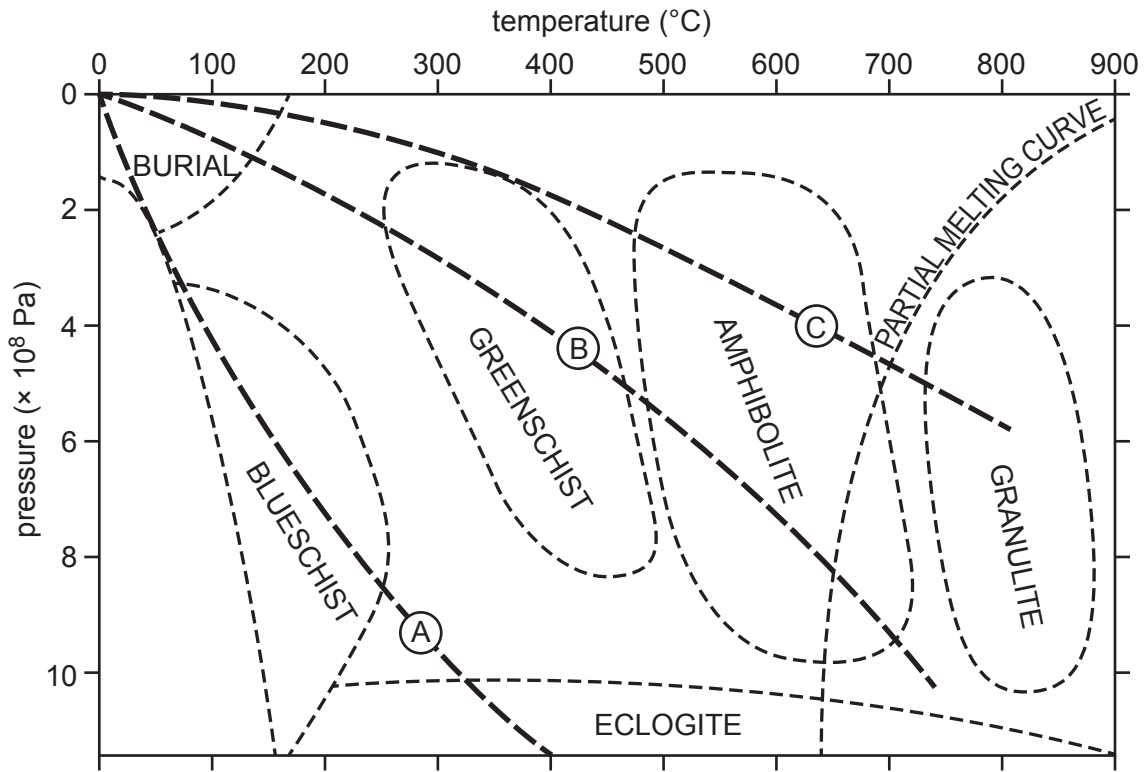


Fig. 29.2

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

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

- (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.

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..... [4]

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

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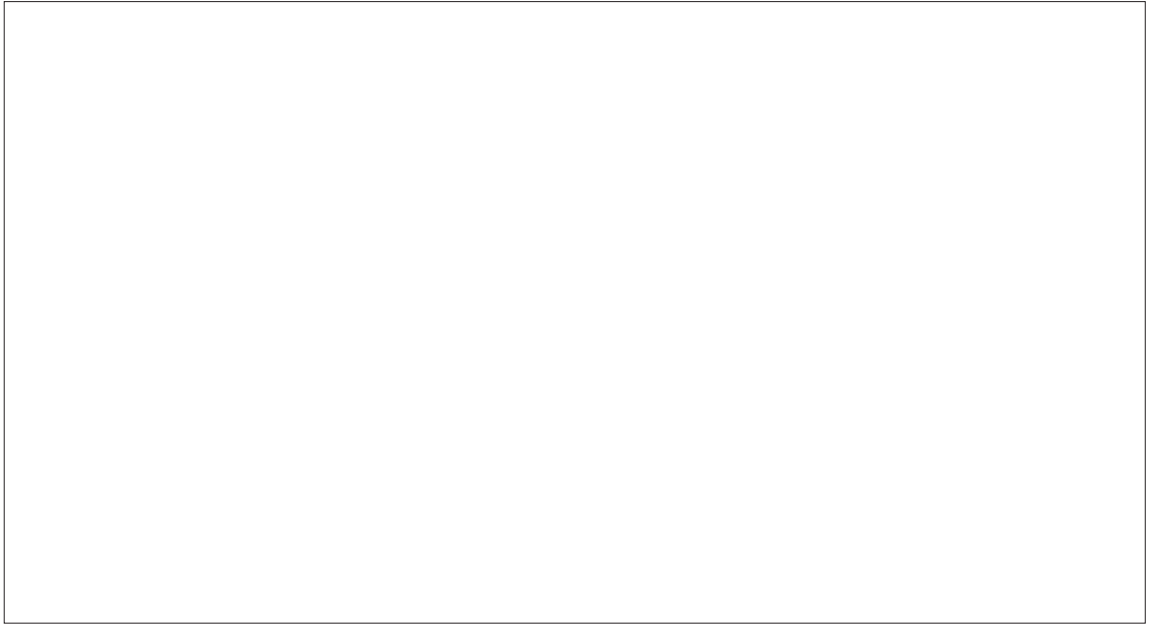
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..... [2]



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

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



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..... [3]

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

Eon	Era	Period
Phanerozoic	Cenozoic	2.6
		Neogene
		23 Palaeogene
		66 Cretaceous
		145 Jurassic
		201 Triassic
		252 Permian
		299 Carboniferous
	Palaeozoic	359 Devonian
		419 Silurian
		444 Ordovician
		485 Cambrian
		541

Fig. 31.1

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

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

(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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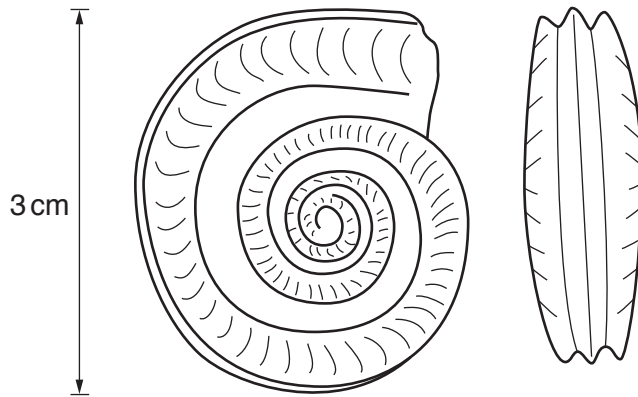
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.....

..... [3]

(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]

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

.....

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.....

.....

..... [2]

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

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

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

(ii) Describe the characteristics of the outer core.

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

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

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[6]

Additional answer space if required.

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33 Scientific research suggests volcanic activity in the Canary Islands started during the Cretaceous and that volcanism occurred during the Miocene. It has been difficult to reconstruct the oldest stages using radiometric dating. All islands except La Gomera have been active in the last million years.

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

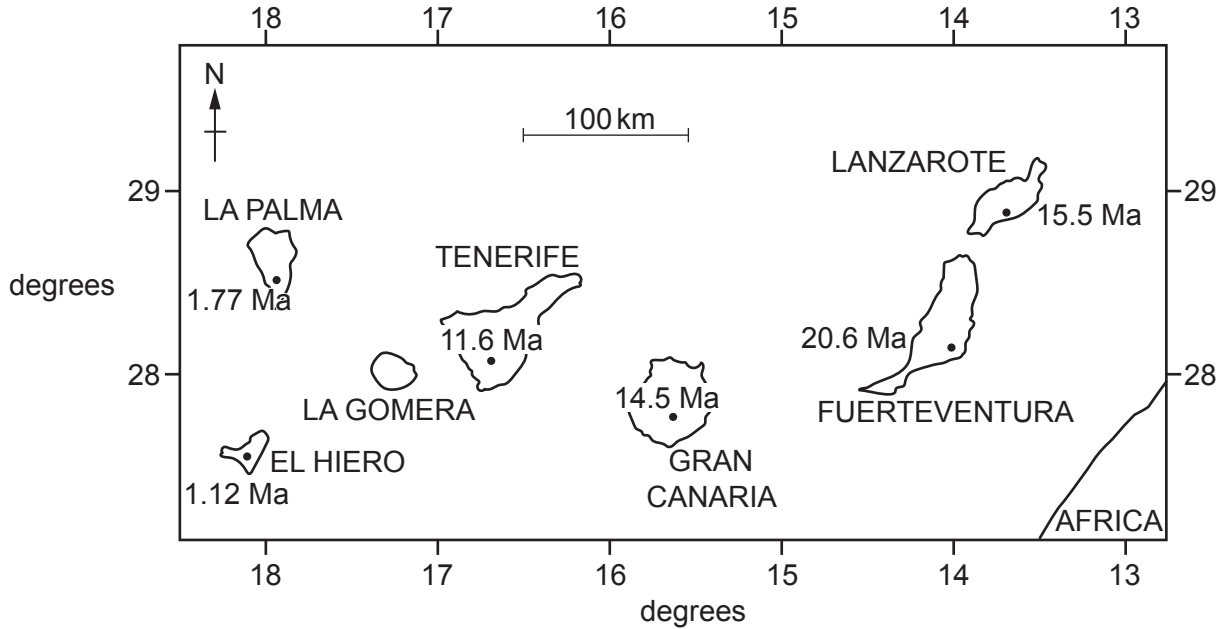


Fig. 33

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

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

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

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

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

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

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

.....

.....

..... [1]

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.

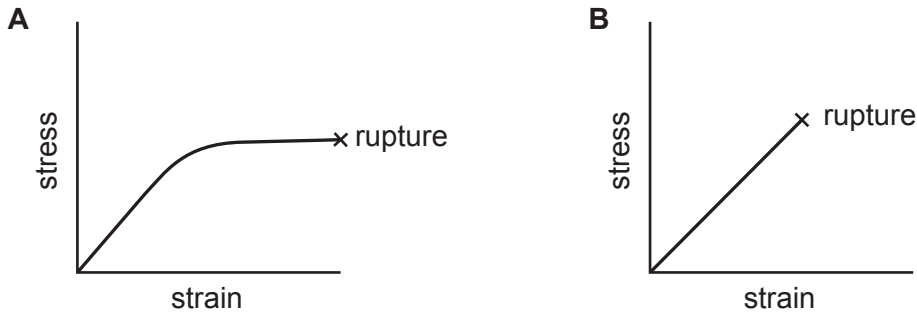


Fig. 34.1

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

rock ..... [1]

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

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

(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.

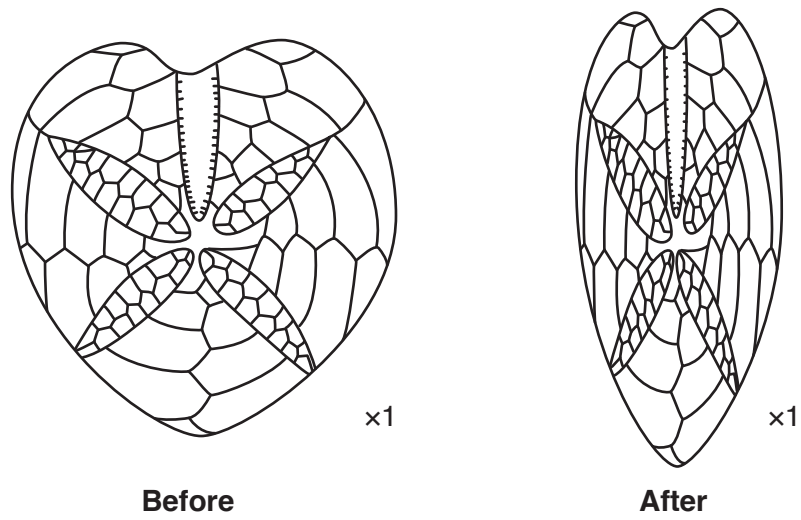


Fig. 34.2

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

strain = ..... [2]

**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.

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..... [2]

**(ii)** Mines can be a source of pollution.

Explain the causes of contaminated minewater.

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..... [2]

(iii) Describe the management of contaminated minewater.

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..... [2]

(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]

**END OF QUESTION PAPER**

**ADDITIONAL ANSWER SPACE**

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

A large area of lined paper for writing. It consists of a vertical solid line on the left side, creating a margin. To the right of this line, there are numerous horizontal dotted lines spaced evenly down the page, providing a guide for writing.

A large area of the page is reserved for writing, featuring a vertical solid line on the left side and horizontal dotted lines extending across the page.



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