GCE

Geology

H414/01: Fundamentals of geology

A Level

Mark Scheme for June 2024

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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 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. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

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

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

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 40% 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 or the RM Assessor messaging system, or by email.

5. **Crossed Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

   Rubric Error Responses – Optional Questions
   Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

Multiple Choice Question Responses
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. *(The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)*

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

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. Award No Response (NR) if:
    - there is nothing written in the answer space

Award Zero '0' if:
    - anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

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 e-mail.

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 scientific 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 science 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 science content determines the level.

The communication statement determines the mark within a level.

Levels of response questions on this paper are **26(f)** and **27(f)**.

11. **Annotations**

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
	Benefit of doubt given
	Contradiction
	Rounding error
	Error in number of significant figures
	Error carried forward
	Level 1
	Level 2
	Level 3
	Benefit of doubt not given
	Noted but no credit given
	Ignore
	Blank page

12. **Subject Specific Marking Instructions**

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
✓	Separates marking points
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

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.

Question			Answer	Marks	AO Element	Guidance
1			A	1	2.1b	Calcite
2			A	1	2.1a	Marble
3			B	1	2.1a	Mantle
4			B	1	1.1c	Giant nebula collapses → Rotation increases and protoplanetary disc forms → Formation of planetesimals
5			C	1	2.1a	Oceanic crust
6			C	1	2.1b	Graph **C**
7			C	1	2.1a	Fold **1** – Nappe **AND** Fold **2** - Isoclinal
8			C	1	2.1b	Diagram C (Accurate but imprecise)
9			A	1	1.1d	Dyke
10			C	1	1.1d	Rock **3**
11			D	1	2.1a	Synform plunging south
12			D	1	1.1c	Sillimanite to andalusite
13			C	1	1.1a	Mudstone
14			C	1	1.1c	Dolerite sill
15			A	1	1.1c	Massive beds of well jointed, fissured limestone
16			C	1	2.1a	Earth dam
17			B	1	2.1a	Aquitard
18			B	1	1.1a	Galena
19			A	1	1.1a	Cretaceous
20			D	1	1.1a	Water temperature 27°C, water depth 15 m **AND** salinity 35‰
21			A	1	1.1a	High salinity and anoxic conditions
22			C	1	2.1a	Deltaic topset beds
23			D	1	1.1c	Subsidence
24			A	1	2.1a	Ammonites and belemnites
25			B	1	1.1a	Cambrian to Permian

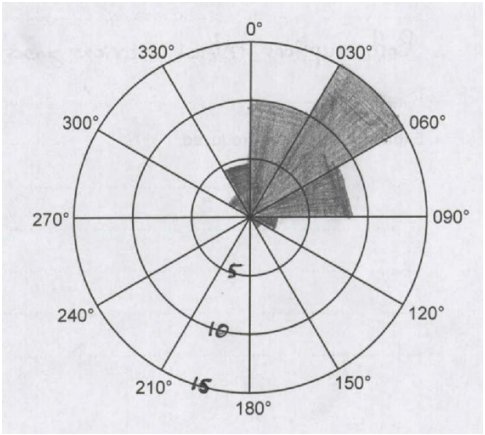
Question			Answer	Marks	AO Element	Guidance
26	(a)	(i)	Volcano **A** = Shield ✓ Volcano **B** = Strato(volcano) / Composite (cone) ✓	2	1 x 1.1a 1 x 2.1a	**ALLOW** mafic / basaltic for **A** **ALLOW** intermediate / andesitic / silicic / rhyolitic for **B** **DO NOT ALLOW** Strata for **B**
26	(a)	(ii)	Volcano **A** – Hot spot / Intraplate ✓ Volcano **B** – Convergent plate boundary / Subduction Zone ✓	2	1.1c	**ALLOW** divergent / constructive for **A** **ALLOW** destructive plate boundary for **B**
26	(b)		• Temperature increases with depth **OR** the geothermal gradient / geotherm crosses the solidus / melting point curve of the rock ✓ • Partial melting **OR** lower temperature minerals melt first ✓ • Water is released **OR** hydrated minerals heat up and release water **OR** crustal minerals dehydrate ✓ • Flux melting **OR** Water (added during subduction) lowers the melting point of minerals ✓ • Melting of mantle wedge / (base of) crust above the subducted plate ✓	Max 3	1 x 1.1a 1 x 1.1c 1 x 2.1a	
26	(c)	(i)	Buoyancy – the upwards force that causes a magma to rise **OR** the ease that magma rises (due to lower density) ✓ Viscosity – is the resistance of a magma to flow **OR** the ease / rate at which a magma flows / moves ✓	1 1	1 x 1.1a 1x 1.1c	**ALLOW AW** **DO NOT ALLOW** floats

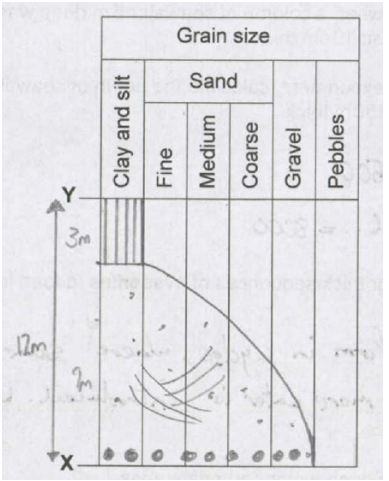
Question			Answer	Marks	AO Element	Guidance
26	(c)	(ii)	• Drop a heavy object / ball bearing through the liquid ✓ • Measure the time taken for the object to fall a known distance ✓ **OR** • Place the liquid in a stoppered test-tube and tilt the tube **OR** place the liquid on a slope ✓ • Measure the time taken for the liquid to flow a known distance ✓ **OR** • Place the liquid in the centre of circular grid ✓ • Measure the time taken for the liquid to flow outwards to a known distance **OR** allow the liquid to flow outwards till it stops and measure the distance / area over which it has flowed ✓	**2**	**3.1f**	**ALLOW** description of any suitable method that includes measuring the time taken for an object to fall through the liquid **OR** the time taken for the liquid to flow a certain distance / the distance over which the liquid has flowed
26	(d)		• Magma rises as (low density) <u>diapirs</u> ✓ • <u>Stoping</u> **OR** occurs as the magma pushes up through joints / faults / bedding planes / mechanically fractures the surrounding rock ✓ • Magma mixing may occur **OR** enclaves of magma of a different composition may be preserved due to incomplete mixing ✓ • Assimilation of country rock **OR** contamination of magma by country rock may occur ✓ • Xenoliths of country rock may be detached and settle / be preserved in the magma ✓	**Max 3**	**1 x 1.1a** **1 x 1.1c** **1 x 2.1a**	**AW**

Question			Answer	Marks	AO Element	Guidance
26	(e)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer =** 3.93 **(m^3 s^{-1}) award 3 marks** Correct substitution of data into the formula for volcano A: $Q = \frac{\pi \times 1.0^4 \times 5.0 \times 10^6}{8 \times 100 \times 5000}$ ✓ Discharge rate for volcano A = 3.926990817 (m^3s^{-1}) ✓ 3.93 to 3 SF (m^3 s^{-1}) ✓	3	2.1b	**ALLOW** if used π as: 3.14 then accept 3.925 = 3.93 3.142 then accept 3.9275 = 3.93 **MAX 2** for correct answer not to 3 sig fig
26	(f)*		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)** Provides a detailed comparison of the eruption styles **AND** volcanic hazards associated with volcanoes **A** and **B** using correct technical terminology. **AND** Gives full explanations linked to the differing compositions and characteristics of the magmas. *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)** Provides some comparison of the eruption styles **OR** the volcanic hazards associated with volcanoes **A** and **B** using correct technical terminology. **AND**	6	**2 x 1.1c** **2 x 3.1b** **2 x 3.1e**	**Indicative points may include:** Comparison of eruption styles may include: • Volcano **A** has effusive / non-explosive / passive / VEI 0-1 / Hawaiian style eruptions whereas volcano **B** has explosive / violent / VEI 2-8 / Strombolian up to Plinian / Ultra-Plinian style eruptions Volcano **A** description of hazards may include: • Main hazards are lava flows and gases • Lava flows are fast moving / flow up to 50 km h^{-1} / flow long distances / flow up to 50 km • Lava flows may destroy property / cause fires / rarely kill people • Very little pyroclastic material is produced Volcano **B** description of hazards may include:

Question			Answer	Marks	AO Element	Guidance
			Gives some relevant explanations linked to the differing compositions and/or characteristics of the magmas. *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)** Provides a correct description of the eruption style **OR** a volcanic hazard associated with either volcano **A** or **B**. There is little or no attempt to provide correct explanations linked to the composition and/or characteristics of the magma. *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.			• Blast damage can be very destructive with large loss of life / trees flattened / buildings destroyed • Lava flows are slow moving / do not flow far from the vent • Main hazards are pyroclastics / pyroclastic flows • Ash fall is widespread and causes damage to agricultural land / roof collapse / respiratory problems and eye irritation / can be a hazard to aircraft • Pyroclastic flows are mixtures of pyroclastics and gases at high temperature / move rapidly causing extensive damage / can cause many deaths • Lahars / tsunamis may be generated • Both **A** and **B** may emit volcanic gases such as CO_2 and SO_2 which may cause suffocation / be poisonous Explanations of differences may include: • Volcano **A** is mafic / basaltic / low silica composition whereas volcano **B** is intermediate / andesitic / silicic / rhyolitic / high silica composition • Magma / lava from volcano **A** is low viscosity / fluid whereas magma / lava from volcano **B** is high viscosity

Question			Answer	Marks	AO Element	Guidance
						• Magma from volcano **A** has low gas content / volatiles can escape / pressure does not build up so mainly lava is produced / eruptions are effusive / non-explosive whereas magma from volcano **B** has a high gas content / volatiles are trapped / pressure builds up / vent may get blocked so mainly pyroclastics are produced / eruptions are explosive • Magma / lava from volcano **A** is at high temperature whereas magma / lava from volcano **B** is at relatively low temperature • Links silicate structure to rate of movement of lava, e.g., high content of framework silicates to slower moving lava

Question			Answer	Mark	AO Element	Guidance
27	(a)	(i)	Arrow from left to right ✓ 	1	3.1b	
27	(a)	(ii)	• Pebbles are moved by traction / roll along stream bed ✓ • When current reduces / pebble meets an obstruction (flat) pebbles stack / are deposited up against each other ✓ • Pebbles are aligned by the current **OR** long axes of the pebbles are parallel (providing maximum resistance to movement) to each other ✓ • Pebbles are inclined / dip upstream **OR** tops of pebbles lean downstream ✓	Max 2	1.1c	**ALLOW** any correct named clast type
27	(b)	(i)	Suitable scale clearly marked along one of the spokes of the rose diagram **OR** appropriate circle ✓ Data plotted correctly ✓	2	2.1b	
27	(b)	(ii)	From the north-east / from 030-060° / from 045° **OR** south-west / 210-240° / 225° ✓	1	3.1b	

Question			Answer	Mark	AO Element	Guidance
27	(c)	(i)	Pebbles / gravel at base then sand in middle and clay at top plotted correctly on the log ✓ Shows a steady fining upwards ✓	2	1 x 1.1b 1 x 2.1b	
27	(c)	(ii)	• Uses Walther's Law to explain a (conformable) vertical sequence is produced by lateral facies changes / lateral environments **OR** to explain the vertical sequence results from lateral channel migration due to erosion on the outside of the meander bend and deposition on the inside ✓ **ANY 3** from: • As velocity decreases deposited sediment gets finer ✓ • Coarse grains / pebbles / gravel / conglomerate at base is channel lag / was deposited in river channel ✓ • Medium grains / sand / sandstone is deposited on point bar / inside of meander bend ✓ • Fine grains / clay / mud / silt is deposited on flood plain **OR** is deposited from suspension when river floods ✓	1 3	2 x 3.1a 2 x 3.1e	**MAX 3** if Walther's Law not used in explanation

Question			Answer	Mark	AO Element	Guidance
27	(d)	(i)	Last to form: K / K-Mg minerals / Sylvite Halite / Chlorides Gypsum / Anhydrite / Sulfates First to form: Calcite / Carbonates ✓✓	Max 2	1.1a	**2 OR 3** correct for **1 MARK** **4** correct for **2 MARKS** **Max 1** if 3 in correct relative order but in incorrect positions **ALLOW** correct chemical formulae for mineral names
27	(d)	(ii)	Least soluble minerals precipitate / crystallise first **OR** minerals precipitate in reverse order of solubility ✓	1	2.1a	**DO NOT ALLOW** use of the term deposition **ORA**
27	(d)	(iii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 9000 (metres) award 2 marks** Correct working shown, e.g., 6/0.1 x 150 ✓ Depth = <u>9000</u> (metres) ✓	2	2.1b	**ALLOW 1 MARK** if answer given is 90 metres (failed to convert cm to m)
27	(d)	(iv)	Periodic / repeated / cyclic influxes / replenishing of seawater ✓	1	3.1b	**AW**
27	(e)	(i)	Formed from the remains of coccolithophores / coccoliths / calcareous algae ✓ Skeletons settle out in low energy conditions **OR** requires warm / tropical conditions **OR** forms a calcareous ooze **OR** undergoes diagenesis **OR** undergoes burial and compaction / cementation ✓	2	1 x 1.1a 1 x 1.1 c	

Question			Answer	Mark	AO Element	Guidance
27	(e)	(ii)	Result from precipitation of silica / SiO_2 during diagenesis OR silica / SiO_2 from sponge spicules ✓	1	2.1a	**ALLOW** precipitates around organic material (such as fossils / shells / burrows) **ALLOW** quartz
27	(e)	(iii)	Below the carbonate compensation depth / CCD ✓ Increased pressure / decreased temperature increases the solubility of calcium carbonate ✓ Calcium carbonate is dissolved / taken into solution ✓	Max 2	2.1a	
27	(f)*		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)** Provides a detailed comparison of the differences between desert and turbidite sandstones **AND** Gives correct explanations related to the differing environments of deposition. *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)** Provides a comparison of the differences between desert and turbidite sandstones **AND** Gives some relevant explanations related to the differing environments of deposition.	6	2 x 1.1a 2 x 1.1c 2 x 2.1a	**ALLOW** greywacke for turbidite sandstone **Indicative points may include:** Differences • Desert sandstone is red in colour whereas turbidite sandstone is grey / dark in colour • Desert sandstone is quartz-rich whereas turbidite sandstone is mixed composition (quartz, feldspar, rock / lithic clasts) • Desert sandstone is compositionally mature whereas turbidite sandstone is compositionally immature • Desert sandstone has iron oxide / haematite cement • Turbidite sandstone has > 15% clay matrix • Desert sandstone is texturally mature whereas turbidite sandstone is texturally immature

Question			Answer	Mark	AO Element	Guidance
			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)** Provides a correct difference between desert and turbidite sandstones. **OR** There is an attempt to provide a correct explanation related to the differing environments of deposition. *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.			• Desert sandstone has well-rounded / high sphericity grains / millet seed sand whereas turbidite sandstone has angular / subangular / subrounded grains • Desert sandstone is (very) well sorted whereas turbidite sandstone is poorly sorted • Quartz in desert sandstone is frosted whereas quartz in turbidite sandstone is glassy / clear • Desert sandstones may contain large scale / dune cross-bedding • Turbidite sandstones may contain graded bedding / sole structures / flute casts / tool marks / climbing ripples Explanations may include: • Grains in desert sandstones are transported by wind whereas grains in turbidite sandstones are transported by water • Desert sandstones are deposited in arid terrestrial areas whereas turbidite sandstones are deposited in submarine fans / deep ocean basins / on abyssal plain • Wind transport in deserts is higher energy / there is no cushioning between the grains

Question			Answer	Mark	AO Element	Guidance
						• All soft minerals have been removed by abrasion / attrition in desert sands • Deposition in a terrestrial / arid / desert environment results in oxidation / red colouration of desert sands

Question			Answer	Mark	AO Element	Guidance
28	(a)	(i)	Gold would be found as it is very dense **AND** has no cleavage **OR** it is malleable and forms nuggets ✓ Cassiterite would be found as it is dense **AND** hard **OR** hardness is 6–7 **OR** has poor cleavage ✓ Chalcopyrite would not be found as it is not very dense **OR** is quite soft **OR** hardness is 3.4–4 **OR** sulfide so oxidises readily ✓ Galena would not be found as it is soft **OR** hardness is 2.5 **OR** it has 3 cleavages **OR** sulfide so oxidises readily ✓	4	2 x 3.1a 2 x 3.1c	**1 MARK** for each mineral Each marking point **MUST** include an evaluation of whether the mineral would be found in a placer deposit with correct reasons **MAX 1** for correctly listing which minerals would be found and which would not be found in placer deposits with no reasons
28	(a)	(ii)	Cross-section diagram of a beach with placer deposit labelled in correct position ✓ **ANY** two points for 1 mark from: • two arrows up and down the beach **OR** swash **OR** backwash labelled • sediment is transported up the beach • wave action sorts / winnows the minerals **OR** less dense minerals transported away • deposition occurs as placer minerals have high density • deposition occurs as energy of waves reduces / backwash weaker than swash **OR** velocity reduces leaving placer minerals on beach ✓	1 1	2.1a	**MAX 1** for plan view

Question			Answer	Mark	AO Element	Guidance
28	(b)	(i)	Area immediately below the water table shaded in vein of copper ore ✓	1	2.1b	
28	(b)	(ii)	Positive anomaly drawn over vein of copper ore ✓	1	2.1b	
28	(b)	(iii)	• Deposit is covered by glacial boulder clay **OR** there is no exposure at surface **OR** deeply buried ✓ • Boulder clay is impermeable so no dispersion / no geochemical trace due to weathering / erosion / transport can occur ✓ • Primary ore is not concentrated enough to form a positive geochemical anomaly / reading (in soil or streams) **OR** the primary ore has been leached ✓	2	2.1a	
28	(c)		• (Exploration) drilling / boreholes **OR** rotary / percussion / diamond drilling is undertaken ✓ • Drilled on a regular grid **OR** a sampling grid is used ✓ • (Drill core) samples are analysed / assayed to find grade / metal content / extent of ore body ✓ • Amount of barren rock / waste rock / gangue material / overburden is determined ✓ • Geostatistical modelling **OR** kriging **OR** use of polygon / triangle method to divide ore deposit up into blocks for calculations ✓ • Work out the volume / mass / size of the ore body / reserves using geophysics / drilling ✓	Max 3	1 x 1.1b 1 x 1.1d 1 x 2.1b	

Question			Answer	Mark	AO Element	Guidance
			• Variations in grade / mineralogy **OR** unexpected geological conditions that will affect grade / volume of ore need to be determined in advance ✓			
28	**(d)**	**(i)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 8.042477193x10^8 OR 804247719.3 (tonnes) award 3 marks** Volume = cross section area x thickness = π r^2 x h **OR** π x 400^2 x 500 **OR** 251327412.3 ✓ Mass = volume x density = 251327412.3 x 3.2x10^3 **OR** 8.042477193x10^{11} **OR** 804247719300 kg ✓ Tonnage = mass in kg / 1000 = 8.042477193 x10^8 **OR** 804247719.3 (tonnes) ✓	**3**	**2.1b**	**ALLOW** if used π as: 3.14 then accept 8.038 x10^8 **ALLOW ANY** correctly rounded number
28	**(d)**	**(ii)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 4.825486316x10^6 OR 4825486.316 (tonnes) award 1 mark** 804247719.3 x 0.6 / 100 = 4.825486316x10^6 **OR** 4825486.316 (tonnes) ✓	**1**	**2.1b**	**ALLOW ECF from 28(d)(i)** **ALLOW** if used π as: 3.14 then accept 4.8228 x10^6 **ALLOW ANY** correctly rounded number

Question			Answer	Mark	AO Element	Guidance
29	(a)	(i)	Arrow at 0 Ma ✓	1	2.1a	
29	(a)	(ii)	At mid-ocean ridge oceanic crust is shallower due to thermal mass **OR** is nearer to heat source (e.g., ridge plumes) **OR** is less dense / more buoyant so rises higher ✓ Older ocean floor gets deeper due to cooling of oceanic crust / lithosphere ✓ Older oceanic crust / lithosphere sinks as it is denser / contracts ✓ Older oceanic crust / lithosphere sinks as there is no magma chamber below ✓ Oceanic crust / lithosphere sinks to level to be supported by the mantle appropriate to its density **OR** due to isostatic adjustment ✓	Max 2	1 x 1.1c 1 x 2.1a	**ORA**
29	(b)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 92.52 (Ma) award 2 marks** Any attempted rearranging of equation to show use of natural log: E.g., $ln(N/N_0) = -\lambda t$ **OR** $t = ln(N/N_0)/-\lambda$ **OR** $t = ln\ (95/100) / -(0.693/1250)$ ✓ Age of sample (t) = 92.52 (Ma) ✓	2	2.1b	**ALLOW ANY** correctly rounded number such as 92.5 **OR** 93 **ALLOW** answer given as positive **OR** negative number

Question			Answer	Mark	AO Element	Guidance
29	(c)	(i)	Detachment faults have very large / up to 100s km displacements **OR** normal faults / hanging wall downthrown / footwall upthrown **OR** angle of fault dip changes / becomes lower / flattens **OR** the faults are curved / listric / low angled ✓	1	2.1a	
29	(c)	(ii)	Gabbro and peridotite are plutonic rocks / form at depth / in magma chambers **OR** form by slow cooling in the crust / upper mantle **OR** gabbro forms at MOR and peridotite forms in the mantle ✓ Faulting has brought these rocks / the lower crust / the upper mantle to the surface ✓	1 1	1.1c 2.1a	
29	(d)	(i)	• Seawater percolates into the (hot) basalt / volcanic rocks / ocean floor ✓ • Oxygenated / sulfate-rich seawater is reduced to hydrogen sulfide-rich fluid by chemosynthetic bacteria ✓ • The water is heated by the hot rocks / magma **OR** the water is superheated to more than 400°C **OR** the hot water is prevented from boiling by high hydrostatic pressure ✓ • Metals / elements are dissolved / leached from the basalt / volcanic rocks as the fluid passes through ✓ • Hot fluid rises back up to the seafloor ✓	Max 3	1 x 1.1a 2 x 1.1c	

Question			Answer	Mark	AO Element	Guidance
			• The fluid cools on contact with cold seawater **AND** causes (immediate) precipitation of metal / sulfide minerals ✓ • The precipitated minerals build up tall chimneys / mounds on the sea floor ✓			
29	**(d)**	**(ii)**	**Feature: Any one** from: form chimneys / mounds on the sea floor **OR** eject hot water / hydrothermal fluids / fluid onto seafloor **OR** host unusual animals / organisms / ecosystems **OR** form black / white smokers ✓ **Product: Any one** from: hot water containing metals in solution **OR** dark clouds of particles **OR** metal / zinc / copper / iron sulfides / sulfides **OR** chalcophile metals **OR** silica / sulfates / carbonates / anhydrite / calcite / barite **OR** may be acidic / low pH **OR** may be alkaline / high pH ✓	**1** **1**	**1.1a**	**ALLOW** any correct named metal sulfide mineral, e.g., chalcopyrite, as a product **ALLOW** gold / platinum
29	**(e)**	**(i)**	Ophiolite complexes / ophiolites ✓	**1**	**1.1a**	
29	**(e)**	**(ii)**	Oceanic crust / ore deposits formed at mid-ocean ridges / divergent plate margins move away by seafloor spreading / in Wilson Cycle ✓ Form at subduction zones / convergent plate margins / collision zones / orogenic belts / fold mountains ✓ Sections of oceanic crust / ore deposits are tectonically moved / obducted / thrust onto continental crust ✓	**Max 2**	**1.1a** **1.1c**	

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