OCR
Oxford Cambridge and RSA

Tuesday 4 June 2024 – Morning

A Level Geology

H414/01 Fundamentals of geology

Time allowed: 2 hours 15 minutes

You can use:
- an HB pencil
- a protractor
- a ruler (cm/mm)
- a scientific or graphical calculator

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

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **110**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **28** pages.

ADVICE
- Read each question carefully before you start your answer.

Section A

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

For each question write the letter in the box.

The diagram shows a thin section of a rock made of one mineral.

×10

Use the thin section diagram to answer questions **1** and **2**.

1 The mineral in the rock has rhombohedral cleavage and is scratched by a copper coin but not by a fingernail.

Which mineral is the rock composed of?

A Calcite

B Orthoclase feldspar

C Plagioclase feldspar

D Quartz

Your answer ☐ **[1]**

2 What is the rock type?

A Marble

B Metaquartzite

C Orthoquartzite

D Phyllite

Your answer ☐ **[1]**

3 The table shows the bulk composition of a sample from a chondritic meteorite that fell to Earth in 1934.

Oxide	Weight (%)
SiO_2	39.1
Al_2O_3	1.9
FeO	31.5
MgO	20.7
CaO	1.5
Others	5.3

Which layer of the Earth has a composition most similar to this meteorite?

A Continental crust

B Mantle

C Oceanic crust

D Outer core

Your answer ☐ **[1]**

4 The nebular hypothesis explains the formation of the Solar System.

What is the correct order of the formation of the Solar System according to this hypothesis?

	Earliest event	→	Latest event
A	Giant nebula collapses	Rotation **decreases** and protoplanetary disc forms	Formation of planetesimals
B	Giant nebula collapses	Rotation **increases** and protoplanetary disc forms	Formation of planetesimals
C	Rotation **decreases** and protoplanetary disc forms	Formation of planetesimals	Giant nebula collapses
D	Rotation **increases** and protoplanetary disc forms	Formation of planetesimals	Giant nebula collapses

Your answer ☐ **[1]**

5 The mineral composition of the layers of the Earth have been inferred using both direct and indirect evidence.

Pyroxene (augite) and plagioclase feldspar are the main minerals in which layer of the Earth?

A Continental crust

B Lower mantle

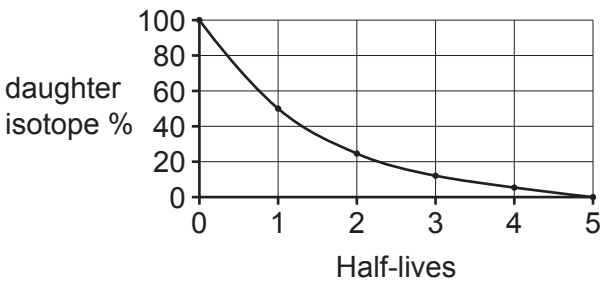
C Oceanic crust

D Upper mantle

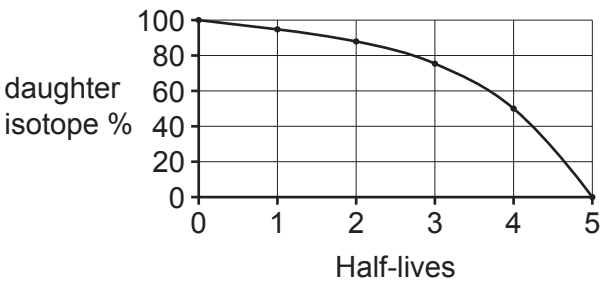
Your answer ☐ **[1]**

6 Which graph, **A**, **B**, **C** or **D**, shows the correct shape for the formation of a daughter isotope during radioactive decay?

A

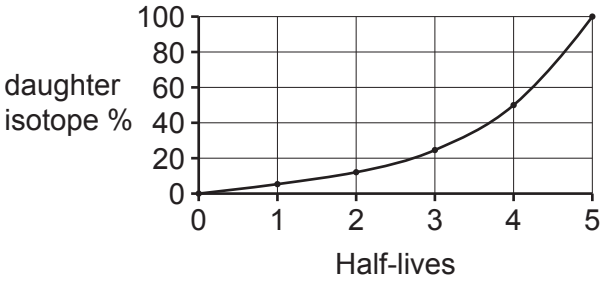


B



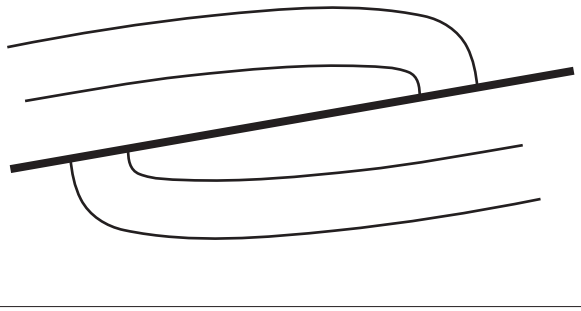
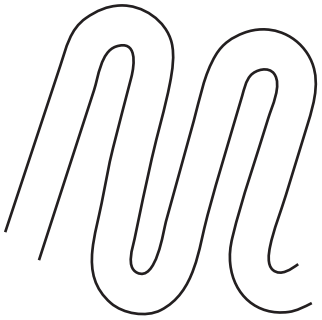
C

D



Your answer ☐ **[1]**

7 The cross-section diagrams show fold structures formed at convergent plate margins.

	
Fold **1** 1 cm = 200 m	Fold **2** 1 cm = 100 m

Identify these fold structures.

	Fold 1	**Fold 2**
A	Isoclinal	Nappe
B	Isoclinal	Overfold
C	Nappe	Isoclinal
D	Overfold	Isoclinal

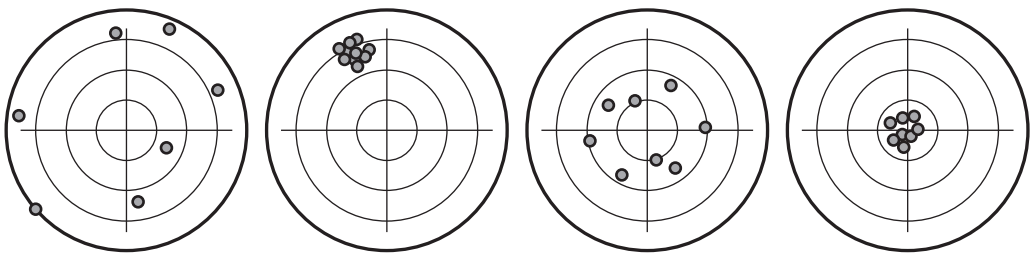
Your answer ☐ **[1]**

8 Global positioning systems (GPS) allow accurate and precise measurement of the relative movement of lithospheric plates.

For the repeat GPS measurements in the diagrams below the true value is at the centre of each chart.

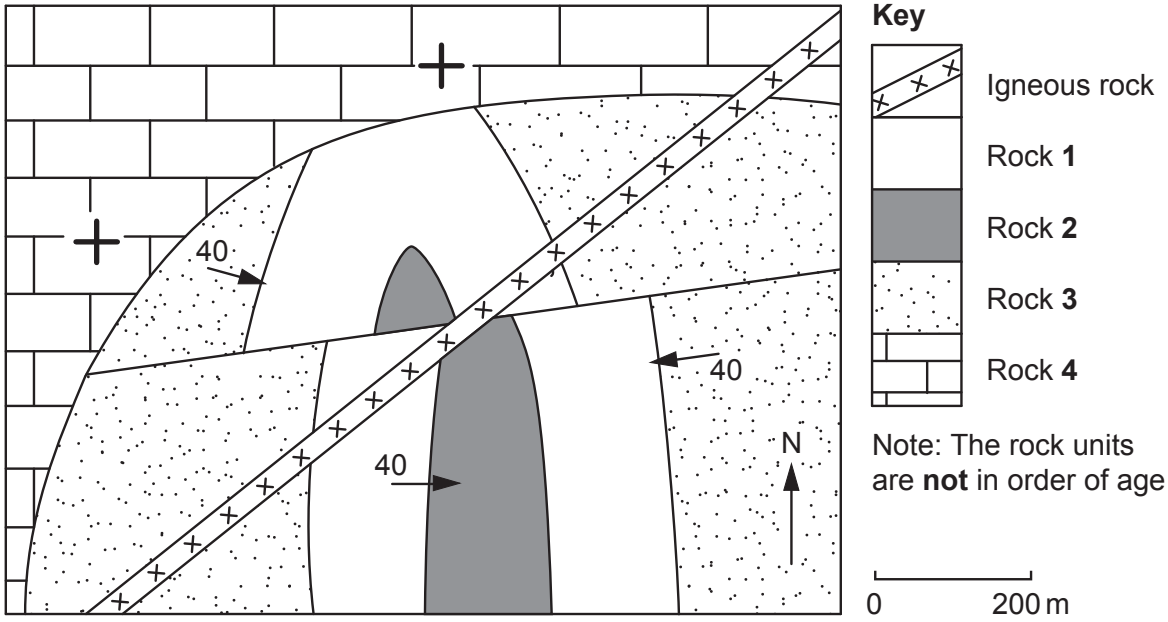
Which diagram, **A**, **B**, **C** or **D**, shows repeat measurements that are accurate but imprecise?

A **B** **C** **D**



Your answer ☐ **[1]**

The geological map shows a flat area. The sedimentary rocks are the right way up.



Use the geological map to answer questions **9**, **10** and **11**.

9 Apply relative dating techniques to determine the youngest feature on the geological map.

A Dyke

B Fault

C Fold

D Unconformity

Your answer ☐ **[1]**

10 Apply relative dating techniques to determine the oldest rock on the geological map.

A Rock **1**

B Rock **2**

C Rock **3**

D Rock **4**

Your answer ☐ **[1]**

11 Identify the fold structure shown on the geological map.

A Antiform plunging north

B Antiform plunging south

C Synform plunging north

D Synform plunging south

Your answer ☐ **[1]**

12 The Al_2SiO_5 polymorphs are useful metamorphic index minerals.

What would be the correct order of formation of the Al_2SiO_5 polymorphs during retrograde metamorphism?

A Andalusite to garnet

B Andalusite to sillimanite

C Kyanite to sillimanite

D Sillimanite to andalusite

Your answer ☐ **[1]**

13 The transmission of seismic energy depends on the competence of the rock.

Through which rock type would the velocity of P waves be lowest?

A Gabbro

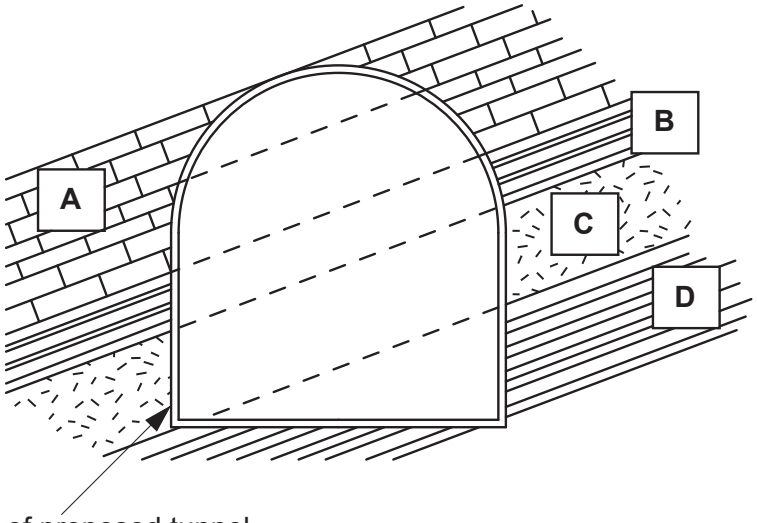
B Limestone

C Mudstone

D Schist

Your answer ☐ **[1]**

The geological cross-section shows an area where a tunnel is due to be constructed.



A Massive beds of well jointed, fissured limestone

B Thin beds of alternating mudstones and sandstones

C Dolerite sill

D Very thin beds of fissile, crumbly shale

Use the cross-section diagram to answer questions **14** and **15**.

14 The tunnel will be constructed using drilling and blasting techniques.

In which rock unit, **A**, **B**, **C** or **D**, is the engineering geology problem of underbreak, where not enough material is removed, most likely to occur?

Your answer ☐ **[1]**

15 There are concerns that the proposed tunnel may flood.

Through which rock unit, **A**, **B**, **C** or **D**, is high water flow most likely?

Your answer ☐ **[1]**

16 A dam and reservoir are planned for water supply. The dam is to be constructed in a broad, shallow valley on clay bedrock.

Which type of dam would be most suitable for this purpose?

A Arch dam

B Buttress dam

C Earth dam

D Gravity dam

Your answer ☐ **[1]**

17 In groundwater supplies, which term would describe a rock unit with a coefficient of permeability of $10^{-6}\,ms^{-1}$ (very low)?

A Aquiclude

B Aquitard

C Confined aquifer

D Unconfined aquifer

Your answer ☐ **[1]**

18 The minerals in rocks that groundwater has flowed through can affect drinking water quality.

The presence of which mineral is most likely to affect the quality of drinking water to toxic levels?

A Calcite

B Galena

C Pyrite

D Quartz

Your answer ☐ **[1]**

19 During which geological time period since the start of the Permian was global sea level at its highest?

A Cretaceous

B Jurassic

C Permian

D Triassic

Your answer ☐ **[1]**

20 The study of the ecology of modern reef-building corals and their comparison with fossil corals allow fossil corals to be used as palaeoenvironmental indicators.

Which combination in the table are the best conditions for good coral growth?

	Water temperature (°C)	Water depth (m)	Salinity (‰)
A	21	60	65
B	23	45	55
C	25	30	45
D	27	15	35

Your answer ☐ **[1]**

21 Which combination of sedimentary conditions led to the exceptional preservation of a range of organisms, including *Archaeopteryx*, in the Jurassic Solnhofen Limestone?

A High salinity and anoxic conditions

B High salinity and oxic conditions

C Low salinity and anoxic conditions

D Low salinity and oxic conditions

Your answer ☐ **[1]**

22 Carboniferous rocks are the main source rocks for natural gas in the Southern Basin of the North Sea.

In which palaeoenvironment were these source rocks deposited?

A Deltaic bottomset beds

B Deltaic foreset beds

C Deltaic topset beds

D Shallow marine platform carbonates

Your answer ☐ **[1]**

23 Which of these is unlikely to result in the loss of oil or natural gas from a trap structure?

A Erosion

B Faulting

C Lateral spill point

D Subsidence

Your answer ☐ **[1]**

24 Cephalopod fossils can be used to zone and correlate rocks in sedimentary basin analysis.

Which cephalopods are used to zone the Jurassic Period?

A Ammonites and belemnites

B Ammonites and ceratites

C Belemnites and nautiloids

D Ceratites and goniatites

Your answer ☐ **[1]**

25 What is the geological time range for trilobites?

A Cambrian to Carboniferous

B Cambrian to Permian

C Ordovician to Permian

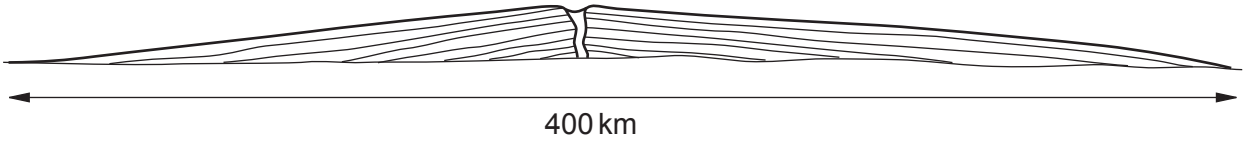
D Ordovician to Triassic

Your answer ☐ **[1]**

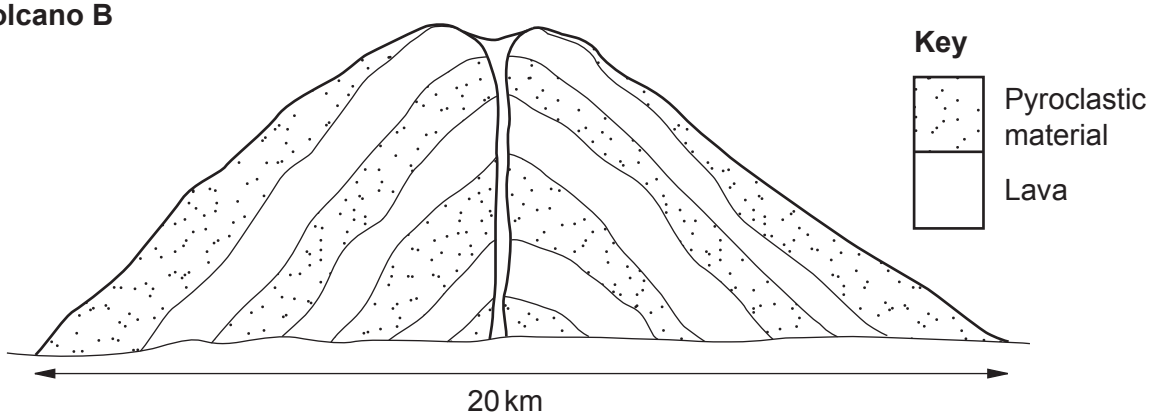
Section B

26 The diagrams show cross-section forms of **two** volcanoes, **A** and **B**.

Volcano A



Volcano B



(a)

(i) Identify the type of volcano shown in each cross-section diagram.

Volcano **A** .....

Volcano **B** .....

[2]

(ii) State the most likely plate tectonic settings for the locations of volcanoes **A** and **B**.

Plate tectonic setting for volcano **A** .....

Plate tectonic setting for volcano **B** .....

[2]

(b) Explain how magma forms at convergent plate margins.

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

(c) Buoyancy and viscosity are two factors that affect the behaviour of magma.

(i) Explain the difference between buoyancy and viscosity.

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

(ii) Outline a simple experiment that could be carried out in a school science laboratory to model the viscosity of magma using a liquid such as golden syrup.

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(d) Describe the process of intrusion by which magma ascends through the crust.

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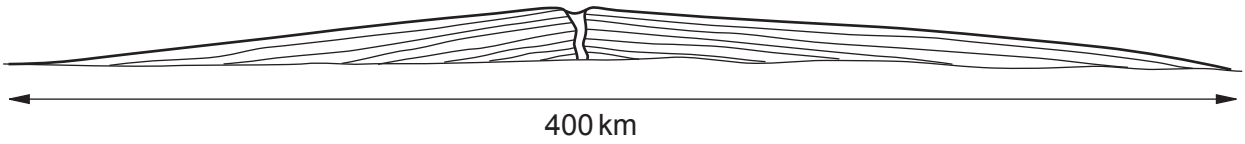
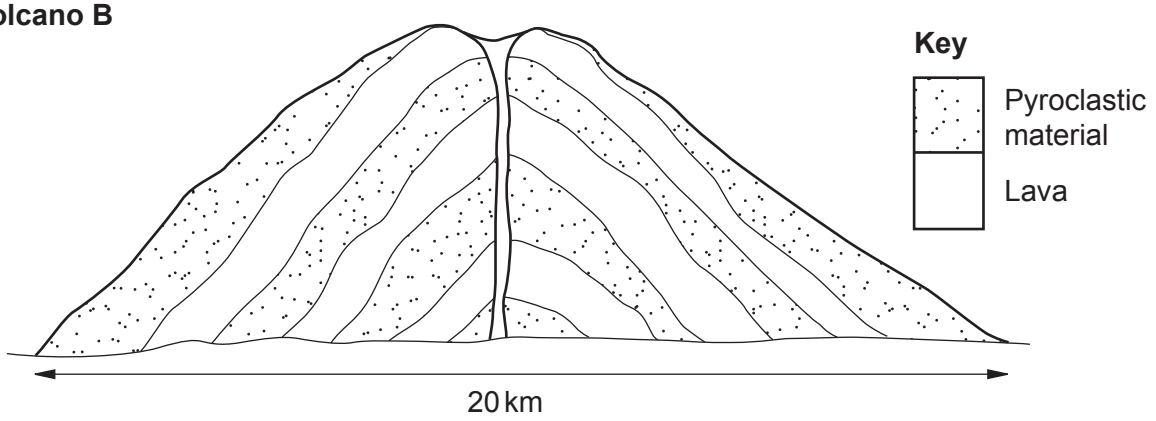
..... **[3]**

Cross-sections of volcanoes **A** and **B** are shown again for reference.

Volcano A



Volcano B



(e) The volume of material erupted from a volcanic vent each second is known as the discharge rate (Q). The discharge rate depends on:

- the depth of the magma chamber (d)
- the pressure within the magma chamber (P)
- the radius of the volcanic conduit (r)
- the viscosity of the magma (μ).

The table shows data for the start of an eruption from volcanoes **A** and **B**.

Volcano	d (m)	P (Pa)	r (m)	μ (Pa s)
A	5000	5.0×10^6	1.0	100
B	7000	3.0×10^7	50.0	450

The discharge rate for volcano **B** is $2.34 \times 10^7\ m^3\ s^{-1}$.

The formula for calculating the discharge rate is: $Q = \frac{\pi r^4 P}{8 \mu d}$

Use the formula and the data in the table to calculate the discharge rate for volcano **A**.

Give your answer to **3** significant figures.

Discharge rate for volcano **A** = ... $m^3\ s^{-1}$ **[3]**

(f)* Compare the nature of the eruption styles and volcanic hazards that would be associated with volcanoes **A** and **B**.

Use your knowledge of different magma compositions and characteristics to explain your answer.

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

Extra answer space if required.

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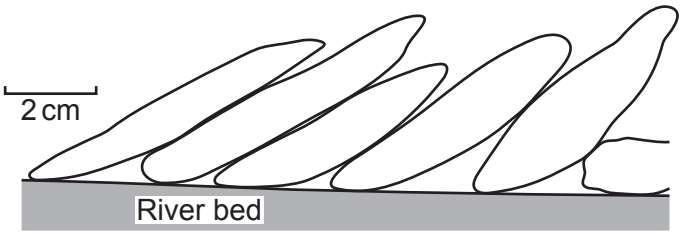
27

(a) The cross-section diagram shows an imbricate structure formed in river sediments.



(i) Draw an arrow above the diagram to show the current direction at the time of formation. **[1]**

(ii) Explain how an imbricate structure forms.

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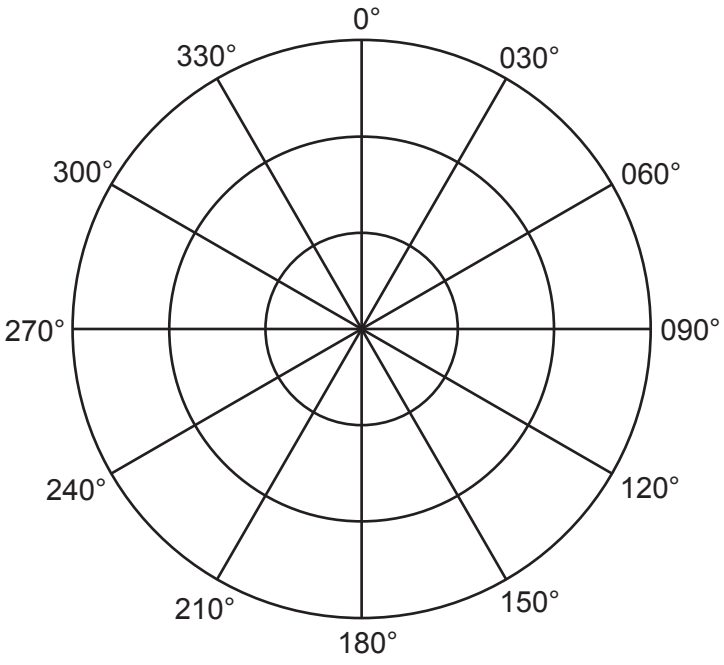
..... **[2]**

(b)

(i) The table shows measurements of dip direction of clasts in an ancient fluvial deposit showing imbrication.

Plot the data from the table on the rose diagram.

Dip direction (°)	Number of clasts measured
001–030	10
031–060	15
061–090	8
091–120	2
121–150	1
151–180	0
181–210	0
211–240	0
241–270	0
271–300	0
301–330	2
331–360	4

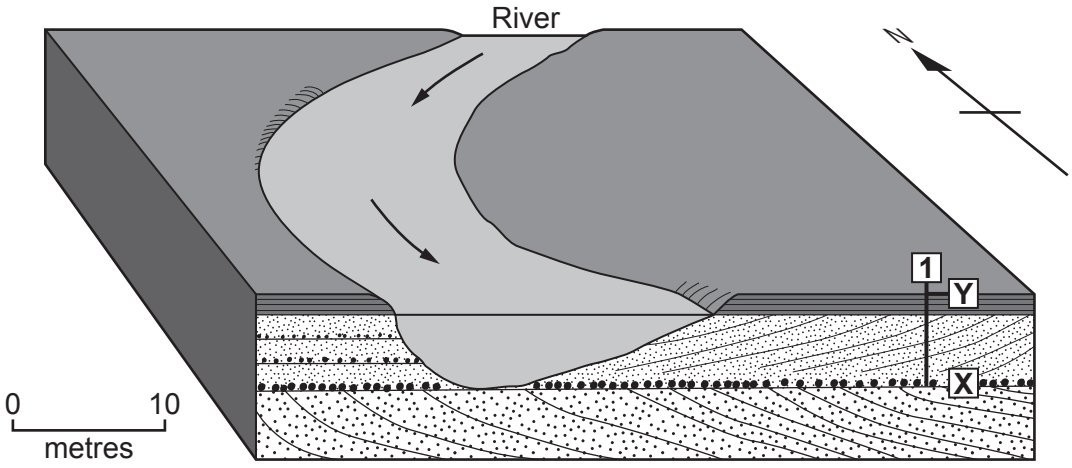


[2]

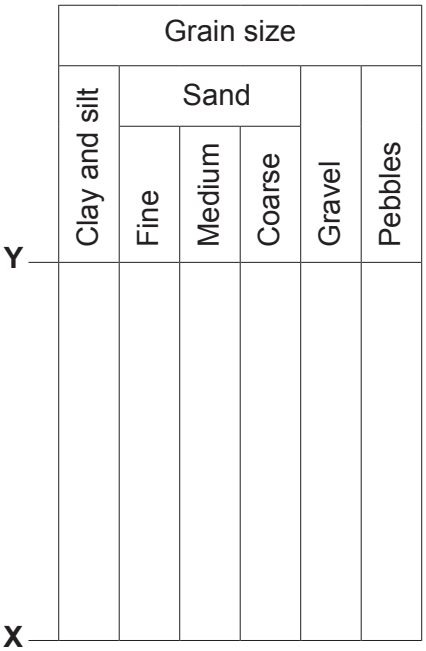
(ii) Interpret the palaeocurrent direction shown by the imbrication.

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

(c) The block diagram shows sediments deposited by a meandering river.



(i) Draw a sketch graphic log on the chart below to show the change in grain size from **X** to **Y** in the vertical sequence at location **1**.



[2]

(ii) Use Walther's Law to help explain how this vertical sequence of fluvial sediments formed.

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

(d) Evaporites can form in playa lakes and shallow marine environments.

(i) State the order of the **four** evaporite minerals that form when a playa lake dries up.

Last to form .....

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.....

First to form .....

[2]

(ii) Explain why the minerals form in this order.

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

(iii) An experiment showed that when a column of seawater 6 m deep was evaporated to dryness it produced an evaporite deposit 10 cm thick.

Based on the results of this experiment, calculate the depth of seawater needed to evaporate to produce an evaporite layer 150 m thick.

= ..... m **[2]**

(iv) Suggest how it is possible for thick sequences of evaporites to form in shallow marine environments.

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

(e)

(i) Describe how chalk forms in deep-water carbonate seas.

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

(ii) Chalk often contains nodules of flint.

Explain the most likely origin of flint nodules in chalk.

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

(iii) Explain why carbonate sediments do not form at depths greater than 5 km in modern marine environments.

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(f)* Describe and explain the differences in texture and mineralogy of sandstones deposited in desert and deep sea turbidite sedimentary environments.

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Extra answer space if required.

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28 Surface processes can be important in concentrating metal ore minerals to form economic deposits.

(a) The table shows properties of some common ore minerals.

Ore mineral	Chemical formula	Cleavage	Density ($g\,cm^{-3}$)	Hardness
Cassiterite	SnO_2	Poor	7.0	6–7
Chalcopyrite	$CuFeS_2$	None	4.2	3.5–4
Galena	PbS	3 at 90°	7.5	2.5
Gold	Au	None	19.3	3

(i) Use the data in the table to evaluate whether each ore mineral is likely to be found concentrated in placer deposits.

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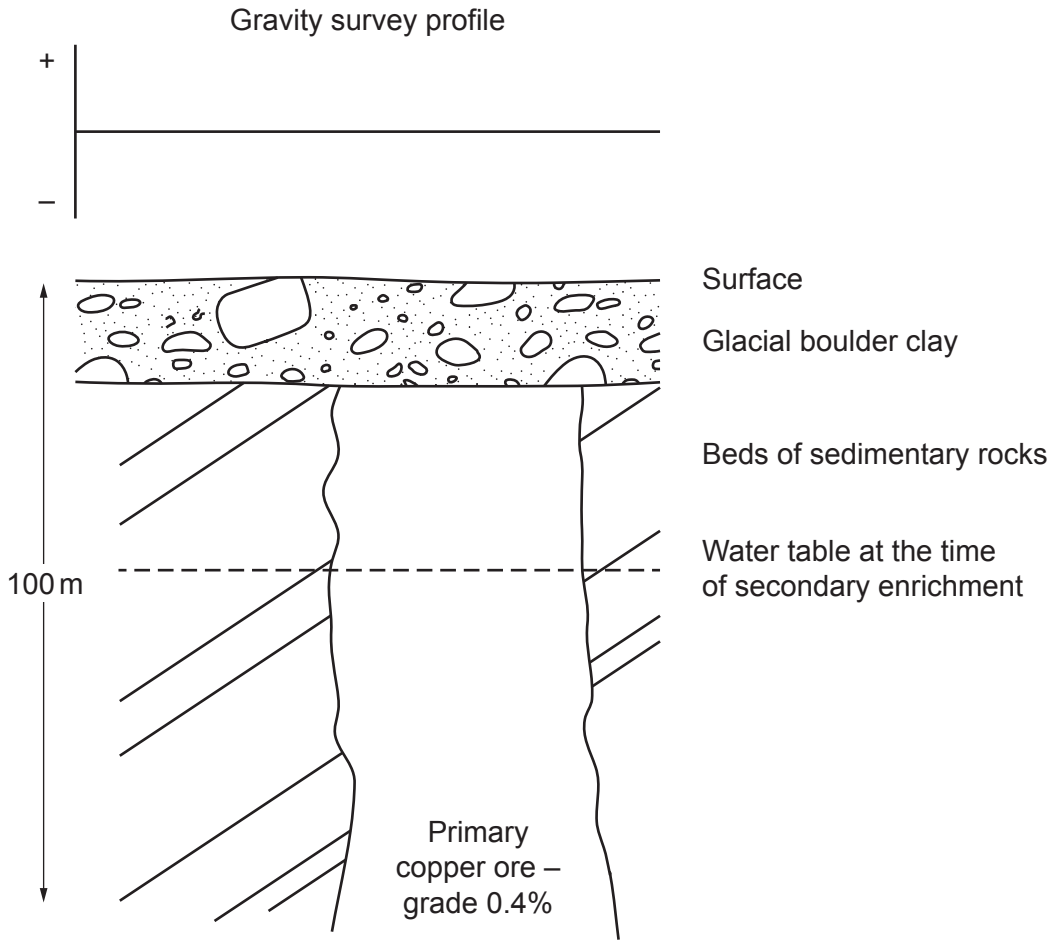
..... **[4]**

(ii) Draw **and** label a cross-section diagram to explain how placer deposits can form on beaches.

[2]

(b) The cross-section diagram shows the geometry of a vein of copper ore discovered using geophysical exploration techniques.

The copper ore has been concentrated by secondary enrichment.



(i) Shade on the cross-section an area where the percentage of copper will be >0.4%. **[1]**

(ii) Draw a sketch graph on the axes above the cross-section diagram to show the shape of the profile that would be produced by a transect gravity survey. **[1]**

(iii) Explain why geochemical exploration techniques may be unsuccessful in locating this vein of copper ore.

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(c) Prior to mining an ore deposit the reserves must be determined.

Describe the follow-up stages of mineral exploration and site investigation that allow reserves to be calculated.

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(d) A porphyry copper ore deposit has a circular cross-section area with a diameter of 800 m and is 500 m thick.

The average density of the ore is 3.2×10^3 kg m^{-3}.

(i) Calculate the mass of this copper ore deposit in tonnes.

Note: 1 tonne = 1000 kg

Mass = ... tonnes **[3]**

(ii) The average grade is 0.6% copper.

Calculate the reserves of copper in this copper ore deposit.

= ..... tonnes **[1]**

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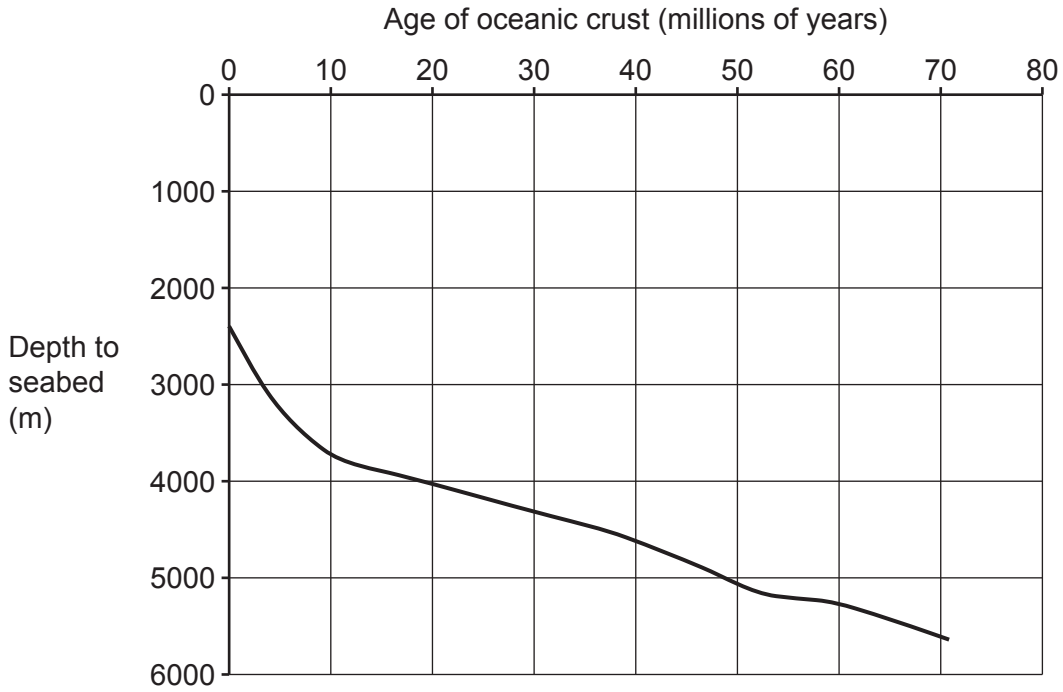
Turn over for the next question

29

(a) The graph shows the relationship between the depth to the seabed and the age of the oceanic crust in the eastern part of the Atlantic Ocean.



(i) Draw an arrow to show the position of the Mid-Atlantic Ridge on the graph. **[1]**

(ii) Explain the change in depth to the seabed shown on the graph.

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

(b) A basalt sample obtained from the seabed by dredging was radiometrically dated using the potassium–argon (^{40}K–^{40}Ar) method.

95% of the parent ^{40}K isotope remained in the basalt sample.

The decay rate equation is: $N = N_0e^{-\lambda t}$

Where:

N = % of ^{40}K in the sample

N_0 = initial % of ^{40}K in the sample at the start of decay

λ = the decay constant = 0.693 / 1250 for the ^{40}K–^{40}Ar system

t = the age of the sample in millions of years

Rearrange the decay rate equation to make t the subject.

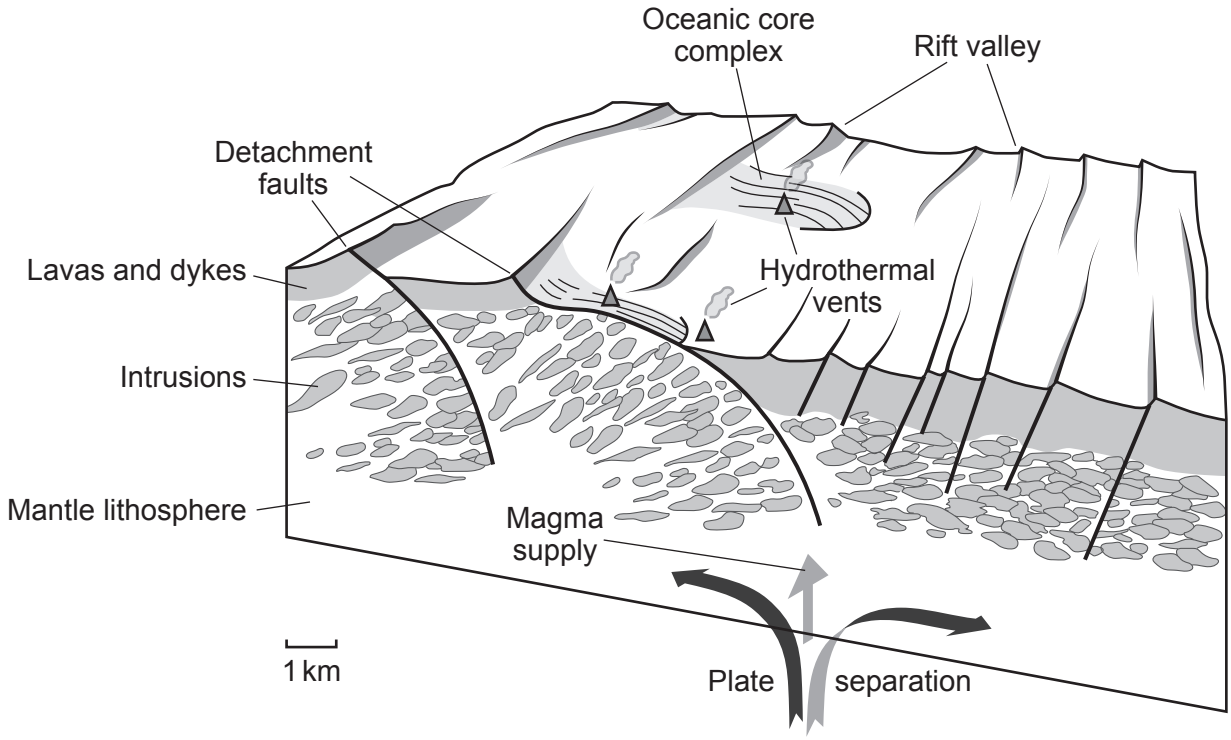
Calculate the age of the basalt sample (t) in millions of years (Ma).

Age of basalt sample (t) = ... Ma **[2]**

(c) The Mid-Atlantic Ridge is a slow-spreading ridge.

Recent research has shown that slow-spreading ridges have unusual features.

The simplified block diagram shows some of these features.



(i) Use information shown on the diagram to describe **one** characteristic of a detachment fault.

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

(ii) Gabbro and peridotite have been found at the surface of oceanic core complexes.

Explain the origin of the gabbro and peridotite and why they are now exposed at the surface.

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

(d) Hydrothermal vents are common along mid-ocean ridges.

(i) Explain how these hydrothermal vents form.

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

(ii) Describe **one** feature and **one** product of hydrothermal vents at mid-ocean ridges.

Feature .....

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Product .....

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[2]

(e) Ore deposits that originated from hydrothermal processes at mid-ocean ridges occur in sequences of oceanic lithosphere found in continental areas.

(i) What name is given to sequences of oceanic lithosphere found in continental areas?

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

(ii) Explain how these sequences become incorporated into continental crust.

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

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use this lined page. You must write the question numbers clearly in the margin.