OCR
Oxford Cambridge and RSA

Accredited

A Level Geology
H414/01 Fundamentals of geology
Sample Question Paper

Date – Morning/Afternoon
Version 2.2

Time allowed: 2 hours 15 minutes

You must have:
- the Insert
- a protractor
- a ruler (cm/mm)
- a pencil

You may use:
- a scientific or graphical calculator

First name									
Last name									
Centre number						**Candidate number**				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- 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.
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **110**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **40** pages.

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 Placer deposits concentrate ore minerals as water velocities decrease and deposition takes place.

Which ore mineral is most likely to be found in a placer deposit?

A cassiterite

B chalcopyrite

C hematite

D pyrite

Your answer ☐ **[1]**

2 The decay of a naturally occurring parent isotope in a rock forms a stable daughter atom.

The ratio of parent to daughter atoms was found to be 25 :75 and the half-life of the parent is 1260 Ma.

What age is the rock?

A 315 Ma

B 945 Ma

C 1890 Ma

D 2520 Ma

Your answer ☐ **[1]**

3 Which rock type is most likely to provide an accurate radiometric date?

A basalt

B limestone

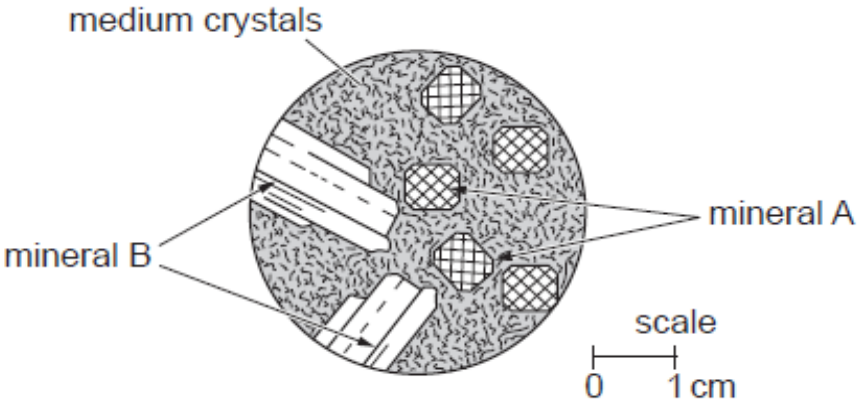
C gneiss

D granite

Your answer ☐ **[1]**

4 The thin section diagram below shows two minerals which can be identified from the properties given in the table.

The groundmass is made up of medium-grained crystals with approximately the same mineral composition as the larger crystals.



Properties	Mineral A characteristics	Mineral B characteristics
Colour of crystals	black	white or grey
Cleavage	2 sets of cleavage almost at 90°	2 sets of cleavage almost at 90°
Hardness	5.5 to 6	6 to 6.5
Crystal shape	some 8-sided	tabular laths

Identify the rock in the diagram.

A granite

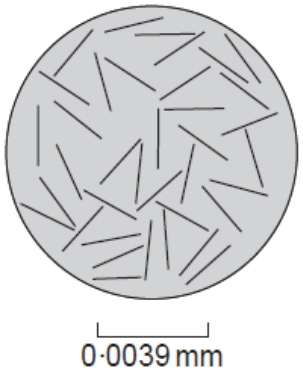
B andesite

C basalt

D dolerite

Your answer ☐ **[1]**

5 The thin section diagram below shows a clastic rock deposited in a marine environment.



Identify the rock shown in the thin section diagram.

A mudstone

B siltstone

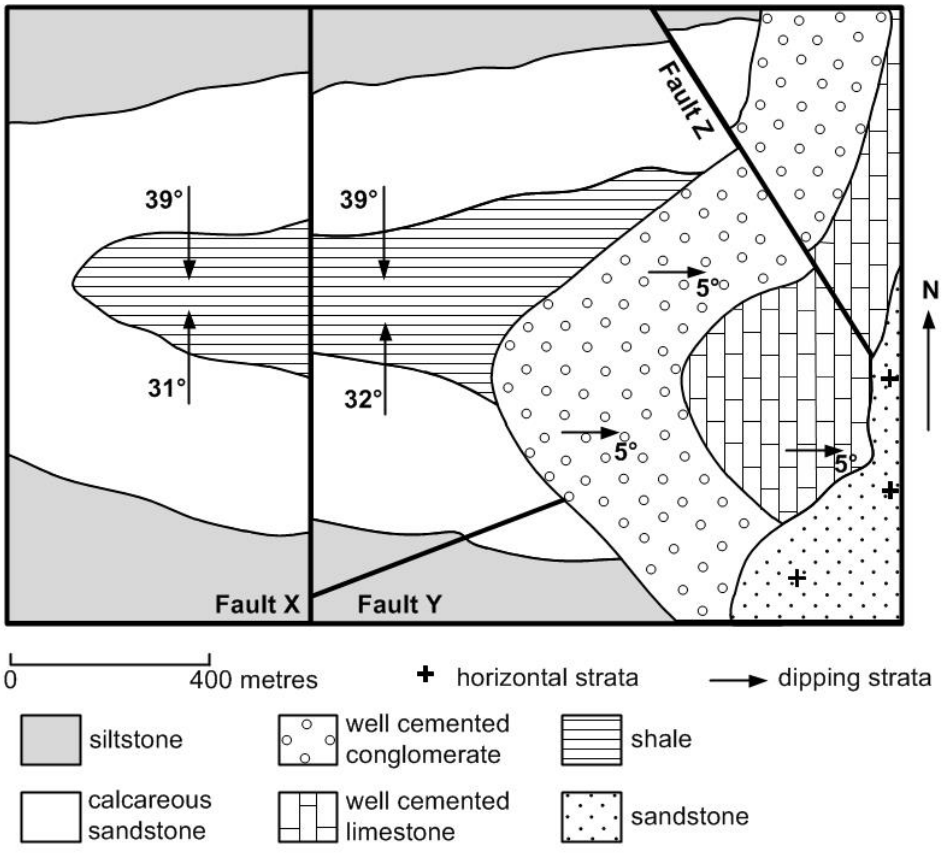
C sandstone

D conglomerate

Your answer ☐ **[1]**

Questions 6 and 7 both refer to the map below.

A sequence of sedimentary rocks is shown on the map.



6 Look at the map.

Which statement about the structure shown is correct?

A There is only one unconformity present.

B There are two unconformities present.

C A plunging antiform is present.

D A plunging asymmetric fold is present.

Your answer ☐ **[1]**

7 Look at the map.

Which statement about the structures and their place in the geological history is correct?

A Fault **X** is older than Fault **Y**.

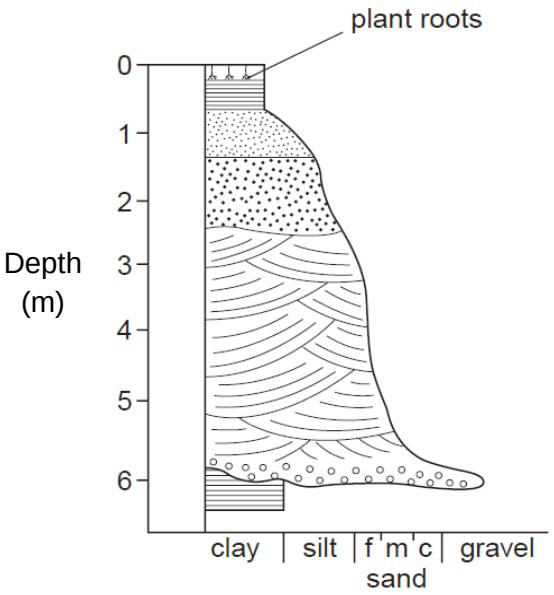
B Fault **X** is older than the deposition of siltstone.

C Fault **Y** is older than Fault **Z**.

D Fault **Z** is older than the folding events.

Your answer ☐ **[1]**

8 Look at the graphic log below.



(f = fine, m = medium, c = coarse)

Which environment does the graphic log show?

A meandering river

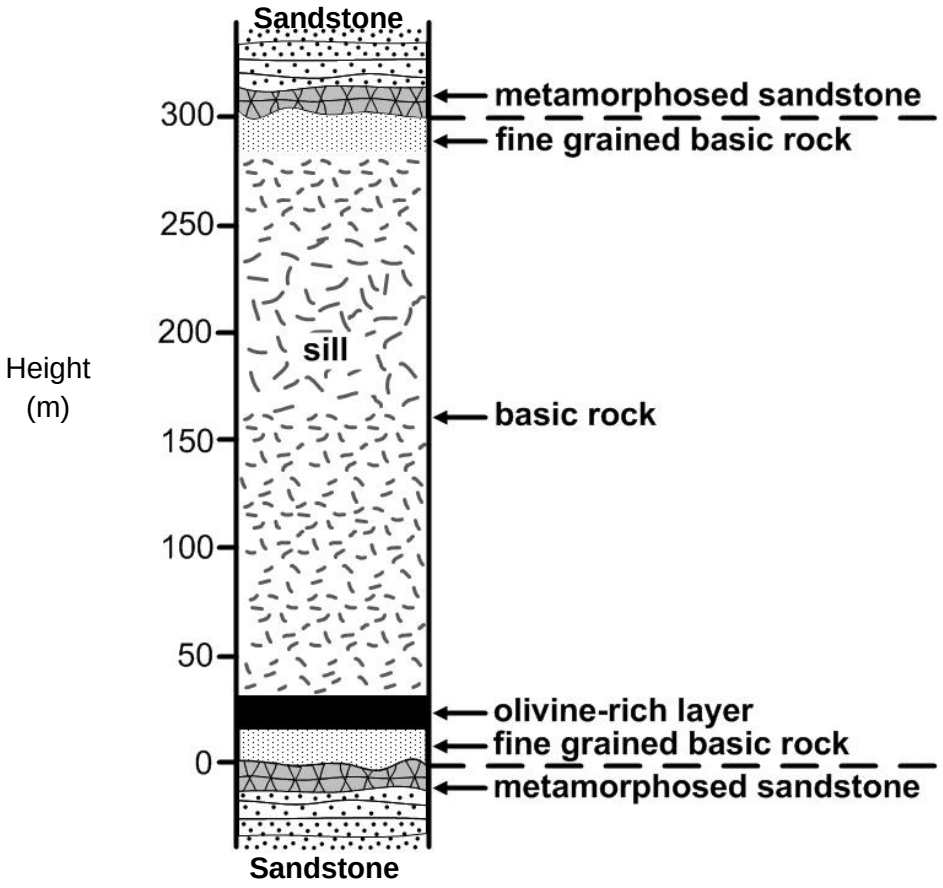
B delta

C desert

D fluvio-glacial

Your answer ☐ **[1]**

9 The diagram below shows a cross section through a large basic sill intruded into sandstones.



The following are statements made about the composition of the chilled margins.

1. They have a more mafic composition than the rocks in the centre of the sill.
2. They have the original composition of the magma forming the intrusion.
3. They contain more plagioclase than the rocks in the centre of the sill.

Which of the statements is/are true?

A 1, 2 and 3

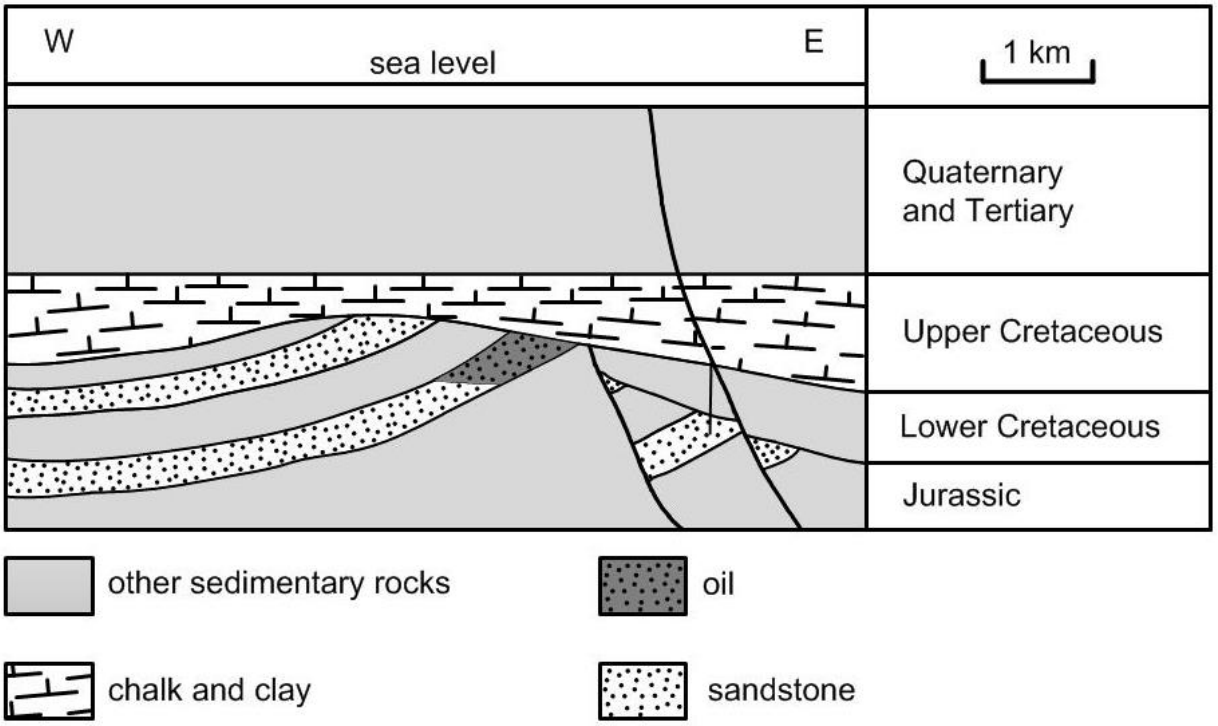
B only 1 and 2

C only 2 and 3

D only 1

Your answer ☐ **[1]**

10 The cross-section below shows the geology of the Brent oil field in the northern basin of the North Sea.



Which of the following statements about the cross-section is correct?

A Source rocks are Jurassic in age.

B Cap rocks are Quaternary and Tertiary sediments.

C Faults trap economic quantities of oil in this cross-section.

D The main reservoir is sealed by a structural trap.

Your answer ☐ **[1]**

11 Which of the following characteristics are **not** seen in Saurischian dinosaurs?

A The pubis in the pelvic structure points forward.

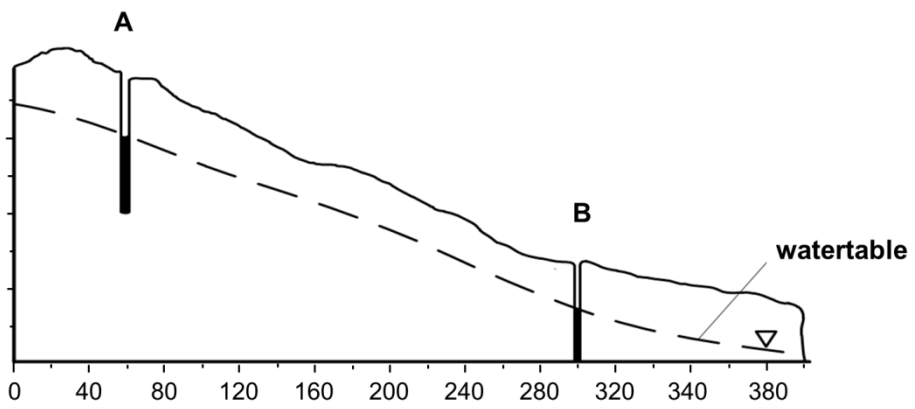
B The front teeth are small or absent.

C Hands consist of only three digits.

D They have long, 'S' shaped necks.

Your answer ☐ **[1]**

12 Two wells in a hillside allow the hydraulic gradient in an unconfined aquifer to be measured.



The horizontal scale is shown. The vertical exaggeration is 4x.

Calculate the hydraulic gradient between well **A** and **B**.

A 0.096

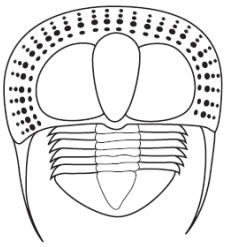
B 0.333

C 0.083

D 0.375

Your answer ☐ **[1]**

13 Look at the diagram of a trilobite.



Magnification x5

Which of the following modes of life is the trilobite adapted for?

A benthonic epifaunal

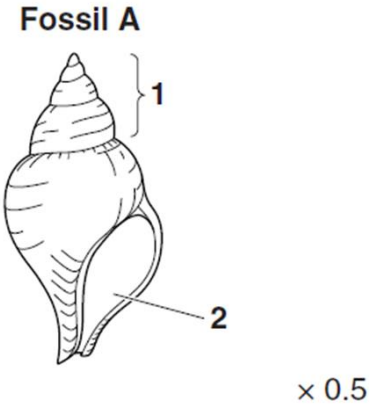
B benthonic infaunal

C planktonic

D nektonic

Your answer ☐ **[1]**

14 The diagram shows a fossil observed by a student in the field.



What is the actual length of **Fossil A**?

A 0.01 mm

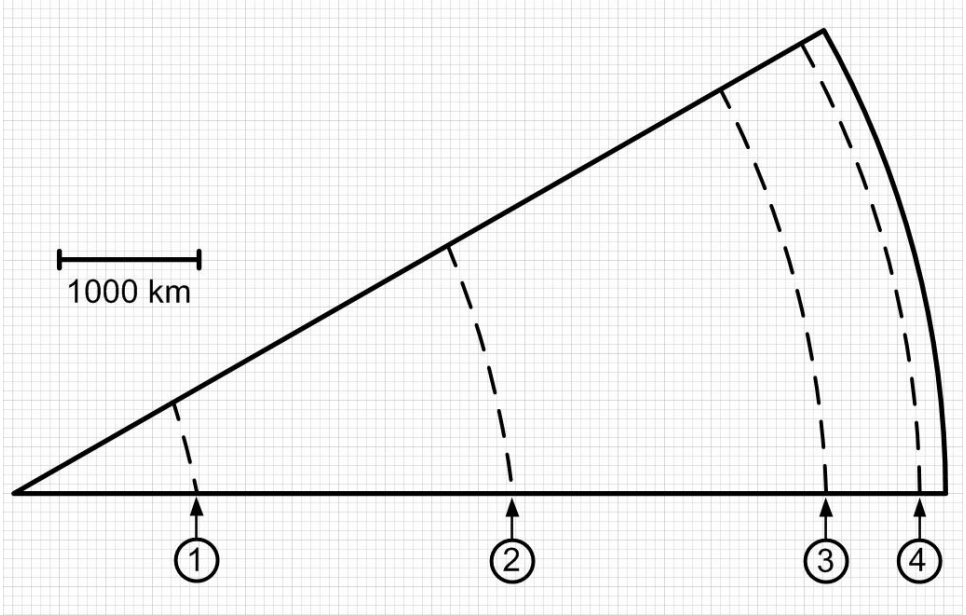
B 41 mm

C 20.5 mm

D 82 mm

Your answer ☐ **[1]**

15 The diagram represents a section through the Earth with four discontinuities.



The depths of the discontinuities have been inferred from analysis of seismic waves. The changes in seismic wave velocity at a discontinuity can be caused by a change in state, a change in composition or a change in density.

Use your understanding of how these factors affect seismic velocity, and the depths of the discontinuities, to select the correct statement.

A There is no compositional change and there is a decrease in velocity at **(4)**.

B There is no compositional change and there is an increase in density at **(3)**.

C There is no compositional change and there is a change of state at **(2)**.

D There is a compositional change and an increase in density at **(1)**.

Your answer ☐ **[1]**

16 Sedimentary structures can provide valuable information including some or all of

1. the environment in which the sediments were deposited
2. whether the beds are the right way up
3. the way the current was flowing at the time of deposition.

Desiccation cracks were recognised in a mudstone.

What would the desiccation cracks allow a geologist to determine?

A 1, 2 and 3

B only 1 and 2

C only 2 and 3

D only 1

Your answer ☐ **[1]**

17 An *Archaeopteryx* specimen fossilised in the Solnhofen Limestone Lagerstätte showed evidence of feathers. This preservation is exceptional because soft parts are usually subject to scavengers and bacterial decay.

How were these feathers preserved?

A Soft parts replaced by clay minerals early in diagenesis.

B Antiseptic conditions due to the presence of bitumen.

C Highly saline conditions in a shallow lagoon environment.

D Rapid burial due to a submarine landslide.

Your answer ☐ **[1]**

18 Ammonoids evolved so rapidly that they can be used to zone the Jurassic period.

Which of the following statements on morphology refers to the **youngest** group of ammonoids?

A The siphuncle is central to the septa.

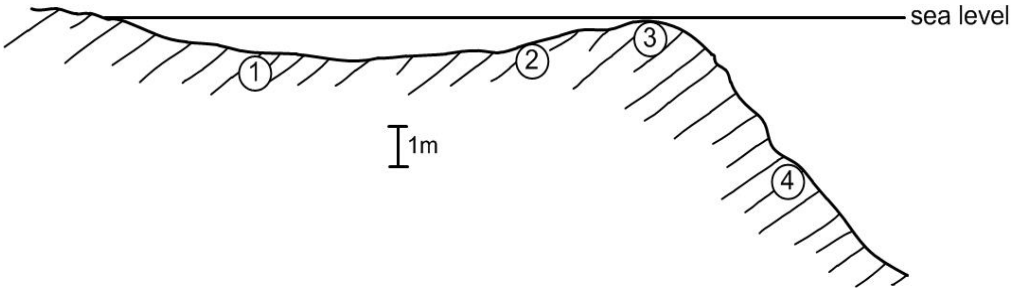
B Sutures have complex lobes and smooth saddles.

C Balance is achieved by adding a calcite guard.

D Septal necks are retrosiphonate (point away from the aperture).

Your answer ☐ **[1]**

19 The diagram represents a cross-section through a carbonate reef.

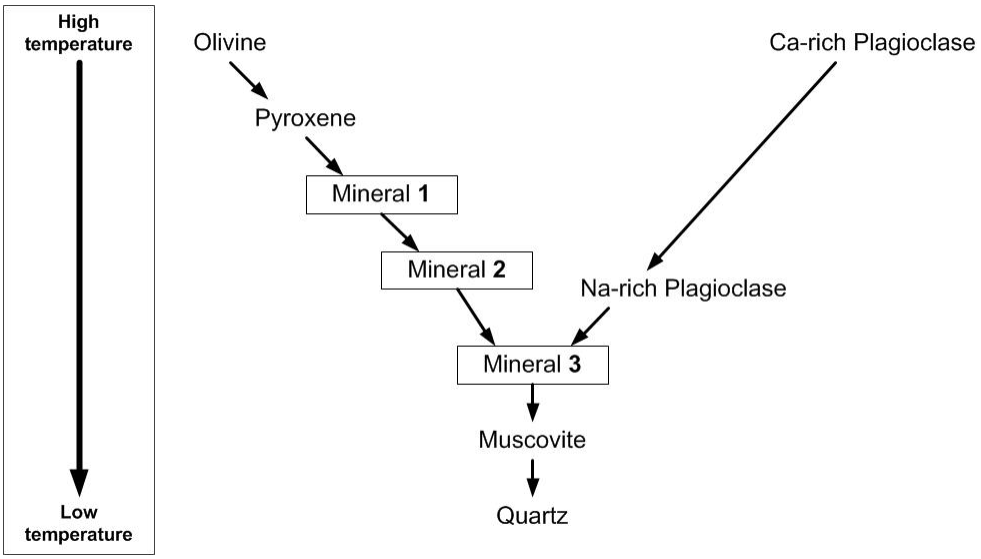


Which row correctly matches the position number with the characteristic limestone for that environment?

A	1 = oolitic	3 = bioclastic	4 = micritic
B	1 = micritic	2 = oolitic	3 = bioclastic
C	1 = bioclastic	2 = oolitic	3 = micritic
D	1 = micritic	2 = bioclastic	4 = oolitic

Your answer ☐ **[1]**

20 In the diagram of Bowen's reaction series below there are three rock-forming minerals missing.



Select the correct row of missing minerals **1**, **2** and **3**.

	Mineral 1	**Mineral 2**	**Mineral 3**
A	hornblende	orthoclase	biotite
B	biotite	hornblende	orthoclase
C	orthoclase	biotite	hornblende
D	hornblende	biotite	orthoclase

Your answer ☐ **[1]**

21 Gradual changes in sea levels over millions of years have produced thick sequences of sedimentary rocks.

During the Triassic period the sea level reached its lowest at –25 m, before gradually rising through the Jurassic period to +50 m and then on to a peak level of +225 m in the Cretaceous period before beginning to fall once more.

Calculate the increase in sea level reached by the end of the Jurassic period as a percentage of the increase in sea level between the Triassic and the Cretaceous period.

A 20%

B 22%

C 30%

D 50%

Your answer ☐ **[1]**

22 Knowing the stratigraphic ranges of fossils can help define the relative age of the rock they are found in.

A rock contained an assemblage of fossils **W**, **X**, **Y** and **Z** whose stratigraphic ranges are shown below.

W = Lower Devonian to end Cretaceous
X = Lower Cambrian to end Permian
Y = End Carboniferous to Recent
Z = Lower Ordovician to end Triassic

What age is the rock in which they were identified?

A Permian

B Triassic

C Jurassic

D Silurian

Your answer ☐ **[1]**

23 It can be difficult to classify minor igneous bodies.

Which of the following statements **only** applies to a sill?

A Vesicles are present.

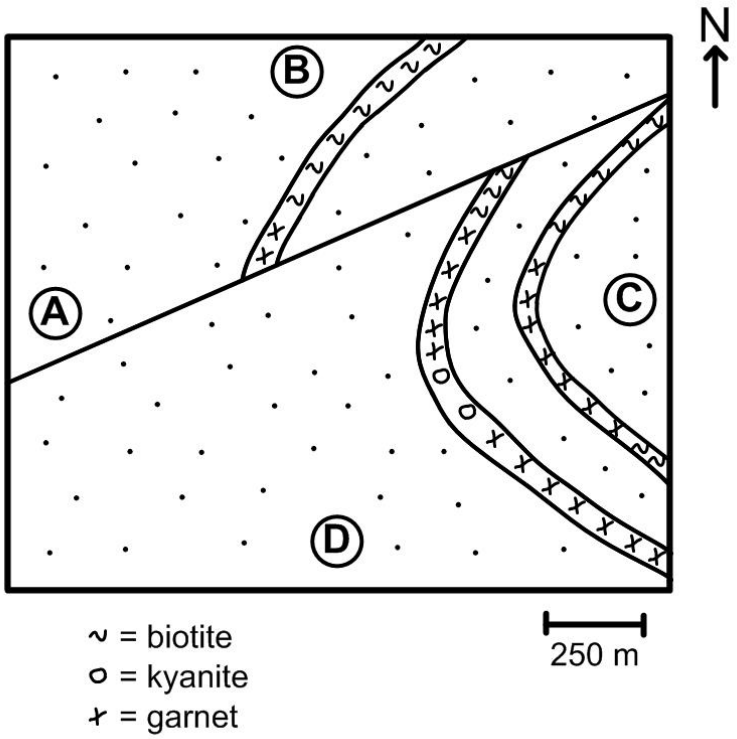
B Xenoliths of the rock beneath are present.

C Xenoliths of the rock above are present.

D The upper margin is reddened.

Your answer ☐ **[1]**

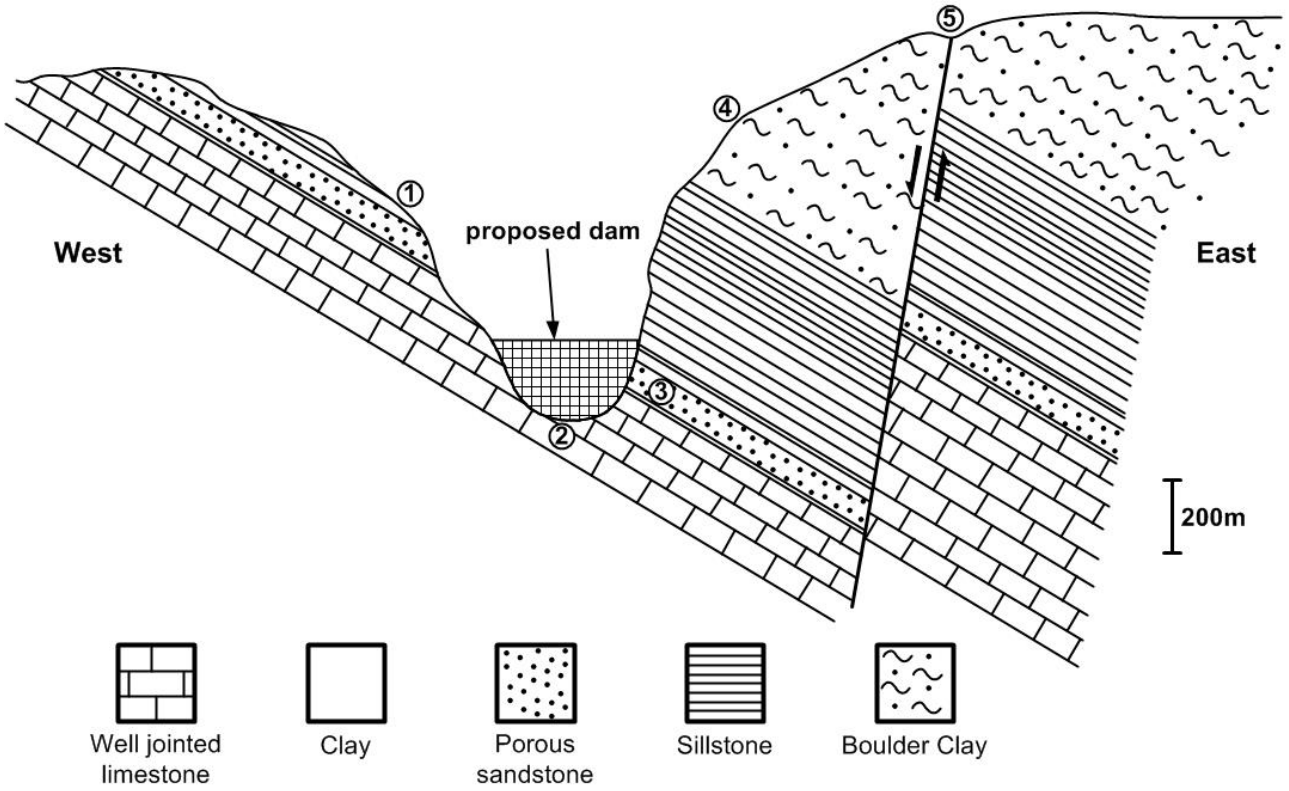
24 The map below shows a succession of rocks which were originally massive sandstones and thinner mudstones. After they were folded and faulted they were subjected to contact metamorphism by a nearby intrusion. The metamorphic grade can be mapped by finding the first appearance of index minerals in the altered mudstones.



Sketch isograds onto the map for the minerals biotite, kyanite and garnet and then decide which of the labels, **A**, **B**, **C** or **D**, is nearest to the intrusion.

Your answer ☐ **[1]**

25 The cross section shows the geology at a proposed site for a thin arch concrete dam. A number of potential problems, labelled **1** – **5** on the diagram, have been identified after geological survey and geotechnical analysis. The engineering geologists have suggested measures to improve the safety of the dam.



Which of the choices, **A**, **B**, **C** or **D**, best reduces the risks shown on this section?

	1	2	3	4	5
A	Re-grade and drain	Cut-off curtain and geomembrane	Grouting	Drains, netting and shotcrete	Drains
B	Re-grade and drain	Drains	Cut-off curtain and geomembrane	Grouting	Drains, netting and shotcrete
C	Grouting	Drains	Cut-off curtain and geomembrane	Re-grade and drain	Drains, netting and shotcrete
D	Drains, netting and shotcrete	Cut-off curtain and geomembrane	Drains	Grouting	Re-grade and drain

Your answer ☐ **[1]**

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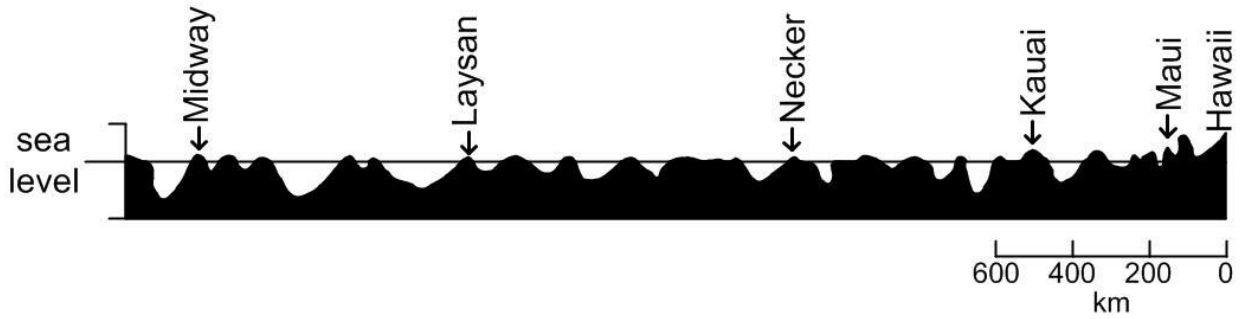
SECTION B STARTS ON THE NEXT PAGE

Section B

Answer **all** the questions.

26 One of the most important pieces of evidence for the movement of tectonic plates is the lines of seamounts and volcanoes (island chains) detected in intra-plate settings worldwide.

The diagram shows a cross-section through the Hawaiian island chain, which was produced by a hot spot currently located under Hawaii.



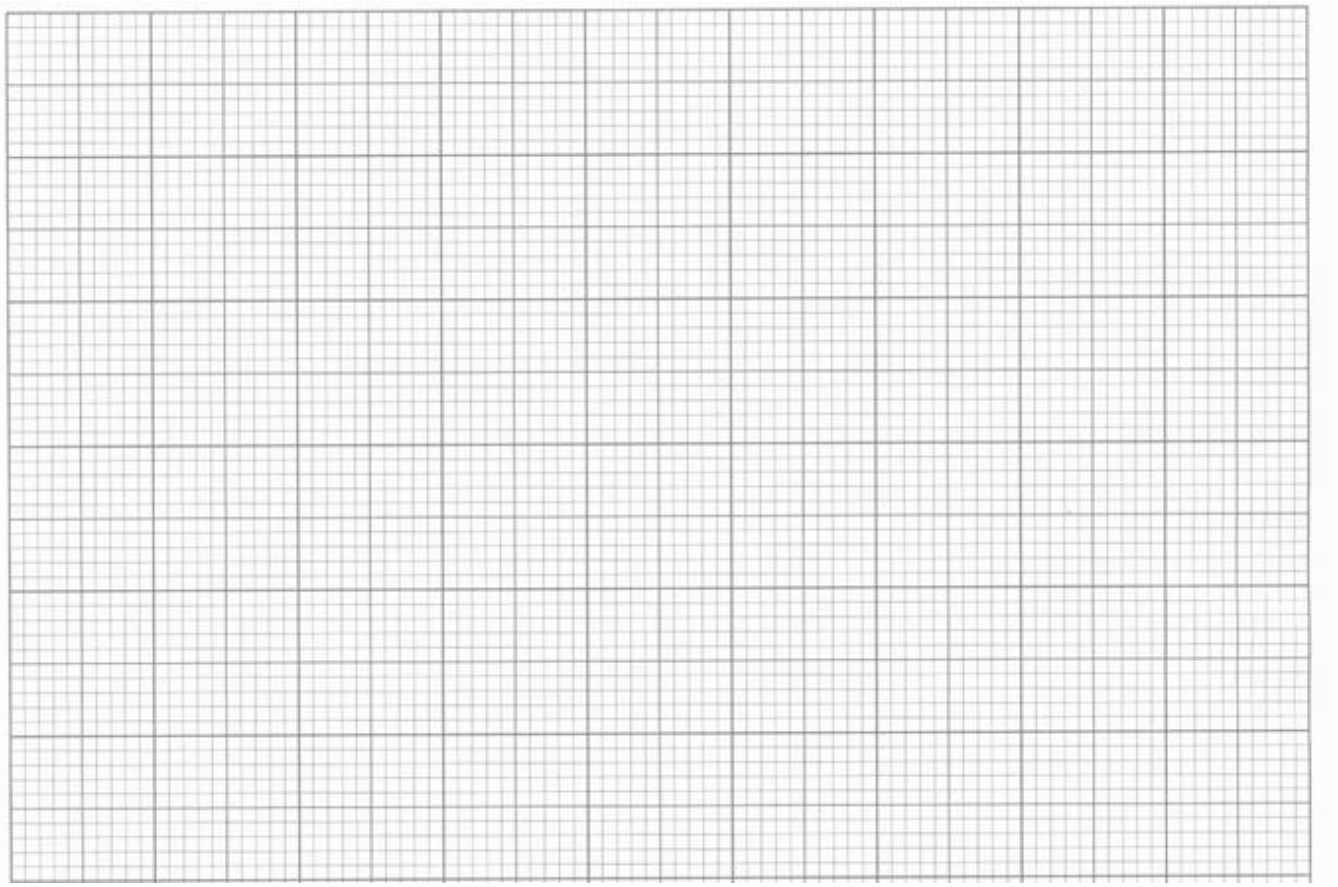
(a) (i) Use the scale to calculate the distance of Necker from Hawaii.

Write your answer in the table below.

Island	Average age of the rocks (Ma)	Distance from Hawaii (km)
Hawaii	0	0
Maui	1	145
Kauai	5	490
Necker	10	.....
Laysan	20	1940
Midway	28	2630

[1]

(ii) Use the grid below to plot the data given in the table above. **[4]**



(iii) Use the graph to determine the average rate of plate movement relative to the hot spot in cm year^{-1} during the last 28 Ma.

average rate = …… cm year^{-1} **[2]**

(b) Mantle plumes have been used to show relative plate motion directly. The early evidence for the motion of the continents had to be indirect and was based on observations of continental geology.

Explain how palaeoenvironments have been used to demonstrate plate motion.

……

……

……

……

……

…… **[3]**

(c) The movement of tectonic plates has been linked to slab pull and ridge push.

Describe the relative importance of slab pull and ridge push as mechanisms for driving plate movement.

……

……

…… **[1]**

27 Clays are formed by the weathering of crystalline rocks.

The equation below shows the chemical weathering of plagioclase feldspar to kaolinite.

$$2NaAlSi_3O_8 + 2H^+ + H_2O \rightarrow Al_2Si_2O_5(OH)_4 + SiO_2 + 2Na^+$$
(albite) (solution) (kaolinite) (silica) (solution)

(a) (i) Name the chemical process and explain your answer.

……

…… **[1]**

(ii) Explain how a physical change in this process assists the breakdown of the source rock.

……

…… **[1]**

(iii) Suggest which rock is the most common source of kaolinite in Great Britain?

…… **[1]**

(b) Shrink–swell behaviour in clays such as smectite is the most damaging geohazard in Britain today, costing the economy an estimated £3 billion over the past 10 years.

(i) Explain how the lattice structure of some clay minerals allows them to expand or contract when water is added or removed.

……

……

……

……

……

…… **[3]**

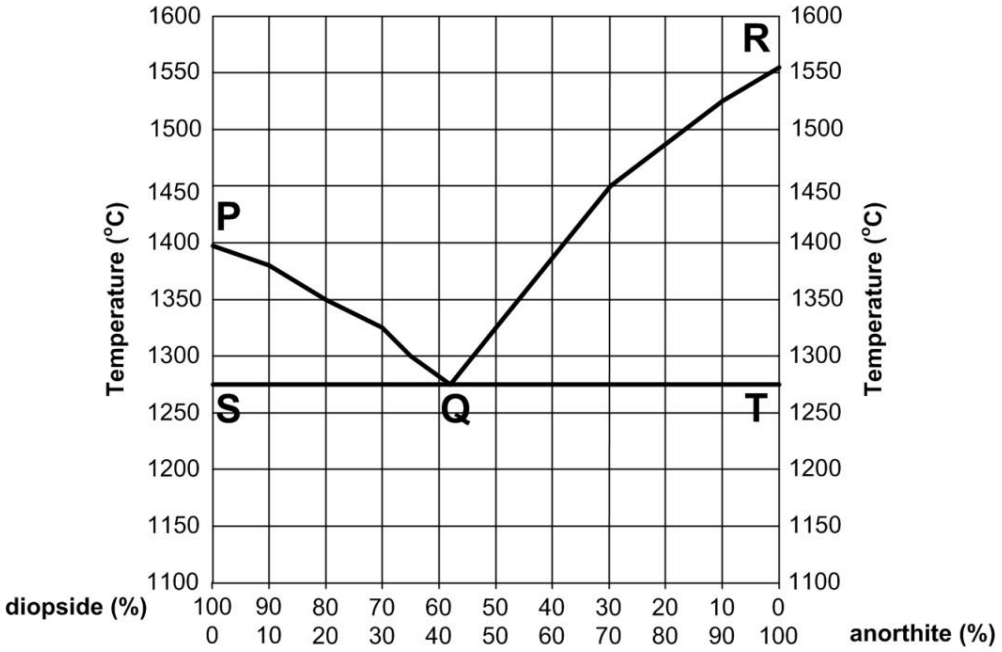
(ii) Outline an engineering solution that mitigates the effects of shrinking and swelling clays.

……

…… **[1]**

28 The texture of igneous rocks is due to the relative sizes and shapes of their component minerals. Understanding the processes of crystallisation reveals the history of how a magma cooled.

A mixture of two different minerals is heated until both are molten. The melt is allowed to cool very slowly. The process of crystallisation is represented on the phase diagram below.



(a) (i) State the phase found in the area above the lines **P–Q–R**.

…… **[1]**

(ii) Describe the phase found in the field bounded by **P, Q** and **S**.

…… **[1]**

(iii) State the phase found in the area below the line **S–Q–T**.

…… **[1]**

(b) (i) The composition of the original magma contained 30% diopside.

Suggest the composition of the first crystals to form as the melt cools?

…… **[1]**

(ii) Label the eutectic point on the diagram. **[1]**

(iii) As the cooling progresses, what is the highest temperature at which all the melt will crystallise?

temperature =…… °C **[1]**

(iv) What will be the ratio of anorthite to diopside in the final crystalline solid?

…… **[1]**

(v) Explain how the changes in the liquid composition shown on the phase diagram account for the crystal compositional changes between first and last crystallisation.

……

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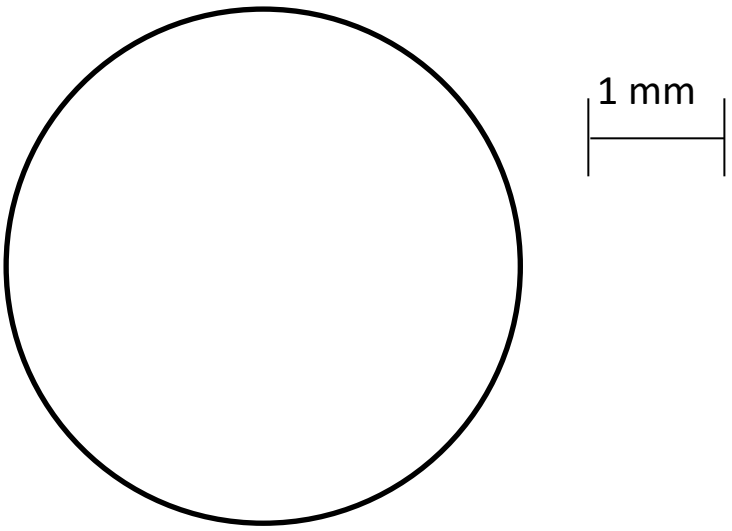
……

…… **[3]**

(c) (i) Anorthite is an end-member of the plagioclase solid-solution series. Diopside is a pyroxene with a very different silicate structure.

Draw an annotated sketch showing the texture of the rock that would result from the slow cooling of this mixture.

The composition is 30% diopside.



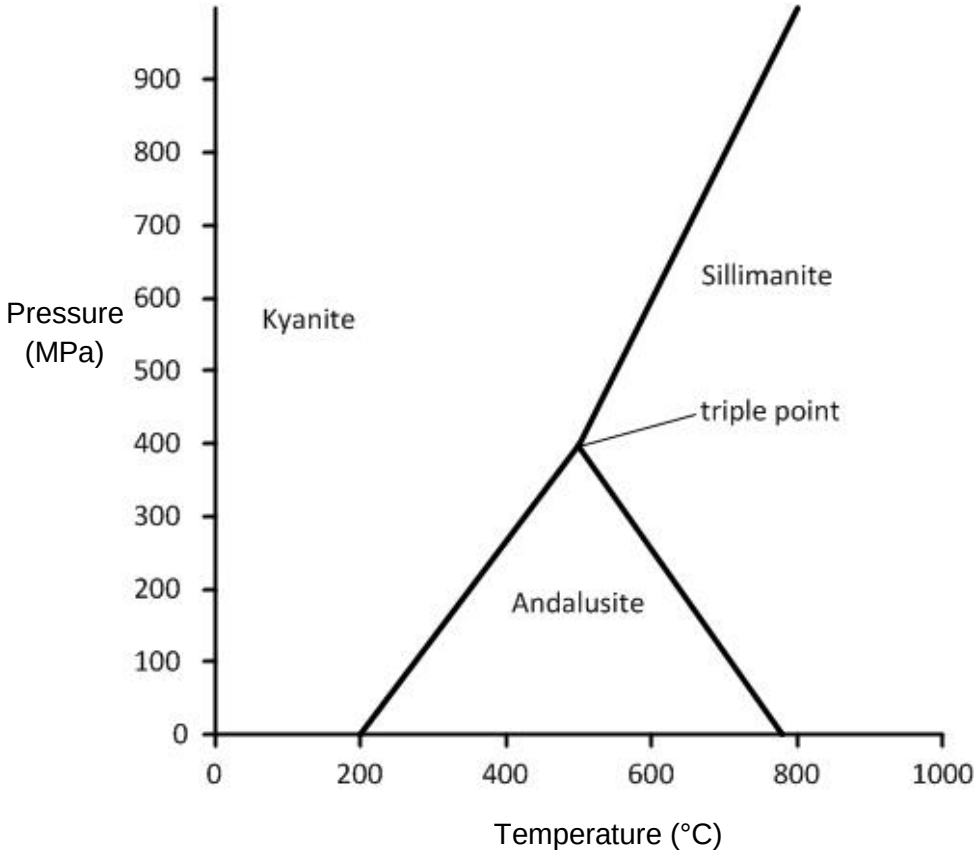
[2]

(ii) What term best describes the igneous texture you have drawn?

…… **[1]**

29 Some metamorphic minerals are sensitive to changes in pressure and temperature and break down to create new crystalline forms having the same chemistry. They can be used as 'geobarometers' and 'geothermometers'. The Al_2SiO_5 polymorphs kyanite, andalusite and sillimanite are particularly useful in the interpretation of metamorphic petrology.

(a) The graph below (a P–T diagram) shows the stability fields of the three polymorphs of Al_2SiO_5.



(i) Explain the significance of the triple point.

……

……

[1]

(ii) On the graph, draw and label dotted lines to represent the metamorphic pathways for contact metamorphism and regional metamorphism.

[2]

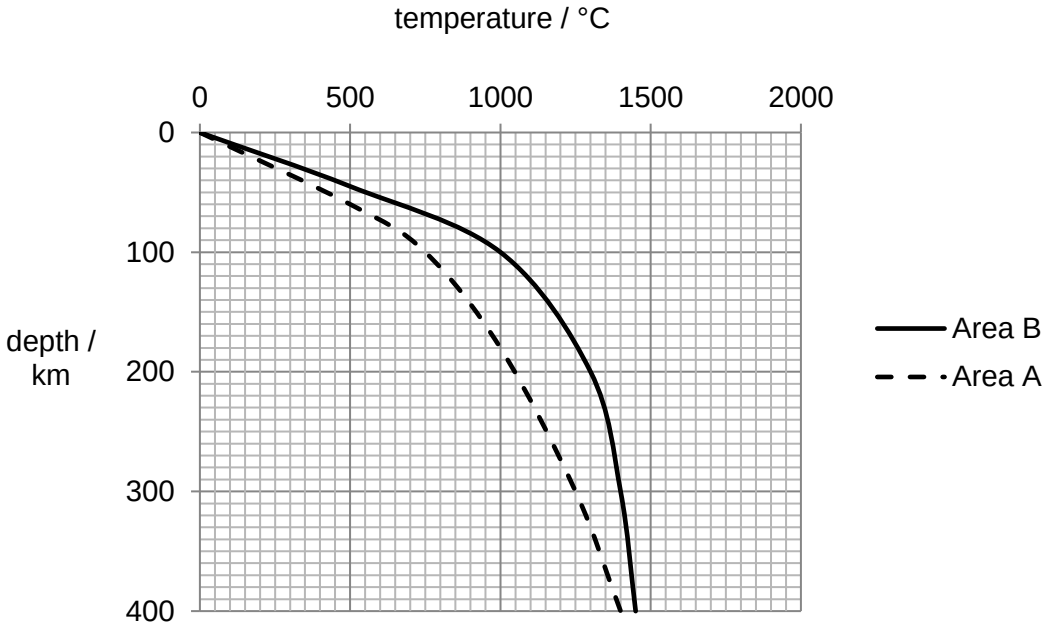
(iii) At subduction zones the geothermal gradient is 15 °C km^{-1}. The pressure rises by approximately 30 MPa km^{-1}.

Calculate the geothermal gradient in terms of how temperature changes with pressure.

Draw and label your calculated geothermal gradient as a dashed line on the graph.

[2]

(b) The graph below shows two geotherms plotted from data gathered from two areas of the Earth (**A** and **B**).



(i) Calculate the gradient of geotherm **A** from 100 to 350 km.

geothermal gradient = …….. °C km^{-1} **[1]**

(ii) Compare the two geotherms shown on the graph. Determine which area has the greater rate of geothermal energy transfer.

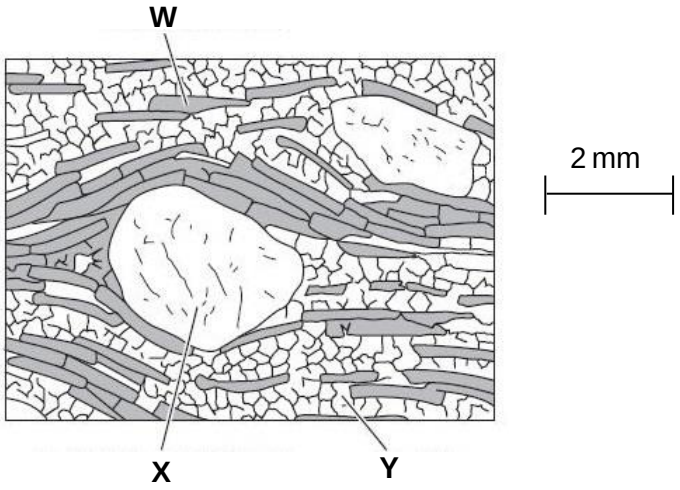
……

……

……

…… **[2]**

(c) The thin section shown below was taken from a metamorphic rock **A** on one of the pathways you have drawn on the graph.



(i) Identify the minerals **W**, **X** and **Y**.

W ……

X ……

Y ……

[2]

(ii) Name the rock from which the section was taken and explain your choice.

name: ……

explanation: ……

……

[2]

(iii) The same metamorphic fabric seen in rock **A** was observed in a thin section of a sample of a less common rock, **B**. In rock **B** the mineral **W** has been replaced by chlorite and mineral **X** contains inclusions of sillimanite.

Consider the information from the thin sections and on your graph. Propose a metamorphic pathway that would produce both rock **A** and **B** and explain why rock **B** is so rare.

……

……

……

……

……

……

……

…… **[4]**

30 Fig. 30.1, **on the insert**, shows an entry in a field notebook of joint sets in a limestone pavement in South Wales. Bedding is sub-parallel to surface shown.

(a) **(i)** Using Fig. 30.1, **on the insert**, measure and record the mean orientation of each joint set.

1……

2……

3……

[2]

(ii) A student was trying to establish the order in which these structures formed but could find no evidence of one joint offsetting another (cross cutting).

Give **two** reasons why one joint would **not** offset another that it crossed.

1……

……

2……

……

[2]

(iii) The student found other evidence in the sketch to help make a geological history.

Use the evidence in the sketch to propose a sequence of events that would had led to the formation of a limestone pavement with these features.

Show how the evidence supports your judgements.

Events in order	**Evidence**
Youngest:	
Oldest:	

[4]

(b) The rock is re-crystallised limestone and is mechanically strong. As an outcrop its strength is controlled by the frequency and openness of the joints.

Determine the joint frequency of the major joint set.

Include units in your answer.

joint frequency =……units…… **[2]**

31 Uniformitarianism allows an interpretation of the environments in which ancient rocks formed, based on sedimentation observed in the present day. Experiments on sediment deposition and transport require analysis of the range of grain sizes involved.

Coarse sediments, such as sands, can be assessed by passing the sample through a stack of sieves and weighing the *fraction* trapped in each. Grain size is expressed in logarithmic (base 2) phi units.

(a) (i) Explain why a logarithmic scale is used to measure sediment grain size.

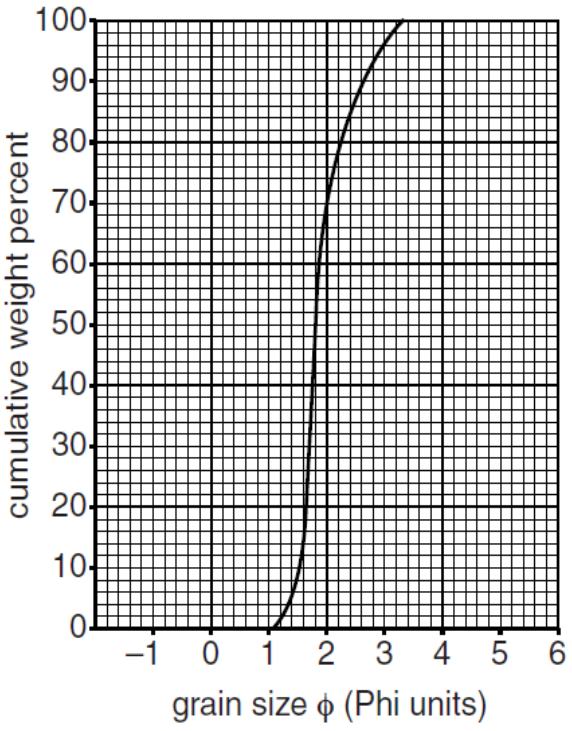
……

……

……

…… **[2]**

(ii) The graph below shows a cumulative frequency curve plotted for a sieved sample. The graph allows approximations to be made of the mean grain size and other size parameters.



Use the Folk & Ward formulae on the next page to find the mean grain size and sorting of the unknown sample.

mean $M = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$

sorting $\sigma = \frac{\phi_{84} - \phi_{16}}{4} + \frac{\phi_{95} - \phi_{05}}{6.6}$

mean = …… ϕ units sorting =…… ϕ units **[2]**

(iii) Use the cumulative frequency graph to find the **median** grain size in ϕ units.

median =…… ϕ units **[1]**

(b)* Finer sediments such as silts are difficult to analyse using sieves. However Stokes' Law shows a relationship between the radius and the terminal velocity of a particle falling through a fluid.

Design an experiment a student could carry out to measure the mean grain size in a well-sorted sample of silt-sized sediment. Include details of the steps they would carry out and how they would process their results. **[6]**

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Additional answer space if required.

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TURN OVER FOR QUESTION 32

32 Fig. 32.1, **on the insert**, shows a vertically exaggerated cross section of the geology through which the Channel Tunnel is constructed.

(a) **(i)** 85% of the tunnel was dug through the Chalk Marl (a carbonate mudstone) using a tunnel boring machine.

Give **two** reasons why this rock was selected over other choices.

1 ……

2 ……

[2]

(ii) Suggest why it was important **not** to tunnel through the Gault Clay?

……

…… **[1]**

(b) Lithostatic pressure is the pressure exerted on a layer of rock by the weight of the overburden (overlying material).

The deepest section of the tunnel is under 55 m of water and 70 m of rock.

The density of water is 1000 kg m^{-3} and the density of the chalk is 2700 kg m^{-3}.

g is 9.8 m s^{-2}.

Calculate the lithostatic pressure on the tunnel lining.

lithostatic pressure =……MPa **[3]**

(c) Methods used to assess the geology along proposed routes included over 4 000-line-kilometres of marine seismic reflection profiling.

Give **two** reasons for using this method.

1……

……

2……

……

[2]

(d) From Fig. 32.1, **on the insert**, you can see that the UK constructed a greater length of tunnel than the French.

Suggest **one** geological reason for this imbalance.

……

…… **[1]**

(e) An earlier proposed route discovered deeply weathered rock close to the UK entrance.

Give **two** ways this could have affected the tunnel construction.

1……

……

2……

……

[2]

33* We have already lost 27% of the world's coral reefs. If present rates of destruction are allowed to continue, 60% of the world's coral reefs will be destroyed over the next 30 years.

The Great Barrier Reef is the largest living structure on the planet, 2300 km long, extending over 14° of latitude, from shallow estuarine areas to deep oceanic waters.

Current threats include increased sedimentation and elevated levels of mineral nutrients in the marine ecosystem (eutrophication) caused by forestry and agricultural practices, increased exposure to ultraviolet light, climate change, and damage by dredging and tourists.

Decide whether these threats are likely to produce geological evidence at the Great Barrier Reef for the start of the Anthropocene epoch. You should explain how these threats will affect carbonate sedimentation, and may be expressed in the future geological record. **[6]**

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Additional answer space if required.

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END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

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

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Oxford Cambridge and RSA

…day June 20XX – Morning/Afternoon

A Level Geology

H414/01 Fundamentals of geology

SAMPLE MARK SCHEME

Duration: 2 hours 15 minutes

MAXIMUM MARK 110

This document consists of 24 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit.

3. Log-in to RM assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM assessor 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM assessor messaging system.

5. Work crossed out:
   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks
   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)
   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor comments box is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. Do not use the comments box for any other reason.
   If you have any questions or comments for your Team Leader, use the phone, the RM Assessor messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:
Read through the whole answer from start to finish, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative geological content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and geological content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.
Once the level is located, award the higher or lower mark:
The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.
The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.
In summary:
The skills and geological content determine the level.
The communication statement determines the mark within a level.

Level of response questions on this paper are **31(b)** and **33**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

The breakdown of Assessment Objectives for GCE Geology:

	Assessment Objective
AO1	**Demonstrate knowledge and understanding of geological ideas, skills and techniques**
AO1.1a	Demonstrate knowledge of geological ideas
AO1.1b	Demonstrate knowledge of geological skills and techniques
AO1.1c	Demonstrate understanding of geological ideas
AO1.1d	Demonstrate understanding of geological skills and techniques
AO2	**Apply knowledge and understanding of geological ideas, skills and techniques**
AO2.1a	Apply knowledge and understanding of geological ideas
AO2.1b	Apply knowledge and understanding of geological skills and techniques
AO3	**Analyse, interpret and evaluate geological information, ideas and evidence to make judgements, draw conclusions, and develop and refine practical design and procedures**
AO3.1a	Analyse geological information, ideas and evidence
AO3.1b	Interpret geological information, ideas and evidence
AO3.1c	Evaluate geological information, ideas and evidence
AO3.1d	Make judgements
AO3.1e	Draw conclusions
AO3.1f	Develop and refine practical design and procedures

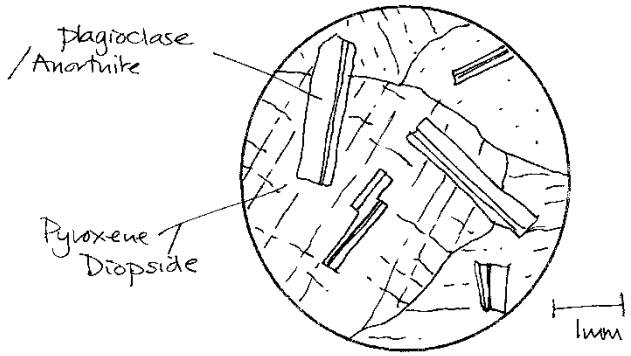
Question			Answer	Marks	AO element	Guidance
1			A✓	1	1.1a	
2			D✓	1	1.1c	
3			A✓	1	2.1a	
4			D✓	1	2.1a	
5			A✓	1	1.1c	
6			B✓	1	2.1a	
7			C✓	1	2.1a	
8			A✓	1	1.1c	
9			B✓	1	1.1c	
10			D✓	1	2.1a	
11			B✓	1	1.1a	
12			C✓	1	1.1d	
13			B✓	1	1.1a	
14			D✓	1	1.1b	
15			B✓	1	2.1a	
16			B✓	1	1.1c	
17			C✓	1	1.1a	
18			B✓	1	1.1a	
19			B✓	1	1.1c	
20			D✓	1	1.1a	

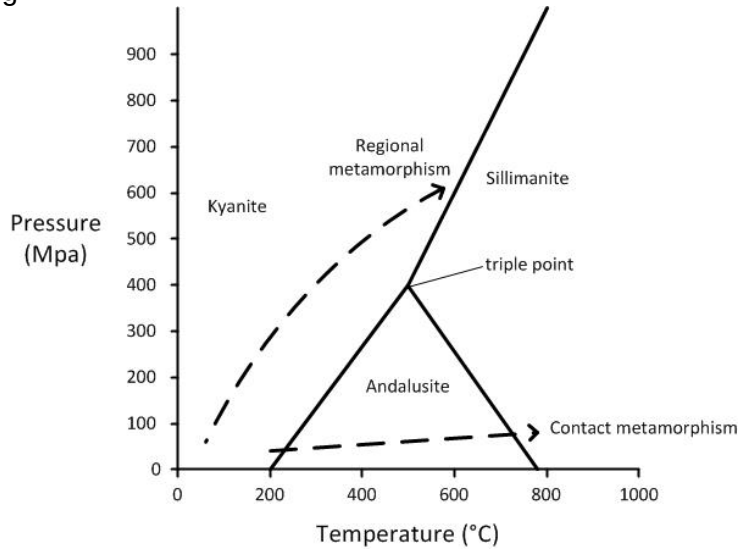
Question			Answer	Marks	AO element	Guidance
21			C✓	1	2.1b	
22			A✓	1	2.1a	
23			C✓	1	1.1c	
24			D✓	1	2.1b	
25			A✓	1	2.1a	
			TOTAL	25		

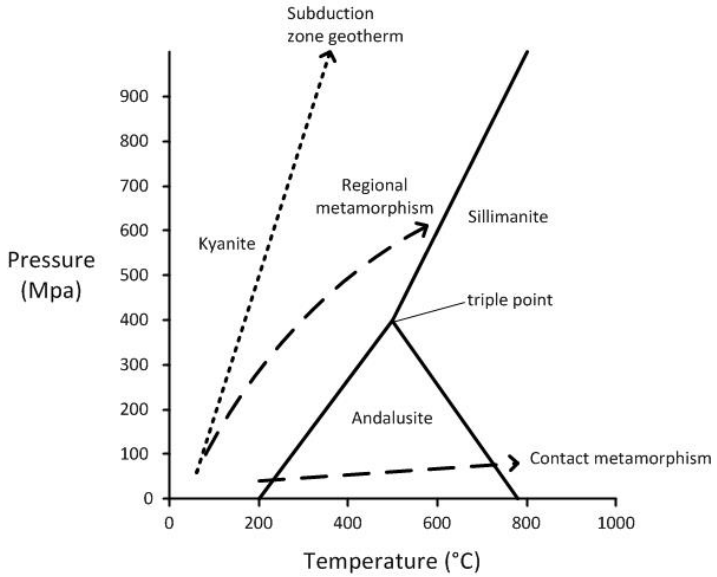
Question			Answer	Marks	AO element	Guidance
26	(a)	(i)	1110 (km) ✓	1	2.1b	
		(ii)	graph plotted with useable equidistant scales taking up more than half the available graph space ✓ labelled axes in km and Ma ✓ points plotted ✓ acceptable best-fit straight line through origin ✓	4	2.1b x 4	**ALLOW ECF** from **(a)(i)**
		(iii)	units conversion for cm year^{-1} ✓ average rate = 9.2 +/– 0.4 ✓	1 1	2.1b 1.1d	**ALLOW ECF** from **(a)(ii)** Must be calculated using the best-fit line
	(b)		assume climate has always been latitude dependent ✓ climate is a factor in the formation of sedimentary rocks / sedimentary rocks indicate the climate in which they were deposited ✓ ancient rock types now mis-matched to their climate must have changed latitude over time ✓	3	1.1c x 3	
	(c)		Ridge push is a small effect and could not of itself account for plate movement. Slab pull is the major driving mechanism ✓	1	1.1a	**AW**
			TOTAL	11		

Question			Answer	Marks	AO element	Guidance
27	(a)	(i)	hydrolysis **AND** Na is replaced by ions (H^+ or OH^-) from water ✓	1	2.1a	
		(ii)	kaolinite/new mineral has a greater volume so rock expands and disintegrates ✓	1	2.1a	
		(iii)	granite ✓	1	2.1a	**ALLOW** acid igneous rocks/feldspar–rich rocks
	(b)	(i)	clay minerals are sheet silicates/phyllosilicates: an octahedral Al and Mg sheet and a Si–O tetrahedral sheet ✓ smectite molecular sheets are in layers only loosely connected by K^+, H^+ or Na^+ ✓ this allows water molecules to be taken between the layers and thus the clay swells ✓	3	1.1c x 3	**ALLOW** labelled correct diagram
		(ii)	**ANY two from** build a strong 'raft' foundation ✓ build foundation on piles down to bedrock/rock below clay✓ keep moisture levels constant by preventing water entering subsurface ✓ lower water table by pumping from boreholes ✓ irrigate to compensate for water loss e.g. on loss of vegetation ✓	2	1.1a × 2	
			TOTAL	8		

Question			Answer	Marks	AO element	Guidance
28	(a)	(i)	liquid ✓	1	1.1c	**ALLOW** molten
		(ii)	solid/crystals/diopside **AND** liquid/melt ✓	1	1.1c	
		(iii)	solid/crystalline ✓	1	1.1c	
	(b)	(i)	100% anorthite/just anorthite/pure anorthite ✓	1	1.1c	**ALLOW** 'anorthite' without further qualification
		(ii)	clearly labelled point **Q** on the diagram ✓	1	1.1a	
		(iii)	1275 (°C) ± 10 ✓	1	2.1b	
		(iv)	30% Di, 70% An **OR** 3 Di : 7 An ✓	1	2.1b	Must be clear which mineral is which part of the ratio. **ALLOW** 'original composition'
		(v)	removal of anorthite crystals causes the composition of the remaining melt / liquid to shift towards the diopside compositional range✓ the liquid composition follows the liquidus (**R** to **Q**) as the temperature falls✓ when the eutectic is reached diopside crystallises out✓	3	1.1c x 3	

Question			Answer	Marks	AO element	Guidance
	(c)	(i)	minerals with at least one recognisable feature in thin section such as lath shape, twinning in plagioclase and 90 degree cleavage in pyroxene ✓ minerals must be labelled ✓ e.g.  	1 1	3.1b 2.1b	**ALLOW** any recognisable thin section drawing showing plagioclase enclosed or partially enclosed by pyroxene **ALLOW** crystal sizes 1 mm or greater
		(ii)	Ophitic **OR** Poikilitic ✓	1	2.1a	**ALLOW ECF** from **(c)(i)**
			TOTAL	13		

Question			Answer	Marks	AO element	Guidance
29	(a)	(i)	at triple point all three polymorphs could co-exist in equilibrium / It represents a unique/very well defined temperature and pressure record ✓	1	1.1c	Triple point = invariant point
		(ii)	for contact metamorphism line allow any labelled line that remains below 150 MPa, start and end temperatures can be ignored ✓ for regional metamorphism line allow any labelled line that follows the trend of the indicated line in the kyanite stability field, passes vertically above the triple point, and remains below 750 °C as pressure increases ✓ e.g.  	2	2.1b x 2	Lines must be labelled for any mark

Question			Answer	Marks	AO element	Guidance
		(iii)	conversion of depth to pressure ✓ any labelled (dashed) line that shows an increase of 15 °C km^{-1} = per 30MPa ✓ e.g.  	2	2.1b x 2	**ALLOW** correct relabelling of pressure to depth on y axis of graph Some candidates will draw in a line from memory for **one mark** Does not have to intersect the origin when drawn
	(b)	(i)	temperature difference = 1325 – 750 = 575 °C depth difference = 250 km $\frac{575}{250} = 2.3$ (°C km^{-1}) ✓	1	2.1b	**ALLOW** 2.2–2.4

Question			Answer	Marks	AO element	Guidance
		(ii)	compares the two curves either morphologically or by using numerical data from the graph ✓ Area **B** has greater increase of heat with depth, therefore higher rate of energy transfer ✓	**1** **1**	**3.1a** **3.1d**	
	(c)	**(i)**	**W** = Mica/muscovite **X** = Garnet **Y** = Quartz ✓✓	**2**	**1.1c x 2**	**3 correct for 2 marks** **2 or 1 correct for 1 mark**
		(ii)	garnet-mica schist ✓ **Any one from** garnet porphyroblast in a foliated rock/micas aligned ✓ micas are more than 1 mm therefore medium grained ✓	**2**	**2.1a × 2**	**ALLOW** schist
		(iii)	rock A during regional/prograde and rock B under retrograde metamorphism of lower pressure and moderate pressure ✓ **OR** rock A during mountain building/orogeny and rock B as roots of mountains were exposed by erosion ✓ changes to rock during regional/prograde metamorphism reduce reaction rates so most rocks remain high grade ✓ **Any two from** silliminite inclusions in garnet show that must have reached high grade conditions/high P & T ✓ chlorite evidence of retrograde low grade conditions where mica/muscovite not stable ✓ garnet and quartz are very stable so not affected by retrograde metamorphism ✓	**4**	**3.1e × 2** **3.1c × 2**	Award mark only if judgement is based on correct justification **ALLOW** clockwise prograde-retrograde P-T pathway on graph
			TOTAL	**16**		

Question			Answer	Marks	AO element	Guidance
30	(a)	(i)	1. 280 – 100° 2. 190 – 010° 3. 335 – 155° ✓✓	2	2.1b x 2	3 sets within +/– 5° for **2 marks** 1 or 2 sets within +/– 5° for **1 mark** **ALLOW** single azimuth for each set e.g. 010°
		(ii)	**Any two from** joints were formed at the same time / by the same stresses ✓ joints are not shear but tensional ✓ offset cannot be seen in this plane/could be vertical movement ✓	2	2.1a × 2	
		(iii)	youngest: 190 and 280° sets formed together – they are at 90° to each other ✓ 335° set formed **either** before **or** after other two sets – not related to other joint orientations ✓ 190 – 010 joints form and are infilled to create veins – must be before other unfilled joints ✓ oldest: Deposition of fossiliferous limestone **AND** youngest erosion to present day surface – it is a limestone pavement ✓	1 1 1 1	3.1b 3.1d 3.1b 3.1d	Events in the correct order **AND** with reference to appropriate evidence evidence statements not required for deposition and erosion events
	(b)		2.56 +/– 0.15 ✓ m^{-1} ✓	2	2.1b x 2	
			TOTAL	8		

Question			Answer	Marks	AO element	Guidance
31	(a)	(i)	**Any two from** the range of grain sizes is so great that it would be impossible to work with them on a linear scale ✓ graphs of grain size would be unable to distinguish between different sand sizes at the same time as plotting cobbles or boulders ✓ sediment/clasts commonly range from 256 mm to 0.004 mm whereas the equivalent phi scale is –8 to +8 ✓	**2**	**1.1d x 2**	Exact ranges not required **ALLOW** any statement indicating the great range of sizes and the reduction in range resulting from a logarithmic scale
		(ii)	mean = 1.9 +/–0.1 ✓ sorting = 0.4 +/– 0.1 ✓	**2**	**1.1d x 2**	
		(iii)	median = 1.8 ✓	**1**	**1.1d**	
	(b)*		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question **Level 3 (5–6 marks)** Coherent experimental procedure suggested including a high level of detail and a clear understanding of the objective. Includes clear details of how to process the results. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and detailed.* **Level 2 (3–4 marks)** A workable experimental procedure suggested, although some key aspects have been missed. Includes clear details of how to process the results.	**6**	**3.1f x 4** **1.1b x 2**	**Indicative points include:** **AO3.1f Development of practical design and procedures** • Support a tall cylinder of water that can be viewed from the side • Measure water temperature as it affects viscosity • Arrange a scale or two marks at a measured distance apart on the cylinder • Carefully place grains beneath the surface with a moistened fine brush to break surface tension • Shake and release grains, time passage between two marks • Calibration with grains of known size • Repeat and record results to obtain a mean time

			There is a line of reasoning presented with some structure. The information presented is relevant. **Level 1 (1–2 marks)** An attempt is made to construct a procedure for the experiment although it does not contain enough detail to be reproducible. Some suggestion of how to process the results has also been made. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*			**ALLOW** the pipette or the hydrometer methods Variables (in Stokes' law) • Water temperature • Viscosity of the fluid • Mass of grain sample • Distance between marks Limitations • limited range of grain sizes in the well-sorted sample *Mention of controlled variables and limitations is not required to achieve Level 3, but may be indicative of a clear understanding of the objective.* **AO1.1b Demonstrate knowledge of geological skills and techniques** Apparatus • Tall cylinder with support • Measuring cylinder • Fine brush • Thermometer • Timer Processing results • Repeats • Mean data • Use of Stokes' law • Appropriate table of results • Appropriate graph of results
			TOTAL	**11**		

Question			Answer	Marks	AO element	Guidance
32	(a)	(i)	**ANY two from** as a mudstone it has low permeability essential for undersea tunnelling ✓ as a chalk it is soft and easily excavated with steel cutting surfaces ✓ as a chalk it is relatively strong and will support itself prior to lining ✓ it is at a relatively shallow depth ✓	**2**	**2.1a × 2**	**ALLOW** reverse arguments
		(ii)	**EITHER:** the clay would expand in contact with water during tunnelling **OR** the clay would soften in contact with water during tunnelling ✓	**1**	**2.1a**	**AW** clay loses shear strength in contact with water
	(b)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.4 (MPa) award 3 marks** method shows use of ρgh to find water pressure 1000 kg m^{-3} x 9.8 m s^{-2} x 55 m = 539000 Pa ✓ method shows use of ρgh to find rock pressure 2700 kg m^{-3} x 9.8 m s^{-2} x 70 m = 1852200 Pa ✓ 539000 + 1852200 = 2391200 Pa converted to MPa = 2.4 (MPa) ✓	**3**	**2.1b x 3**	

Question			Answer	Marks	AO element	Guidance
	(c)		**ANY two from** seismic profiling provides a continuous record along the route identifying structures ✓ seismic profiling will identify faults and folds ✓ seismic profiling may show weathered rock and erosion of the sea floor ✓	**2**	**1.1c x 2**	
	(d)		the French side has steeper dips **OR** the French side has more faulting ✓	**1**	**3.1a**	
	(e)		**ANY two from** weathered rock is more permeable, difficulties if large volumes of water enter during excavation ✓ weathered rock is weaker and would require more lining materials ✓ weathered rock will result in slower progress and more expense ✓	**2**	**1.1c x 2**	**ALLOW** necessary to move the tunnel further from Dover / English coast
			TOTAL	**11**		

Question	Answer	Marks	AO element	Guidance
33*	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Interprets the evidence to reach a clear decision on whether the geological record would represent the start of the Anthropocene epoch. **AND** Provides a detailed discussion of the effects on carbonate sedimentation on the Great Barrier Reef. **AND** Suggests of how the changes in sedimentation might appear in the future geological record. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Uses the evidence to reach a decision on whether the geological record would represent the start of the Anthropocene epoch. **AND** Provides a discussion on the effects on carbonate sedimentation on the Great Barrier Reef. **AND/OR** Makes an attempt to suggest how the evidence of these effects might appear in the future geological record.	6	**2.1a x 4** **3.1b x 1** **3.1d x 1**	**Indicative points include:** **AO2.1a Applies knowledge and understanding of the threats to carbonate sedimentation on the Great Barrier Reef** Sediment and microorganisms cloud water, reducing the light available Sediment e.g. from increased run-off from deforested areas deposited on corals blocks the sun and harms the polyps Agricultural run-off contains mineral nutrients that promote seaweed growth and cover the reef Sea levels rise increase depth of water at reef Increase in CO_2 causes acidification, reacting with calcium carbonate of calices Warmer water causes corals to expel algae Dredging physically destroys corals Tourists touching sensitive polyps harms them **AO2.1a Applies knowledge and understanding of changes in sedimentation to the future geological record** Erosion surfaces (from dredging) with broken coral Higher energy sediments, bioclastic limestone/oolitic limestone as reef floods High energy sedimentary structures such as crossbedding Disappearance of species from fossil record Corals killed at the same time over a wide area

			There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence. **Level 1 (1–2 marks)** Indicates whether the start of the Anthropocene epoch may/may not be present linked to the geological record. **AND** Attempts to discuss the effects of the threats on carbonate sedimentation on the Great Barrier Reef, though this may be lacking in detail. **AND/OR** Makes some suggestion of how the evidence of these effects might appear in the future geological record. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*			due to rapid sea level rise / acidification Peak of detritivores/fungal spores and non-carbonate mud/clay/marl Eventual appearance of new species adapted to new conditions First appearance of plastic and metals such as aluminium, steel in deposits **ALLOW** other Anthropocene evidence e.g. appearance of concrete, fly ash and fall out from nuclear tests across the planet, elevated greenhouse gas emissions trans-global species invasions. **AO3.1b Interprets geological record as representing a stratotype** Continuous marine deposit Synchronous over the Great Barrier Reef Index fossils Numerical dating possible (nuclear tests) Isotopic carbon and oxygen evidence **AO3.1d Makes judgement on whether start of the Anthropocene** Comparison of changes in fossil record to studied mass extinction events Rate of change of sea level, and of temperature from isotopic record Change in style of sedimentation of sufficient magnitude
			TOTAL	**6**		

Summary of updates

Date	Version	Change
January 2019	2.1	Minor accessibility changes to the paper: i) Additional answer lines linked to Level of Response questions ii) One addition to the rubric clarifying the general rule that working should be shown for any calculation questions
February 2022	2.2	Updated copyright acknowledgements in SAM.