OCR
Oxford Cambridge and RSA

Tuesday 06 October 2020 – Afternoon

A Level Geology

H414/01 Fundamentals of geology

Time allowed: 2 hours 15 minutes

You can use:
- a ruler (cm/mm)
- an HB pencil
- 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 **32** pages.

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

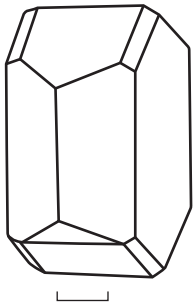
SECTION A

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 Crystal shape is strongly affected by cooling rates. Very slow cooling rates in plutonic intrusions produce crystals such as the one below.



Identify the crystal shape shown.

A anhedral

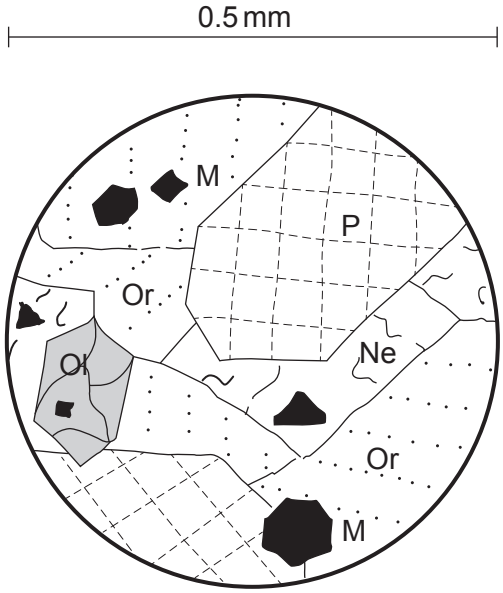
B euhedral

C equant

D platy

Your answer ☐ **[1]**

The thin-section diagram below is of an unusual igneous rock. Five of the minerals that make up the rock have been identified and labelled.



Questions **2** and **3** refer to this diagram.

2 Using your knowledge of igneous textures, identify the apparent order in which the minerals crystallised.

A first (P – Or – Ne – Ol – M) last

B first (M – Ol – P – Ne – Or) last

C first (M – Or – Ne – Ol – P) last

D first (Or – Ne – P – Ol – M) last

Your answer ☐ **[1]**

3 Which of the following best describes the texture of the igneous rock?

A fine, porphyritic

B medium, vesicular

C fine, equicrystalline

D medium, porphyritic

Your answer ☐ **[1]**

4 An igneous rock showing flow-banded texture was formed by which of the following processes?

A crystals settling at the base of the magma chamber

B gas bubbles forming as volatiles exsolve during cooling

C coarse crystals forming by slow cooling in the magma chamber

D separation of minerals in lava

Your answer ☐ **[1]**

5 A forward-looking infrared (thermal) camera produces an image using a colour spectrum that correlates to the detected temperature. A lava measured appears to be at 900 °C.

Which of the following terms is most likely to describe its chemistry?

A intermediate

B mafic

C silicic

D ultramafic

Your answer ☐ **[1]**

6 An infrared camera was used in preference to direct measurement with a thermocouple probe.

Which of the following reasons would explain that choice?

A greater accuracy

B greater safety

C greater resolution

D better penetration of ash clouds

Your answer ☐ **[1]**

7 Which of the following provides evidence for the rheid nature of the asthenosphere?

A the negative gravity anomaly over Cornwall

B the positive gravity anomaly over Cornwall

C the negative gravity anomaly over Scandinavia

D the positive gravity anomaly over Scandinavia

Your answer ☐ **[1]**

8 Which of the following statements describes advection?

A a process by which thermal energy is transferred through a substance with no overall movement of that substance

B a process by which thermal energy is transferred through a medium by a substance (fluids or rheids) due to buoyancy differences within the substance

C a process by which thermal energy is transferred through a medium by a fluid

D a process whereby electromagnetic radiation is generated by the thermal motion of particles in the substance

Your answer ☐ **[1]**

9 Approximately two thirds of the Earth's geothermal energy results from radioactive decay. The half-life of Uranium-238 is 4.47×10^9 years.

Approximately, what fraction still remains of the Uranium-238 that was present when the Earth was formed?

A $\frac{1}{4}$

B $\frac{1}{2}$

C $\frac{3}{4}$

D $\frac{7}{8}$

Your answer ☐ **[1]**

10 In an early attempt to classify the elements according to how they occur in the Earth, elements which combine readily with oxygen such as aluminium, calcium, potassium and titanium were classed by Goldschmidt as which of the following?

A atmophile

B chalcophile

C lithophile

D siderophile

Your answer ☐ **[1]**

11 The chemical properties of the elements determine the type of compounds and/or phases they form. This influences density and therefore where they occur in the layered Earth.

Which of the following statements would explain the existence of metals in the crust that were expected to be only found in the core?

A they have anomalous chemistry and form sulfides

B they are the result of deep weathering of granites

C they were in meteorites landing after the crust had solidified

D oxygen was not available in the Proto-Earth

Your answer ☐ **[1]**

12 The present understanding of plate tectonics rests upon the development of earlier models. The geosyncline model was developed in the nineteenth century based on the geology of the Appalachian and Caledonian mountains.

Which of the following ideas were used to explain orogeny at that time?

A continents are carried by convection of the mantle

B lateral compression is caused by the contraction of the Earth as it cools

C continents move towards the equator due to gravitational and centrifugal forces

D cold lithospheric plates sink into the mantle carrying continents as they are subducted

Your answer ☐ **[1]**

13 A student sampled fossils in three different beds, keeping a tally of the different types of fossils and their frequency.

Which of the following statistical tests should be used to see if these beds contain significantly different assemblages?

A Standard deviation

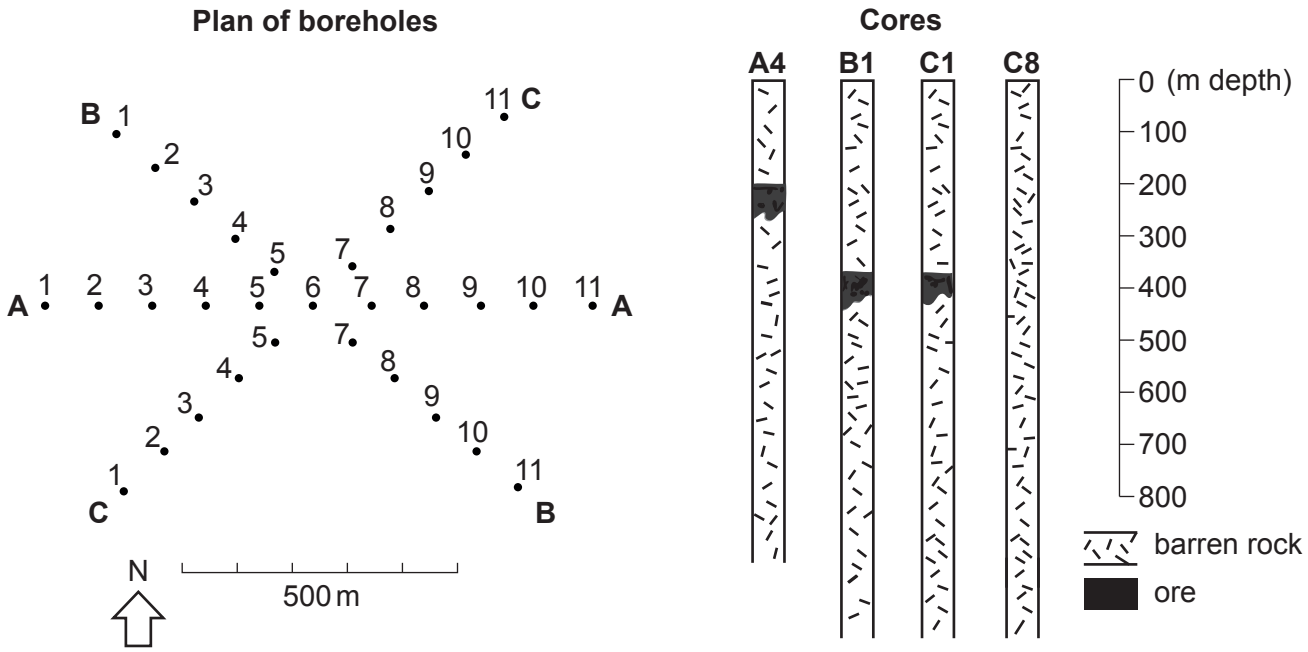
B Man-Whitney *U*-test

C Spearman's rank

D Chi squared

Your answer ☐ **[1]**

14 To assess the reserves prior to mining, a star-shaped pattern of exploratory boreholes was centred on an indication of the metal ore at the surface (gossan). The diagram shows the plan of boreholes and the core recovered for four of the boreholes.



Using this evidence, what is the most likely extent and structure of the ore body?

A a 200 m radius, vertical cylinder centred on A6

B a sheet-like body dipping shallowly (20°) to the south

C a sheet-like body dipping steeply (45°) to the west

D two horizontal sheets, each about 50 m thick

Your answer ☐ **[1]**

15 The geological conditions play an important part in establishing and maintaining a sustainable mining operation.

Which of the following conditions would **least** affect the viability of a deep coal mine using longwall retreat extraction?

A frequency of faulting

B dip of strata

C depth of overburden

D throw of faults

Your answer ☐ **[1]**

16 Earthquake forecasting is widely used and refers to the probability of an earthquake occurring, with reference to the frequency and magnitude of damaging events, in a given area over a period of years.

What is the main criticism of this method?

A it does not account for uncertainty in the geographical location

B there is a lack of physical and mathematical evidence

C there is uncertainty in the magnitude for previous earthquakes

D it does not account for the different ways in which waves propagate

Your answer ☐ **[1]**

17 An earthquake of magnitude 6.0 has an annual probability of 0.02.

Which of the following statements describes the risk of a seismic event?

A An earthquake of that magnitude will definitely happen within 50 years of the last one.

B There is a lower chance of an earthquake as one happened 2 years ago.

C There is a higher chance of an earthquake because it has been nearly 50 years since the last one.

D There is a 2% chance that an earthquake of that magnitude will occur this year.

Your answer ☐ **[1]**

18 The amniotic egg allowed dinosaurs to successfully adapt to life on land.

Which of the following components is also found in eggs laid in water?

A a hard shell

B a porous shell

C a yolk sac

D albumen

Your answer ☐ **[1]**

19 The Burgess Shale has become the best known Konservat-Lagerstätt in the fossil record and is located in the Canadian Rockies. Early ideas that the exceptional preservation involved an underwater avalanche have been replaced by an understanding of the unique chemistry of the sea-water and site of deposition.

Using your knowledge of preservation and early diagenesis, which of the following chemical environments resulted in the preservation of the fossils?

A decreased calcium carbonate concentrations and decreased oxygen and sulfate

B enhanced calcium carbonate concentrations and increased oxygen and sulfate

C decreased calcium carbonate concentrations and depletion of oxygen and high sulfate

D enhanced calcium carbonate concentrations and depletion of oxygen and sulfate

Your answer ☐ **[1]**

20 Which of the following microfossils is **least** likely to be useful in the biostratigraphic analysis of sediments when locating hydrocarbon reserves?

A coccolithophores – phytoplankton with calcareous skeletons, a major component of chalk

B conodonts – minute tooth-like fossils composed of apatite occurring in rocks of Palaeozoic age

C foraminifera – protists with an external shell, of which there are 40,000 species

D radiolaria – protozoa that produce intricate mineral skeletons, typically made of silica

Your answer ☐ **[1]**

21 Once an exploratory well has been drilled and the cuttings analysed for geology and biostratigraphy, more information on the solid rock can be gained by down-hole geophysics. Organic content can be measured by gamma ray logs. Resistivity and porosity are also routinely measured.

Which of the following combinations of outputs is most likely to show trapped oil?

A high porosity, high resistivity, high gamma ray count

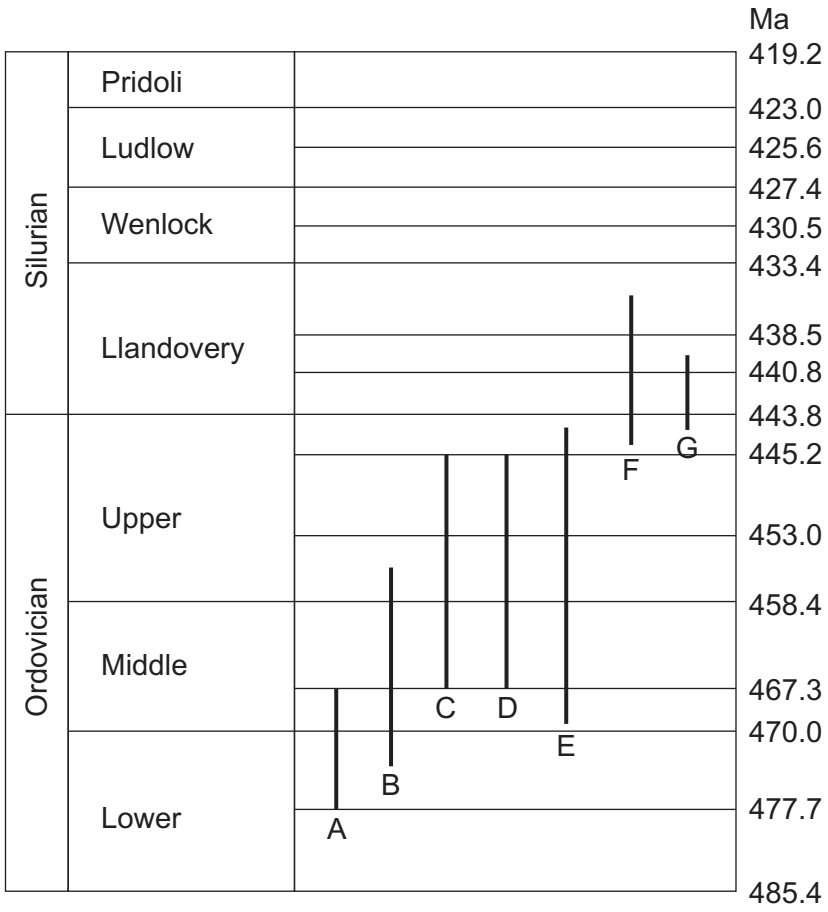
B high porosity, low resistivity, low gamma ray count

C low porosity, low resistivity, high gamma ray count

D low porosity, high resistivity, low gamma ray count

Your answer ☐ **[1]**

22 Graptolites are used to zone the Welsh Basin. There are graptolite biozones identified throughout the Ordovician and Silurian. The diagram shows a simplified evolution of graptolite genera. Solid lines show the fossil ranges, plotted to scale, based on absolute age dating.



Which combination of graptolite genera provides the most precise age range for the rock in which they are found?

A A, B and E

B B, C and E

C C, D and E

D E, F and G

Your answer ☐ **[1]**

23 The average crustal abundance of copper is 0.007%. The global average grade for copper ore extracted in 2016 was 0.62%.

Which of the following represents the concentration factor necessary for economic ore extraction in 2016?

A 0.0043

B 0.011

C 8.86

D 88.6

Your answer ☐ **[1]**

24 Chalcopyrite is one of the most common copper sulfide minerals.

Which of the following is the formula for the mineral?

A Cu_5FeS_4

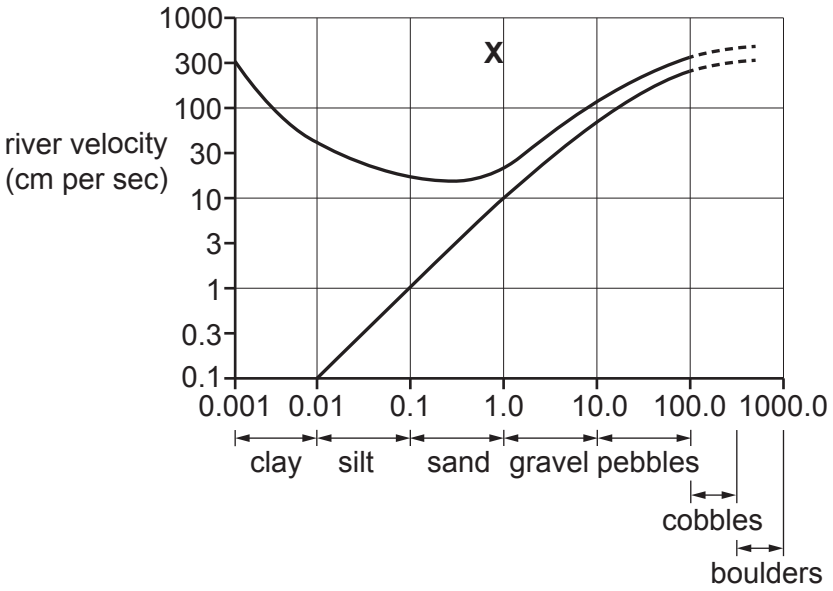
B CuS_2

C $CuFeS_2$

D CuS

Your answer ☐ **[1]**

25 The graph shows a Hjulstrom curve.



Which of the following processes best describes the area marked **X**?

A erosion

B deposition

C saltation

D transportation

Your answer [ ] **[1]**

SECTION B

Answer **all** the questions.

26 **(a)** Complete the paragraph by choosing the most appropriate terms from the list below.

burial **death assemblages** **traces** **soft parts**

life assemblages **morphology** **taphonomy**

A species of an extinct organism can only be classified using ..... .

Fossils are the remains of organisms which are preserved in rocks. The process of fossilisation is called ..... and this determines how well preservation has occurred.

Well-preserved fossils are often ..... .

[3]

(b) Explain why fossils that are preserved within most sedimentary rocks are not a true record of what lived in those environments.

.....

.....

.....

.....

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

(c) Fig. 26.1 shows diagrams of U-shaped and vertical trace fossils (burrows) from a shallow sea environment.

× 0.25

Fig. 26.1

Using Fig. 26.1, interpret the environment of deposition.

.....

.....

.....

.....

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

(d)* Fig. 26.2 shows the external morphology of a fossil bivalve and a brachiopod, not to scale.

bivalve brachiopod

Fig. 26.2

Using Fig. 26.2 and your own geological knowledge, describe and explain the differences between a brachiopod and a bivalve.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

Additional answer space if required.

.....

.....

.....

.....

.....

(e) Ornithischian and Saurischian are the names of two different orders of dinosaurs.

(i) Ornithischian and Saurischian dinosaurs show major differences in their skeletons.

Describe **one** difference which can be used to classify these dinosaurs **and** explain the advantage of that characteristic.

.....

.....

.....

.....

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

(ii) Complete the table by identifying the features characteristic of a Saurischian Sauropod dinosaur. Indicate your answers using a tick (✓).

Feature	Characteristic of Sauropod?
Large olfactory lobes	
Gastroliths	
Peg like teeth	
Thumb spike	
Short neck	
Laid amniotic eggs	

[3]

(iii) State one possible cause for the mass extinction of the dinosaurs.

.....

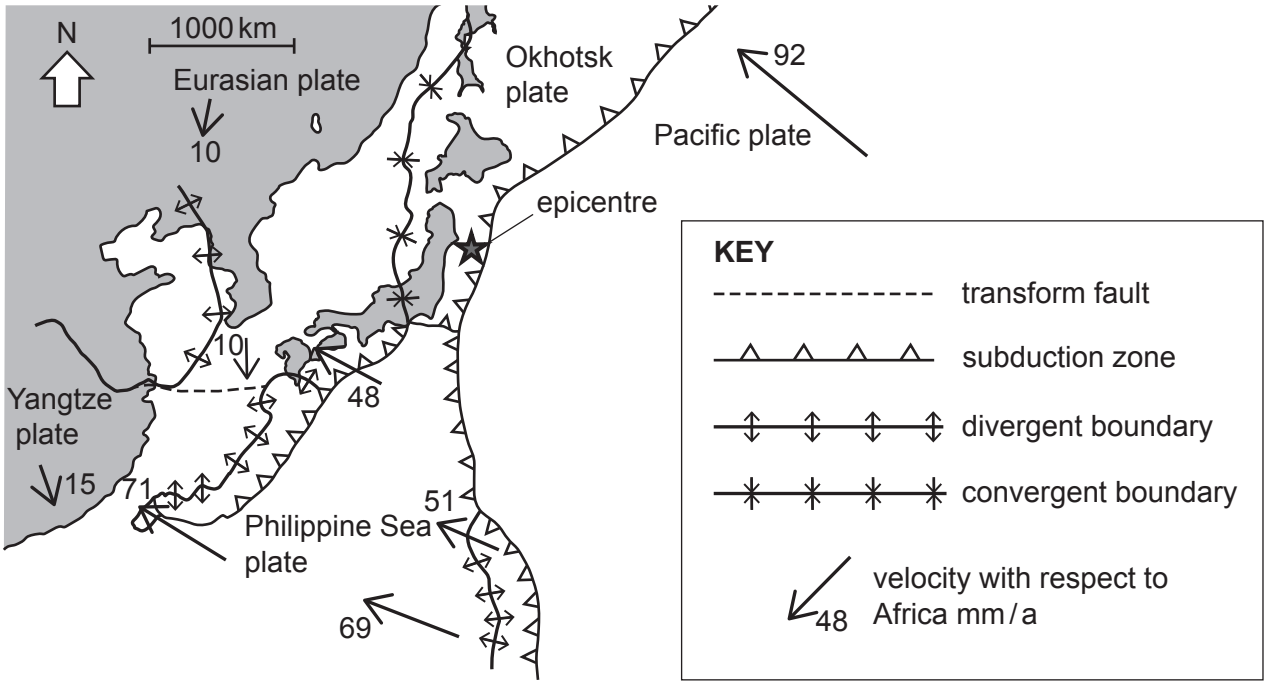
..... **[1]**

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

Turn over for the next question

27 The map shows the different plate margins in the region of Japan along with their relative plate motion.



(a) (i) What kind of stresses dominate at conservative margins such as the one to the south-west of Japan?

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

(ii) Conservative margins include transform faults, which are often the cause of earthquakes.

Explain the elastic rebound theory which accounts for many of the observed properties of earthquakes.

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

(b) (i) The map shows the epicentre of the 2011 Tohoku earthquake. It had a magnitude of 9.1 and resulted in a devastating tsunami.

Explain why earthquakes at convergent plate boundaries in the Japan region are the most likely cause of such devastating tsunami.

.....

.....

.....

.....

.....

.....

.....

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

(ii) Describe **two** ways by which the effects of a tsunami could be mitigated by the use of GIS.

.....

.....

.....

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

(iii) The Pacific plate is closing with the Okhotsk plate at a rate of 90 mm / a and the subduction zone dips at 30°.

Calculate how long it would take the subducting plate to reach a depth of 150 km.

number of years = ... Ma **[4]**

(iv) Describe how you would recognise geological evidence of past tsunami events.

.....

.....

.....

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

28 The diagram shows a bathymetric section across an ocean ridge.

Bathymetric section, Vine, F. J; Matthews, D. H. (1963). "Magnetic Anomalies Over Oceanic Ridges" Springer Nature. Item removed due to third party copyright restrictions. Link to material: https://www.nature.com/search?q=Vine%2C+F.+J%3B+Matthews%2C+D.+H.

(a) (i) Explain why this ocean ridge has a rift valley at its axis.

.....

.....

.....

.....

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

(ii) State whether this ocean ridge is fast-spreading or slow-spreading **and** give a reason for your choice.

.....

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

(iii) Describe the mechanisms that form ocean core complexes at ocean ridges.

.....

.....

.....

.....

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

(b) Explain why there is a negative Bouguer gravity anomaly over the axial rift.

.....

.....

.....

.....

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

(c) As new oceanic lithosphere is created at the ridge and spreads away from the axis, it cools as it ages. As it cools, it sinks and there is a straightforward relationship between its age and the depth of sea water above it.

The relationship is defined by the equation: $w = k\,t^x$

where w is the depth, t is the age, k is a constant and x is a power.

The table shows age and depth measurements from the Mid Atlantic Ridge.

t (Ma)	w (m)
5	726.7
10	1027.7
15	1258.7
20	1453.4
25	1625.0
30	1780.1
35	1922.7
40	2055.5
45	2180.2

(i) The constant k for this part of the ocean is 325. Rearrange the equation and use logarithms on any pair of the data.

Calculate the power x.

x = ... **[3]**

(ii) State how you would use a graphical method to find the constant of proportionality k.

.....

.....

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

(iii) How would a fast-spreading rate affect the topography of the ocean ridge, given that the relationship between cooling and water depth remains the same?

.....

.....

.....

.....

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

(d) (i) How does the topography of the ocean ridge contribute to sea-floor spreading?

.....

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

(ii) It is estimated that slab pull provides twice the force on the lithosphere as ridge push.

Suggest why this is **and** why plate velocities in the Pacific and Atlantic oceans support this comparison.

.....

.....

.....

.....

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

(e)* Explain how magma is generated at divergent margins **and** why it has mafic chemistry.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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

Additional answer space if required.

.....

.....

.....

.....

.....

29 The global demand for copper has increased dramatically in recent years. From 1991 to 2015 the world's copper extraction has doubled from 9.3 to 18.7 million tonnes. The average grade of copper extracted in 2016 was 0.62%. There is realistic concern over the future of available copper, as reserves are finite.

(a) (i) Identify and describe **one** geological process that results in an increased concentration of copper in an ore deposit.

.....

.....

.....

.....

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

(ii) The table shows changes in the estimated copper ore grade, as it was extracted, from 1900 to 2000.

Year	Average grade of copper %
1900	4.00
1920	1.98
1940	1.78
1960	1.75
1980	1.50
2000	1.10

Explain why the grade of mined copper has decreased throughout the twentieth century.

.....

.....

.....

.....

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

(iii) Calculate the percentage change in the grade of extracted copper ore between 1920 and 2000.

percentage change = ... % **[2]**

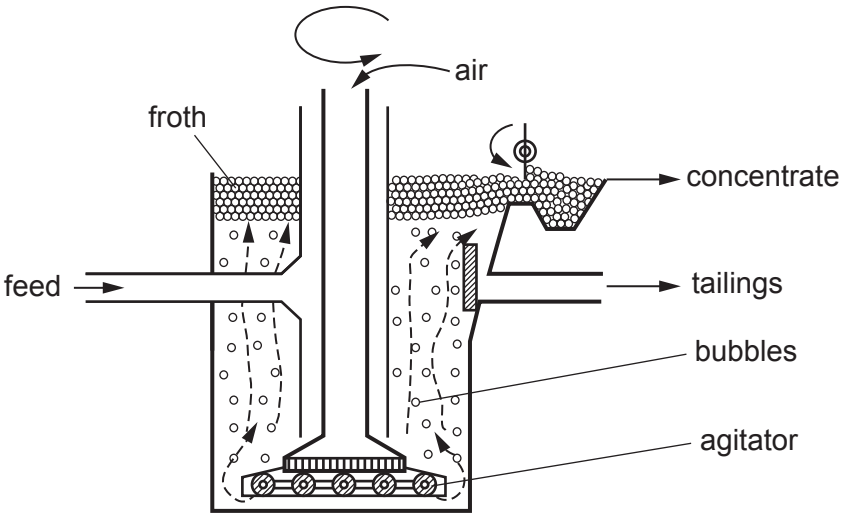
(iv) Complete the table to indicate how copper deposits can be located in the field.

Method of exploration	**How method is used to locate copper deposits**
Geochemical	....
Geophysical	....

[2]

(b) Escondida is the largest copper mine in the world.

At Escondida, 77% of the copper is found as sulfide ore which can be concentrated by froth flotation. The diagram shows a generalised froth flotation cell.



Describe and explain how froth flotation can be used to process the copper ore extracted from Escondida mine.

.....

.....

.....

.....

.....

.....

.....

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

(c) While mines are operational, the water used in the mineral extraction process is treated before being discharged into rivers. Once mines are no longer useful for mineral extraction, they are abandoned.

The formation of acidic waters is a major issue in abandoned mines and is known as acid mine drainage (AMD).

(i) Describe the chemical changes that enable mine water to become acidic.

.....

.....

.....

.....

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

(ii) Water from closed mines can be treated by passive methods.

State **and** explain how one passive treatment method is used to reduce the impact of AMD.

.....

.....

.....

.....

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

30 The North Sea oil and gas basin has been successfully exploited since the early 1970s. Due to diminishing reserves, the location of the remaining oil and gas now requires sophisticated geophysics and geological knowledge.

(a) The basic requirements are a source rock, maturation, a reservoir rock, a caprock and some form of trap to achieve economic exploitation of the hydrocarbons.

(i) State what makes a good source rock and name the depositional environment in which it formed.

.....

.....

.....

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

(ii) Explain the process **and** results of maturation.

.....

.....

.....

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

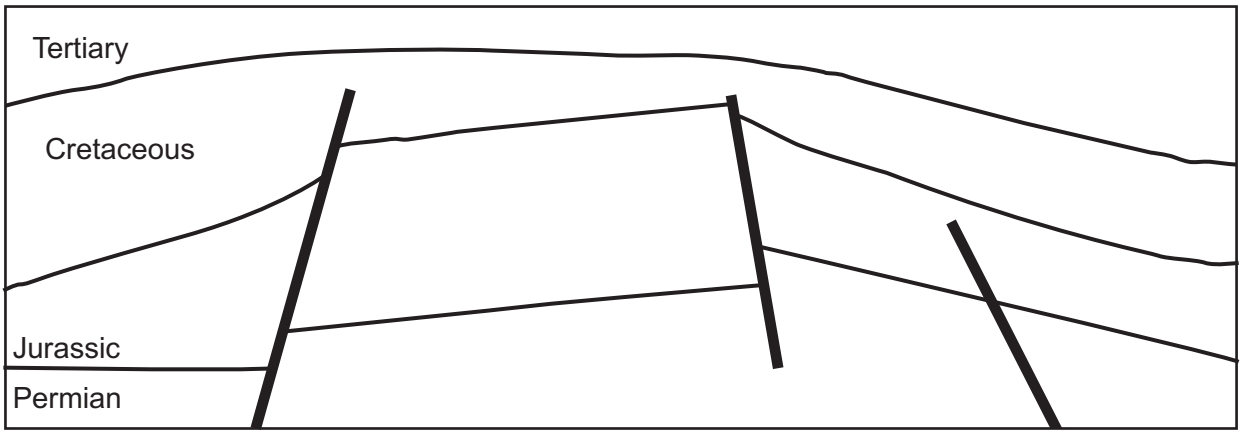
(iii) Once formed, the fluid hydrocarbons will rise with the water that is squeezed out of the rock. They would eventually escape at the surface unless prevented by the geology.

Complete the table by identifying one property and giving one example for caprocks and reservoir rocks.

	Property	**Example**
Caprock	.....	.....
Reservoir rock	.....	.....

[2]

(iv) The diagram shows a simplified cross section of the Piper Field in the northern North Sea.



Label the diagram to show the source, reservoir and caprocks. Shade where you might expect oil to be trapped. **[5]**

(b) To locate suitable traps, it is necessary to conduct geophysical surveys over the area being investigated.

Explain the role of gravity surveys in locating oil fields.

.....

.....

.....

.....

..... **[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).