GCE

Geology

H414/01: Fundamentals of geology

Advanced GCE

Mark Scheme for November 2020

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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

Annotations available in RM Assessor

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

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

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

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.

Section A

			Answer	Mark	AO	Guidance
1			**B** - Euhedral	1	2.1a	
2			**B** – (M – Ol – P – Ne – Or)	1	2.1b	
3			**C** - fine , equicrystalline	1	1.1a	
4			**D** – separation of minerals in a lava	1	1.1a	
5			**C** - silicic	1	2.1c	
6			**B** – greater safety	1	2.1b	
7			**C** – the negative gravity anomaly over Scandinavia	1	2.1a	
8			**C** – a process by which thermal energy is transferred through a medium by a fluid	1	1.1c	
9			**B** – 1/2	1	2.1a	
10			**C** - Lithophile	1	1.1a	
11			**C** – they were in meteorites	1	1.1c	
12			**B -** lateral compression is caused by the contraction of the Earth as it cools	1	1.1c	
13			**D** - Chi squared	1	2.1b	
14			**C** – a sheet-like body dipping 45^{o} to the west	1	2.1b	
15			**C** – depth of overburden	1	1.1c	
16			**B** – a lack of physical and mathematical evidence	1	1.1d	
17			**D** – there is a 2% chance that an earthquake will occur this year	1	1.1c	
18			**C** – the yolk sac	1	1.1a	
19			**D** - enhanced calcium carbonate concentrations and depletion of oxygen and sulfate	1	1.1c	
20			**B** - conodonts	1	2.1a	
21			**A** - High porosity, high resistivity, high gamma ray count	1	2.1a	
22			**D** – E, F and G	1	2.1b	
23			**D** – 88.6	1	2.1a	
24			**C** - $CuFeS_2$ = Chalcopyrite	1	1.1a	
25			**A** - Erosion	1	2.1a	

Section B

Question			Answer	Mark	AO element	Guidance
26	(a)		Morphology ✓ Taphonomy ✓ Life assemblages ✓	3	2.1a	
26	(b)		***ANY** two from* Most fossils are fossilised hard parts **OR** many organisms lack hard parts / teeth / skeletons ✓ The fossil record in biased / incomplete ✓ They could be derived fossils / eroded out of the original sedimentary rock ✓ Many fossils are not preserved in their original environment **OR** many fossils are in death assemblages ✓ Soft parts decay **OR** are scavenged on death ✓ Particular conditions are needed for preservation (taphonomy) ✓ Most preservation is in marine environments **OR** most preservation is in depositional environments **OR** lack of terrestrial fossils **OR** lack of fossils in erosional environments ✓	2	1.1a 1.1c	
26	(c)		***ANY** two from* Bedding would have been laid down horizontally **OR** bedding disrupted by burrowing / bioturbation ✓ Bottom suitable for life **OR** oxygen in sediment suitable for burrowing (aerobic) **OR** oxygen in water suitable for life (oxic) **OR** bottom has organic rich sediment ✓ U-shaped burrows show evidence of erosion **OR** high energy indicated by need for protective burrows **OR** low / medium energy	2	3.1b	

Question			Answer	Mark	AO element	Guidance
			indicated by (fine-grained) sediment suitable for burrowing **OR** burial of burrows shows a depositional environment ✓			
26	**(d)**		*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5-6 marks)** Good discussion of both internal and external morphology of both brachiopods and bivalves. Morphology discussed is linked to mode of life. Terminology used is correctly applied to the function / form / mode of life the fossil when it was alive. *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)** Gives a clear account comparing the external morphology of both fossil types and uses the terminology correctly throughout **OR** Gives a clear account comparing either mode of life or internal morphology of both bivalves and brachiopods but with some minor inconsistencies *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Describes and compares the external gross morphology of both types of organism shown but may not use all the correct technical terms and may make minor errors **OR** Discusses the mode of life of each fossil but answer lacks clear coherence / points not linked to each fossil type explicitly, but more general discussion regarding mode of life / feeding.	**6**		**AO2.1a Apply knowledge and understanding of geological ideas** May include hard parts: • Shell shape: two different sized valves (inequivalve) for brachiopods and equal sized valves (equivalve) for bivalves. • Shell symmetry: median plane for brachiopods and along hinge line for bivalves. • Two teeth within hinge of brachiopod whilst teeth and sockets along hinge plate of bivalve. • Spirallia, cardinal process in brachiopods. • 2 or 3 sets of muscle scars in brachiopods (adductor and diductor), 1 set for bivalves (adductor). May include soft parts: • Comparison of shell opening and closing devices (using diductor and adductor muscles in brachiopods and adductor and ligaments in bivalves). • Bivalves have a foot, whilst brachiopods have a pedicle. • Bivalves have pallial line and sinus, brachiopods do not have this structure. • Brachiopods have a lophophore, bivalves have gills. **AO3.1b Interprets geological information, ideas and evidence** May include:

Question			Answer	Mark	AO element	Guidance
			There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant. *No response or no response worthy of credit* **0 marks**.			• Interprets diagrams and discusses mode of life of bivalves and brachiopods. • Links hard and soft parts to mode of life and method of feeding eg. siphons and pallial sinus or muscles to open and close valves. **AO3.1e Draws conclusions** May include: • Relates morphology to mode of life in both bivalves and brachiopods. •
26	**(e)**	**(i)**	Ornithischian hip bones / pubis point backwards (bird hipped) **AND** Saurischian hip bones / pubis point forwards (reptile hipped) ✓ Ornithischian hip bones / pubis point backwards (bird hipped) allowed a more upright posture **OR** enabled organisms to exploit different niches ✓ Saurischian have long S shaped necks **OR** ornithischian have shorter necks ✓ Saurischian neck allows rapid / precise movement **OR** allows access to higher vegetation ✓ Saurischian have asymmetrical digits ✓ Saurischian asymmetrical digits allowed grasping ✓ Some ornithiscians have bony plates ✓ Ornithiscian bony plates could be for heat exchange ✓	**Max. 2**	**1.1a** **1.1c**	**ALLOW** alternative wording to describe the hip configuration **DO NOT ALLOW** non-skeletal differences

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>26</td><td>(e)</td><td>(ii)</td><td>
<table>
<tr><th>Feature</th><th>Characteristic?</th></tr>
<tr><td>Large olfactory lobes</td><td></td></tr>
<tr><td>Gastroliths</td><td>✓</td></tr>
<tr><td>Peg like teeth</td><td>✓</td></tr>
<tr><td>Thumb spike</td><td></td></tr>
<tr><td>Short neck</td><td></td></tr>
<tr><td>Laid amniotic eggs</td><td>✓</td></tr>
</table>
✓✓✓</td><td>3</td><td>1.1a
1.1c</td><td>5 or 6 lines correct = 3 marks
3 or 4 lines correct = 2 marks
2 lines correct = 1 mark</td></tr>
<tr><td>26</td><td>(e)</td><td>(iii)</td><td>ANY one from
Asteroid impact OR meteorite impact ✓
Major volcanic activity OR Deccan Traps described ✓</td><td>1</td><td>1.1c</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>20</td><td></td><td></td></tr>
</table>

Question			Answer	Mark	AO element	Guidance
27	(a)	(i)	Shear	1	1.1a	
		(ii)	***ANY** four from* Shear strain / deformation results as crust moves in opposing directions **OR** shear strain results from frictional resistance ✓ Elastic strain energy builds up over many years ✓ Stress builds until it exceeds the strength of the faulted rock ✓ Sudden release of the stored strain energy results in earthquake ✓ Energy released as seismic waves ✓ Some permanent strain remains ✓	4	1.1a 1.1c	*Max 2* if pressure, stress, friction used instead of strain energy or shear strain
	(b)	(i)	***ANY** three from* Earthquakes occur at shallow depths ✓ Subduction zones are in the ocean margins ✓ Rapid relative convergence of plates ✓ Large magnitude / magnitude above 6.5 earthquakes common ✓ Convergence occurs in a series of sudden movements ✓ Convergence results in vertical movement of the seabed ✓ Deformation / drag of the overriding plate by the subducting plate ✓	3	2.1a 3.1c	
		(ii)	***ANY** two from* Mapping of high risk / low-level ground **OR** mapping the effects of previous tsunami ✓ Overlay with population density ✓ Show communication links at risk ✓ Plan responses for emergency services ✓ Show installations needing particular protection e.g. power stations, hospitals ✓ Data available for all coasts ready for update with epicentre position ✓ Track wave heights in the ocean ✓ Show areas liable to liquefaction ✓	2	2.1a	
		(iii)	3.33 Ma ✓✓✓✓	4		**DO NOT ALLOW** full marks for result in years or more than 3 significant figures

Question			Answer	Mark	AO element	Guidance
			Calculation of length of subducted slab using appropriate trigonometry; Sin 30^{o} = 150 km / h h = 150 / 0.5 km h = 300 km Calculation of time taken to subduct and conversion of units 300 km / 90 mm a^{-1} = 300 x 10^{3} m / 90 x 10^{-3} m a^{-1} = 3.33 Ma		**2.1b**	*Max 3* for working if incorrect answer **ALLOW** ecf from slab length above
		(iv)	***ANY** two from* Marine deposit in a continental environment **OR** marine deposit above sea-level at that time ✓ Layer of coarse sand **OR** rip-off clasts **OR** broken shells in otherwise fine succession **OR e**rosive base **OR** poorly sorted **OR** graded bedding **OR** boulders in finer sediment ✓ Massive beds **OR** very thick layers ✓	**2**	**2.1a**	
			Total	**16**		

Question			Answer	Mark	AO element	Guidance
28	(a)	(i)	***ANY** two from* The ridge axis is the site of spreading / creation of new lithosphere ✓ It is a tensional tectonic environment / regime ✓ Normal faulting results ✓ Paired normal faults may form rift valleys **OR** form horsts and grabens ✓	2	1.1c	
		(ii)	Slow-spreading ridge **AND** ***ANY** one of* It has an axial rift ✓ It has rugged topography ✓ The ridge is steep-sided ✓	1	2.1a	As slow or fast is a 50/50 guess there must also be a valid reason for the choice.
		(iii)	***ANY** two from* Basalt lava flows at the surface ✓ Intrusion of dolerite dykes forces the crust apart ✓ (High-angle) normal faults result from the extension ✓ Uplift of the footwall brings lower crust / gabbro and upper mantle / peridotite to the surface ✓ Gabbro is added (to the uplifted footwall) from the magma chamber ✓ Spreading lowers the angle of fault dip (to around 30^{o}) ✓ Movement on the fault contributes to lateral spreading ✓ Seawater and talc lower friction on the fault plane ✓	2	1.1a 1.1c	
	(b)		Asthenosphere close to the surface **OR** Hotter mantle / partial melting close to the surface ✓ Melt / hotter mantle / asthenosphere is lower density ✓	2	2.1a	
	(c)	(i)	$t^x = w/k$ *x (log t) = log (w/k)* *e.g. x(log 5) = log (2.236) **OR** log (726.7/325)* *x = 0.5 ✓✓✓*	3	3.1a	

Question			Answer	Mark	AO element	Guidance
		(ii)	Plot a graph of ***w*** against t^x **AND** ***k*** is given by the gradient of the straight line ✓	1	2.1b	Must say *what* is plotted for the gradient mark **ALLOW** negative gradient
		(iii)	***ANY*** *two from* Higher spreading rate results in greater displacement in the same time ✓ Therefore slope / gradient of ridge is less steep for fast spreading ridges ✓ Fast-spreading means there will be no axial rift **OR** there will be a dome like topography **OR** the topography will be smoother ✓	2	3.1f	
	(d)	(i)	gravity acting on the ridge slopes (is a mechanism for spreading) **OR** gravity has a greater effect on taller / higher / steeper ridges ✓	1	2.1c	
		(ii)	Ridges only rise 3 km above abyssal plain **OR** Ridge gradient is very low / 1.5° **OR** Subduction zones can be steep / up to 45° **OR** Descending slab can be 100s km long **OR** Lithosphere can be pulled without deformation / compression usually taken up by thrusting **OR** gravity has a greater effect on the large mass of the subducting slab **OR** gravity has a lesser effect on the smaller mass of the ridge ✓ The Pacific is fringed by subduction zones acting on the plates **OR** The Atlantic ocean has no subduction zones ✓	2	2.1a	**ALLOW** plates of Atlantic Ocean are partly continental lithosphere

Question	Answer	Mark	AO element	Guidance
(e)*	*Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.* **Level 3 (5-6 marks)** Shows and records an understanding of the cause and effects of decompression melting at divergent margins **AND** gives detailed explanations for the chemistry of the magma. *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)** The principles of decompression melting are presented logically **AND** gives some explanation of the chemistry. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Decompression melting is given as the explanation of magma generated at margins but other descriptive evidence is not relevant to the explanation. There is a basic explanation of the chemistry. *There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant.* *No response or no response worthy of credit* **0 marks**.	**6**	**2.1a** **2.1c** **3.1b**	May include • Upwelling of the mantle • Lithosphere under tension thins • Asthenosphere close to the surface • Pressure is reduced but mantle is still hot • Partial melting results • Called decompression or adiabatic melting • Pressure drop lowers melting point • Allows geotherm to cross solidus **AND** • Partial melting of ultramafic peridotite produces mafic magma • Rapid transit to the surface does not allow magmatic differentiation • No addition of silicic melt from continental crust / no assimilation • Lower melting point minerals melt first. • These minerals are relatively rich in S and Fe / Mg poor.
	Total	**22**		

Question			Answer	Mark	AO element	Guidance
29	(a)	(i)	Secondary enrichment ✓ Due to chemical weathering of deposit and leaching of copper sulfate in oxidation zone above a water table **OR** insoluble sulfide deposited in reducing zone / below water table ✓ **OR** Placer deposit ✓ Dense material accumulation described where water energy has dropped ✓	**2**	**2.1a**	1 mark for identified process 1 mark for the description. **ALLOW** copper porphyry deposit described correctly **ALLOW** any correct placer, e.g. behind projections on sea bed, plunge pools etc.
	(a)	**(ii)**	***ANY** two from:* High grade deposits have already been extracted so need to exploit lower grade deposits ✓ Methods of ore processing have improved / been developed so that lower grade deposits can be mined ✓ Methods of mining have improved / been developed so that lower grade deposits can be mined ✓ Metal is now more valuable due to its scarcity, so lower grade extraction possible ✓	**2**	**3.1a** **3.1b**	**ALLOW** 1 mark if correct method used but incorrect dates used from the table.
	(a)	**(iii)**	Using equation : Final grade - original / original grade X 100 1.10 – 1.98 = -0.88 0.88/1.98 = - 0.44 -0.44 x 100 = -44.4% **OR** -44% ✓✓	**2**	**2.1b**	**DO NOT ALLOW** values beyond 3 significant figures. **ALLOW** 44% as only change is asked for
	(a)	**(iv)**	*Geochemical* Stream / vegetation / soil / water sampling **AND c**omparison of values of metals from samples from different locations to build up map of anomalies to locate deposit ✓ *Geophysical* Magnetic / gravity / EM survey / resistivity **AND c**hanges in Earth's magnetic field measured with positive anomalies representing ore minerals / increase in gravity represents denser minerals which could be ore minerals /	**2**	**2.1b**	If both names correct but incorrect explanation then 1 max

Question			Answer	Mark	AO element	Guidance
			conductivity increases in EM or resistivity surveys where metallic minerals are present ✓			
	(b)		***ANY** three from:* Separates hydrophobic minerals from hydrophilic ones ✓ Fine material mixed with water to form a slurry to separate ✓ Target mineral is made hydrophobic by adding chemicals ✓ Slurry is agitated and air added to form bubbles to which hydrophobic minerals attach ✓ Minerals float to top of cell and are removed ✓ Tailings do not float so well and are removed by lower tube ✓	**3**	**2.1a**	
	(c)	**(i)**	***ANY** two from:* Sulfur minerals / sulphides break down due to oxidation (and / or bacterial action) ✓ This forms sulfur dioxide (SO_2) and reacts with water to form sulfuric acid (H_2SO_4) ✓ This acidic water then leaches out other minerals present in the rock ✓ Named minerals / elements (lead, mercury, arsenic) leach into the water ✓	**2**	**2.1a** **1.1c**	
	(c)	**(ii)**	Aerobic filters / aerobic wetlands / reed beds **AND** contain limestone ✓ Neutralises acid and oxidation precipitates metal salts / oxides / hydroxides ✓ **OR** Anaerobic filters / anaerobic wetlands **AND** contain limestone to neutralise acid ✓ compost creates reducing conditions to precipitate metals / sulfides **OR** microorganism / bacteria precipitate metals / sulfides ✓ **OR**	**2**	**1.1a** **1.1c**	Paired method and brief explanation of how AMD is mitigated for two marks

Question			Answer	Mark	AO element	Guidance
			CaO / $CaCO_3$ filters / limestone ponds / limestone channels ✓ $CaCO_3$ is dissolved by / reacts with acid / increases pH to precipitate metal sulphides and neutralise acid ✓			
			Total	**15**		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>30</td><td>(a)</td><td>(i)</td><td>ANY two from
High / >1% organic content / >0.5% total organic carbon ✓
Marine mudstones OR black shales OR organic shales OR oil shales ✓

Deep water (enough to reduce oxidation) / anoxic ✓
Plankton accumulates / algal blooms ✓
OR
Accumulation of terrestrial vegetation ✓
Low oxygen conditions / swamp ✓
Burial to form coal ✓</td><td>2</td><td>1.1a

1.1c</td><td></td></tr>
<tr><td></td><td>(a)</td><td>(ii)</td><td>Burial AND temperatures raised ✓

ANY one from:
Over time organic matter forms kerogen ✓
Kerogen breaks down to form petroleum ✓
Correct inclusion of oil (50-100°C) OR gas window temperatures (100 - 200°C) ✓</td><td>2</td><td>1.1a

1.1c</td><td></td></tr>
<tr><td></td><td>(a)</td><td>(iii)</td><td><table><tr><th></th><th>Property</th><th>Example</th></tr><tr><td>Caprock</td><td>impermeable</td><td>mudstone / shale OR salt / evaporates OR greywacke OR well cemented sandstones OR unjointed limestones</td></tr><tr><td>Reservoir rock</td><td>(highly) permeable</td><td>desert sandstone / jointed limestone / deltaic sandstone / poorly cemented sandstone</td></tr></table>✓✓</td><td>2</td><td>1.1a

1.1c</td><td>one mark for each row

4 correct = 2 marks
2 or 3 correct = 1 mark

ALLOW high porosity

ALLOW named examples</td></tr>
<tr><td></td><td>(a)</td><td>(iv)</td><td>Oil in the Upper Jurassic ✓
Oil shown trapped by faults ✓
Reservoir rock labelled in the upper Jurassic ✓
Source rock labelled anywhere in the Jurassic ✓
Cap rock shown in Cretaceous ✓</td><td>5</td><td>2.1a

1.1c</td><td>must have horizontal base but otherwise levels not critical

Source is also in U Jurassic but not essential for mark</td></tr>
</table>

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			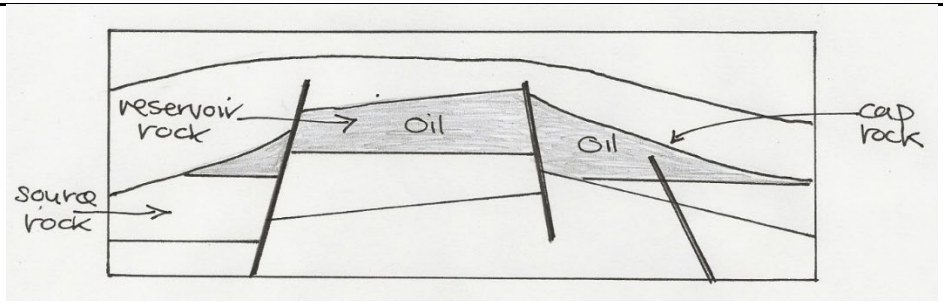			
	(b)	(i)	***ANY** two from* Negative gravity anomalies indicate sedimentary rocks deep enough to allow maturation ✓ Negative gravity anomaly could indicate a salt dome trap ✓ Positive anomaly due to anticline **OR** positive anomaly due to an uplifted block ✓	**2**	**1.1b**	
			Total	**13**		

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Question			Answer	Marks	AO element	Guidance
1			**A**	1	1.1a	**A** – arkose
2			**C**	1	1.1a	**C** – rock 1 = metamorphic, rock 2 = igneous, rock 3 = sedimentary
3			**C**	1	1.1a	**C** – medium grade metamorphic
4			**C**	1	2.1b	**C** – sub-angular, 45, 35, 20
5			**B**	1	2.1a	**B** – greywacke
6			**C**	1	2.1a	**C** – melting point = 2446°C
7			**C**	1	1.1c	**C** – the density of the Earth
8			**B**	1	1.1c	**B** – the magnetic field is axial – aligned with the spin axis of the Earth
9			**B**	1	1.1a	**B** – the Great Oxidation Event
10			**A**	1	1.1c	**A** – Chalk = aquifer; Gault Clay = aquiclude; silts and clays = aquitard
11			**B**	1	2.1a	**B** – +100m
12			**A**	1	1.1a	**A** – formation and break up of major continents
13			**C**	1	2.1b	**C** – a measure of the spread of the data about the mean
14			**C**	1	1.1c	**C** – it calculates the ground motion caused by an earthquake at a given site.
15			**C**	1	2.1b	**C** – 6525 years
16			**C**	1	2.1b	**C** – 3.98 MPa
17			**D**	1	2.1a	**D** – slab pull at subduction zones
18			**D**	1	2.1b	**D** – plagioclase 45%, pyroxene 35%, olivine 20%
19			**D**	1	1.1c	**D** – magma << dense than the surrounding rock
20			**B**	1	1.1d	**B** – the Sun and chondrites are made from the same original material
21			**A**	1	2.1b	**A** – 1445^{o}C
22			**B**	1	1.1c	**B** – 70% An 30% Di
23			**A**	1	1.1c	**A** – partial melting of those minerals with higher melting points produces magma
24			**D**	1	2.1b	**D** – synsedimentary faulting
25			**A**	1	2.1b	**A** – anticline

Question			Answer	Marks	AO element	Guidance
26	(a)	(i)	sheets **OR** 3 oxygen atoms shared in one plane ✓	1	1.1a	
	(a)	(ii)	**Any one from:** the bonding between sheets is weak leading to one perfect cleavage✓ the spaces between sheets contain hydroxyl (OH) ions which results in low density ✓	1	1.1c	
	(b)	(i)	pyroxene / augite / any other correct named pyroxene **OR** amphibole / hornblende / any other correct named amphibole ✓	1	1.1a	
	(b)	(ii)	**Any two from:** chains of tetrahedra result in a negative charge ✓ this is balanced by cations linking the chains together ✓ bonds between chains are weaker resulting in cleavages ✓ in a single chain (pyroxene) there are 2 cleavages at 90^{o} ✓ in a double chain (amphibole) there are 2 cleavages are at 60^{o} / 120^{o} to each other ✓	2	2.1a	
	(c)	(i)	framework **OR** each of the 4 oxygens in the tetrahedron are shared with other Si atoms ✓	1	1.1a	
	(c)	(ii)	**Any two from:** frameworks are isotropic / have the same properties in all directions ✓	2	2.1a	

Question			Answer	Marks	AO element	Guidance
			only contains strong Si-O bonds ✓ there are no planes of weakness therefore no cleavage ✓ there are no planes of weakness so has conchoidal fracture ✓ this makes the mineral structure strong therefore hardness is 7 / high ✓			
	(c)	(iii)	**Any one from:** each silicon atom is covalently bonded with 4 oxygen atoms (forming the silica tetrahedron) ✓ each of the 4 oxygen atoms is shared with other silicon atoms in the framework ✓ **Any one from:** the silicon has a half share of each of the oxygen atoms giving the silica formula ✓ there must be a ratio of 2:1 oxygen to silicon atoms to balance the overall charge ✓ silicon ions have a 4+ charge and oxygen ions have a 2- charge ✓	**1** **1**	**1.1a** **2.1a**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>27</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th>Experiment</th><th>Sand length L (m)</th><th>Head $h_2 - h_1$ (m)</th><th>Hydraulic gradient</th><th>Flow rate Q ($m^3 s^{-1}$ x 10^{-3})</th></tr>
<tr><td>1</td><td>0.58</td><td>1.11</td><td>1.9</td><td>0.60</td></tr>
<tr><td>2</td><td>0.58</td><td>2.36</td><td>4.1</td><td>1.28</td></tr>
<tr><td>3</td><td>0.58</td><td>4.00</td><td>6.9</td><td>2.00</td></tr>
<tr><td>4</td><td>0.58</td><td>4.90</td><td>8.4</td><td>2.38</td></tr>
<tr><td>5</td><td>0.58</td><td>5.02</td><td>8.7</td><td>2.53</td></tr>
<tr><td>6</td><td>0.58</td><td>7.63</td><td>13.2</td><td>3.63</td></tr>
</table>
</td><td>1</td><td>1.1b</td><td>Both hydraulic gradients calculated correctly and recorded in table to a maximum of 2 decimal places for 1 mark</td></tr>
<tr><td>27</td><td>(a)</td><td>(ii)</td><td>axes plotted to make best use of the available graph AND axes labelled correctly, including units for flow rate Q ✓

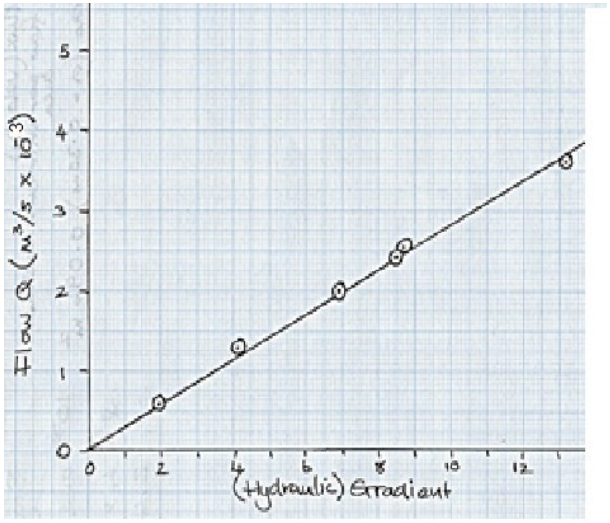
5 or more points plotted correctly (within a mm) ✓

line of best fit passes through zero AND has approximately equal points above and below the line ✓</td><td>1

1

1</td><td>1.1a

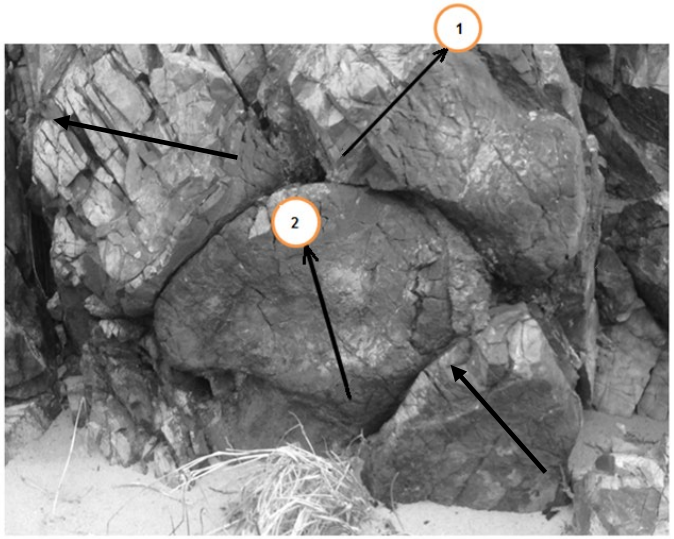
1.1c

1.1d</td><td> 
</td></tr>
<tr><td>27</td><td>(a)</td><td>(iii)</td><td>the relationship is linear
OR there is a direct correlation between Q and the hydraulic gradient
OR there is a positive correlation between Q and gradient
OR the relationship is directly proportional ✓</td><td>1</td><td>3.1a</td><td>ALLOW description of relationship e.g. as the hydraulic gradient increases the flow rate increases</td></tr>
</table>

Question			Answer	Marks	AO element	Guidance
27	(a)	(iv)	k within range 2.84 x 10 $^{-3}$ to 3.24 x 10 $^{-3}$ ✓	1	2.1b	**ALLOW** positive or negative value for k.
27	(a)	(v)	pressure in the water supply could change during measurement ✓	1	3.1f	
27	(a)	(vi)	**Any one from:** a constant head supply / reservoir would improve the accuracy / precision ✓ Maintaining a constant water pressure / flow rate would improve accuracy / precision✓ Use a longer column of sand which would improve accuracy / precision✓	1	3.1f	**ALLOW AW**
27	(b)		flow rates should increase (for the same gradient) **OR** permeability / k will be higher ✓ finer grains fill up pore space / pore throats between coarser grains **OR** there is less resistance to flow around coarse grains **OR** there is less friction as water flows between coarse grains **OR** the pore spaces between coarse grains are larger allowing easier flow **OR** coarser grains increase the amount of interconnected pore space ✓	1 1	1.1c 2.1a	 **ORA**
27	(c)	(i)	**Any one from:** lower permeability allows more time for grains to act as a natural filter✓ lower permeability / longer residence time allows time for bacteria to remove organic matter in suspension ✓ lower permeability / longer residence time allows time for clay minerals to remove organic matter in suspension ✓	1	1.1c	**ORA**

Question			Answer	Marks	AO element	Guidance
	(c)	(ii)	**Any two from:** calcium / Ca^{2+} **AND** limescale problems **OR** soap lather difficulties **OR** may be beneficial for bone growth / teeth ✓ sulfate / SO_4^{2-} **AND** bad taste **OR** diarrhoea ✓ magnesium / Mg^{2+} **AND** describes a hard water problem ✓ hydrogen carbonate / HCO_3^- **AND** describes a hard water problem ✓ chloride / Cl^- **AND** bad taste ✓ nitrate / NO_3^- **AND** methaemoglobinemia / blue baby syndrome **OR** cancer risk (when reduced to nitrite) ✓ Fe^{2+} / Fe^{3+} / iron gives a discolouration to the water✓ H^+ / hydrogen could lead to acidic water✓ F^- / fluoride can improve dental health / can be toxic✓	2	1.1a x 1 1.1c x 1	**MUST** link correct stated ion to a correct affect for 1 mark **ALLOW** any correct named ion found in drinking water linked to a correct affect note: SiO_2 and $CaCO_3$ are **not** ions

Question			Answer	Marks	AO element	Guidance
28	(a)	(i)	sediments **OR** calcareous ooze **OR** siliceous ooze **OR** fine clays **OR** chert ✓	1	1.1a	**ALLOW** ooze
	(a)	(ii)	it is unconsolidated **OR** contains a high proportion of water **OR** the layers beneath are igneous / crystalline rock **OR** low incompressibility **OR** low rigidity ✓	1	3.1b	
	(a)	(iii)	**Any two from:** ridges are spreading centres **OR** new oceanic crust forms at ridge ✓ oceanic crust increases in age with distance from the ridge ✓ older crust has more time to accumulate sediment ✓ sediment is deposited slowly as marine "snow" ✓	2	2.1a	**ALLOW AW**
	(a)	(iv)	**formation of sheeted dykes** **Any one from:** form in an extensional / tensional regime ✓ resulting from ridge push / gravity acting on the ridge flanks ✓ **Any one from:** magma moves towards the surface up long fissures ✓ fissures form parallel to the ridge axis / within the axial rift ✓ the original dyke has two chilled margins✓ relatively quick cooling of magma forms dolerite / medium textured mafic rock ✓	1 1 1	2.1a 3.1b 3.1d	**ALLOW** joints and fractures

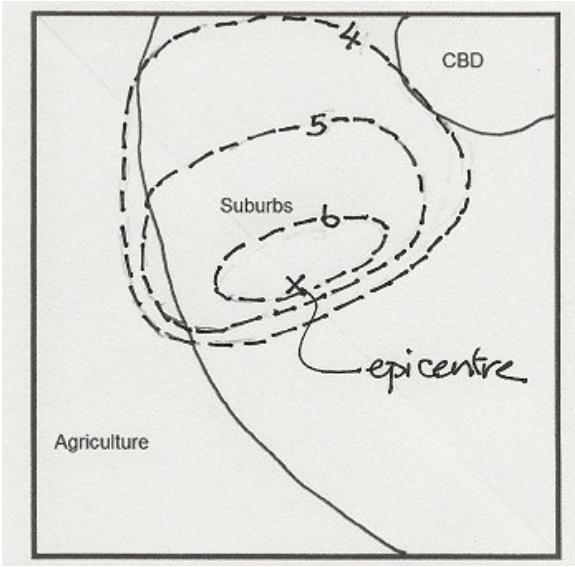
Question			Answer	Marks	AO element	Guidance
			as spreading continues new dykes follow the line of weakness of previous intrusions ✓ **explanation of chilled margins** **Any one from:** the previous dyke is split forming a half dyke with a single chilled margin✓ one side of each dyke was in contact with hot magma, so each dyke only has one chilled margin✓ statistical analysis of the sides the chills are on gives the direction of the ridge axis ✓			
28	**(b)**	**(i)**	**EITHER** arrow as shown ✓  	**1**	**2.1a**	**ALLOW** +/- 20^{o} **1** is the actual direction of younging **2** is the direction of younging using the most obvious 'neck' in the photograph
28	**(b)**	**(ii)**	**formation of pillow lavas** **Any two from:** lava is extruded onto the seafloor / lava erupts underwater✓ rapid cooling by the water forms a glassy 'skin' ✓	**2**	**2.1 a**	

Question			Answer	Marks	AO element	Guidance
			lava continues to be extruded inflating the pillow ✓ lava is extruded as a tube and may roll down slope ✓ settles onto previous pillows but is still plastic ✓ **explanation of younging direction** fills space between previous pillows to make a 'neck' downwards / dome upwards / convex upwards ✓	**1**	**1.1c**	**DO NOT ALLOW** vesicles as a way-up indicator as they are not visible in the photograph **AW** "pinched" for "neck"
28	**(c)**		**Any one from:** radioactive decay within the Earth✓ decay of heat producing elements / K / U / Th✓ unstable parent atoms / isotopes changing to stable daughter atoms / isotopes release heat✓ **Any one from:** heat left over / residual / primordial from formation of the Earth ✓ gravitational potential energy of formation of the Earth✓ (kinetic energy from) early bombardment / collisions during formation of the proto-Earth✓ (potential energy from) the process of differentiation of the core, mantle and crust✓ the change in state at the outer – inner core boundary from liquid to solid✓ latent heat of crystallisation as inner core crystallises ✓	**1** **1**	**1.1a** **2.1a**	
28	**(d)**		*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.*	**6**	**1.1a x 2** **1.1c x 2**	**Indicative points may include:**

Question			Answer	Marks	AO element	Guidance
			Level 3 (5 – 6 marks) Gives a detailed description and explanation of how hydrothermal processes result in the formation of sulfide ores, including the principles of convective circulation of seawater within the fractures of the upper oceanic crust. **AND** Describes how the discharge of fluids / brines and the precipitation of sulfide ore minerals are the final stage in the concentration of metals from low crustal abundance. *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)** Gives a description and explanation of how hydrothermal processes result in the formation of sulfide ores, including the principles of convective circulation of seawater within the fractures of the upper oceanic crust. **OR** Describes ow the discharge of fluids / brines and the precipitation of sulfide ore minerals are the final stage in the concentration of metals from low crustal abundance. *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)** There is an attempt at a description and/or explanation of how hydrothermal processes result in the formation of sulfide ores. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*		**2.1a x 2**	• reasons why upper oceanic crust is fractured • temperatures attributed to the hot brine, e.g. 380°C • water heated by the presence of magma at high crustal levels • depths to which fluids circulate or volume of crust involved in the circulation may be estimated • the fluids / brines are extremely reactive at high temperatures, e.g. have a low pH • there is evidence of metasomatism of crustal rocks • the fluids / brines circulate becoming increasingly charged / concentrated and escape at the sea floor. • occurs at black smokers • reduction in temperature when the fluid meets cold seawater results in the formation / precipitation of sulfide ores • changes in chemistry (combining with H_2S) may result in the formation / precipitation of sulfide ores • dense sulfide minerals are deposited local to the vent • correct named examples of ore minerals may be given – galena, sphalerite, chalcopyrite, pyrite • may form chimneys • if the minerals are subsequently buried (by lavas or sediments) they will not dissolve into the seawater

Question			Answer	Marks	AO element	Guidance
			0 marks *No response or no response worthy of credit.*			

Question			Answer	Marks	AO element	Guidance
29	**(a)**	**(i)**	**Any three from:** choose height of building so natural frequency does not match seismic wave frequencies ✓ avoid irregular designs which are susceptible to twisting forces ✓ avoid ornamentation and fascias which may be dislodged ✓ avoid large open spaces, such as atria ✓ use steel-framed buildings (more ductile and able to deform without collapse) ✓ resist shear forces by using diagonal beams / cross bracing / cables ✓ isolate foundations / base isolation systems – able to distort or slide in response to horizontal forces ✓ absorb sway, e.g. with active mass damping, hydraulic systems ✓ use of flexible structures / flexible pipes✓ use a building code to prevent building on unsuitable ground✓	**3**	**1.1a x 1** **2.1a x 2**	**ALLOW** construction of deep foundations / piles to solid geology **ALLOW** any other correct civil engineering strategy that can reduce the impact of seismic events

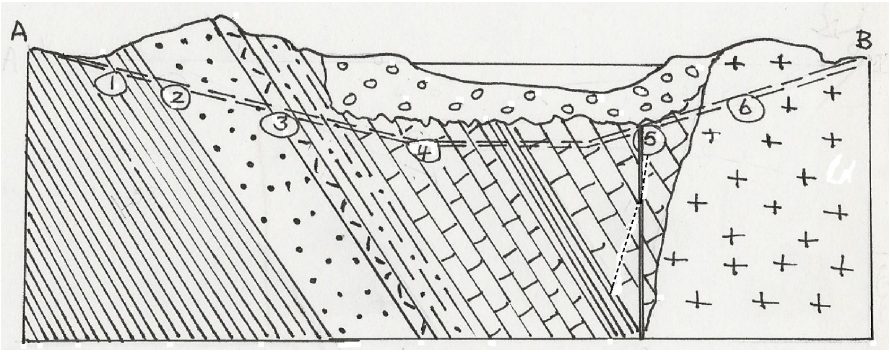
Question			Answer	Marks	AO element	Guidance
29	(a)	(ii)	liquefaction ✓ **Any two from:** vibrations / shaking cause the sediment to behave as a (viscous) liquid ✓ (pressure builds and) water forces the grains apart to liquefy the sediment / water separates from the grains and rises to the surface ✓ P-wave / seismic wave pulses / vibrations raise the pore pressure of water between the sediment grains ✓ the pores are small so there is insufficient opportunity for the pressure to drop between pulses / vibrations ✓	**1** **2**	**1.1a** **1.1c**	**ALLOW AW**
29	(a)	(iii)	3 closed, concentric isolines drawn ✓ isolines have realistic intensity values labelled, e.g., highest between 5 and 8 ✓ highest isoline encloses epicentre ✓ isolines drop away more quickly to the south (over the granite) ✓ isolines are 'squeezed' by competent buildings in the CBD **OR** by lack of apparent damage in the agricultural areas ✓	**5**	**3.1a x 1** **3.1b x 2** **3.1d x 1** **3.1e x 1**	**ALLOW** labelling in roman or arabic numerals e.g., of possible answer 
29	(b)		**First check answer on answer line**	**3**	**2.1b**	

Question			Answer	Marks	AO element	Guidance
			If answer = 1.41 x10^{18} **award 3 marks** correct rearranging of equation, e.g., Log E = $^3/_2$ Mw + $^3/_2$ 6.1 ✓ use of logarithms to calculate correct answer of 1.41 x10^{18} Joules / J ✓ answer given to no more than 3 sig figs ✓			
29	**(c)**	**(i)**	**Any two from:** as waves spread from the focus the energy is spread over a larger area / dissipated ✓ energy is absorbed as seismic waves travel through rocks ✓ waves are scattered as they pass through the rock ✓ imperfect elastic response leads to attenuation ✓ some energy is converted to heat ✓	**2**	**2.1a**	**ALLOW AW**
29	**(c)**	**(ii)**	**Any two from:** ground conditions may amplify movement / amplitude **OR** ground movement / amplitude depends on competence of (bed)rock / soil ✓ faults may not be visible at the surface / blind faults ✓ fault failure may occur infrequently **OR** many faults move frequently with little energy released ✓ sections of faults may be locked increasing risk **OR** sections of faults may creep reducing risk ✓	**2**	**1.1c**	**ORA**

Question			Answer	Marks	AO element	Guidance
			risk depends on magnitude **OR** magnitude is poorly predictable **OR** earthquake magnitude varies for individual faults ✓ risk may be affected by tsunami or landslide potential✓			

Question			Answer	Marks	AO element	Guidance
30	(a)	(i)	degree to which repeated measurements under unchanged conditions are the same **OR** how close repeated measurements are to each other ✓	1	3.1d	**ALLOW AW** **DO NOT ALLOW** how accurate the measurements are
30	(a)	(ii)	eastward = –10.5 (mm y^{-1}) ✓ northward = 21.0 (mm y^{-1}) ✓	2	3.1b	**ALLOW** 9.0 to 12.0 (mm y^{-1}) for eastward **ALLOW** 19.5 to 22.5 (mm y^{-1}) for northward
30	(a)	(iii)	**Any one from:** divergent plate boundary passes through Iceland **OR** Mid-Atlantic Ridge / mid-ocean ridge passes through Iceland ✓ **Any one from:** North American plate separates from Eurasian plate **OR** relative overall separation is approximately West – East ✓ western Iceland is on North American plate **OR** is moving NW away from the ridge axis ✓ Mid-Atlantic Ridge in western Iceland is NE- SW so separation of NW – SE is expected ✓	1 1	3.1a 3.1b	
30	(b)		correctly named example of a fossil used as evidence for continental drift / plate movements, e.g. *Mesosaurus* / *Lystrosaurus* / *Cynognathus* / *Glossopteris* / land plants / corals / trilobites ✓ **Any two from:** matching fossils of the same type and age are found on different continents ✓ the organisms could not have swum / moved / spread across former oceans suggesting the continents were joined at the time ✓	3	2.1a	**ALLOW** any correct named fossil example explanation **MUST** match named fossil(s)

Question			Answer	Marks	AO element	Guidance
			(the same species) suggests different continents were joined at the time and have moved apart due to plate movements ✓ (different species) suggests different continents were separated at the time and have moved together due to plate movements ✓ (assuming uniformitarianism) fossils are found in different climatic zones / latitudes to where they were alive ✓ suggests the continents were in a different climatic zone / latitude than they are today so must have moved to present day positions ✓			

Question			Answer	Marks	AO element	Guidance
31	(a)		**Any five from:** dipping beds are correctly drawn using ornament / rock names in key ✓ dipping beds have dip of approx. 50° east (less than 60°) ✓ concordant dolerite sill is drawn in correct position ✓ fault is drawn at correct position below river ✓ fluvio-glacial drift deposits with steep sides and flat base / u-shaped valley are correctly drawn **OR** base of fluvio-glacial drift deposits is **above** the tunnel profile ✓ river drawn with an asymmetric profile to correct approx. max depth of 10 m ✓ steep margin to granite intrusion correctly drawn ✓ metamorphic aureole correctly drawn parallel to the granite contact ✓  	**5**	**1.1d x 1** **2.1a x 2** **2.1b x 1** **3.1a x 1**	

Question	Answer	Marks	AO element	Guidance
(b)	*Refer to marking instructions on page 5 of mark scheme for guidance on marking this question.* **Level 3 (5–6 marks)** There is a coherent and logical account of the effects of rocks and structures encountered in locations **1** to **6** which cover properties important to tunnel construction such as permeability and rock strength. *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)** The effect of some of the rock types and structures are recognised and some relevant properties are explained. *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)** The geology at some of the locations **1** to **6** is correctly identified and some relevant properties for each stated. *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.*	**6**	**1.1a x 2** **1.1c x 1** **2.1a x 2** **2.1b x 1**	**Indicative points may include:** **location 1** • shales are weak / fissile so overbreak / collapse of roof and walls may occur • impermeable so water flow should not be a problem • will require roof support and ground improvement **location 2** • desert sandstones are very well sorted and have well rounded grains • the sandstone could be (relatively) easy to cut through if uncemented **OR** could be hard to cut through if cemented • likely to be porous and permeable forming an aquifer **OR** problems may arise with water flowing into the tunnel • as it is contained between impermeable strata it could be a confined aquifer with the water under pressure • may require roof support and ground improvement and drainage **location 3** • there is a sill / concordant intrusion / minor intrusion / hypabyssal intrusion • surrounding rocks will be baked / indurated / metamorphosed • rocks at this location will be less permeable • hard rock will require a change of excavation method / slow progress • explosives may be needed, requires less support and drainage • competent and easier to drill **location 4** • limestone is characterised by joints and bedding planes

Question			Answer	Marks	AO element	Guidance
						• limestone is a soft rock so easily cut / bored • could encounter high flow rates of groundwater • could be karstic / have voids and caves creating weaknesses **OR** may have joints / bedding planes enlarged by solution • glacial erosion above may lead to weaknesses and changes in rock strength • may require added roof support • may require drainage **location 5** • fault encountered • may allow passage of water / pressurised flows • may cause local weakness • sudden change of rock type may slow tunnelling progress • fault may become active / reactivate causing damage to tunnel / threatening life • will require roof support and drainage **location 6** • granite is hard / crystalline rock so tunnelling will have to be by drilling and blasting • this is a slow / expensive / dangerous process • rockbursts should not be a problem as at a shallow depth • impermeable and so should not require drainage • overall many changes in geology which will require changes in the tunnelling methods which is slower
	(c)		**Any two from:** the major intrusion has created a metamorphic aureole in the country rock / contact metamorphism ✓ fluids from the magma may have escaped into the country rock causing the mineralisation ✓	**2**	**1.1c**	

Question			Answer	Marks	AO element	Guidance
			hydrothermal processes / circulating groundwater can dissolve metals and concentrate / precipitate ore minerals ✓ precipitation occurs as fluids / brines cool / chemistry changes ✓ this may occur in fractures / joints resulting in veins **OR** the ore may be disseminated through the rock ✓ fault may have acted as a conduit for fluids / brines ✓ secondary enrichment may have acted on the ores ✓ placer deposits may form within the river deposits ✓ minerals precipitate as acidic fluids react with the alkaline limestone ✓			
	(d)	**(i)**	**First check answer on answer line** **If answer = 67366 (m^3) award 2 marks** correct recall and use of formula to calculate volume of spoil removed ($V = \pi r^2 l$) ✓ $3.14 \times 5.7^2 \times 660 = 67366$ (m^3) ✓	**2**	**1.1b**	
		(ii)	**Any two from:** cannot be used in the construction of a tunnel ✓ cannot be moved any distance / too expensive to transport ✓ liable to be disposed as spoil heaps **OR** used as infill to local topographic lows **OR** used as landfill in abandoned quarries✓	**2**	**1.1c**	

Question			Answer	Marks	AO element	Guidance
			some could be used as foundations for (tunnel approach) roads ✓ spoil heaps may be unstable ✓ spoil heaps create visual / air pollution ✓ spoil will be a mixture of rock types / chemistry of dump site will vary ✓ will affect surface water / groundwater quality / chemistry / flow ✓			

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GCE

Geology

H414/01: Fundamentals of geology

A Level

Mark Scheme for June 2022

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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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 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 available in RM Assessor.
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:

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. 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 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.

Level of response questions on this paper are **26b** and **30b**

11. **Annotations**

Annotations available in RM Assessor

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

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

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

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	Mark	Guidance	AO
1			**B** - permeability ✓	1		1.1a
2			**A** - deep water ✓	1		1.1a
3			**D** - shallow marine ✓	1		2.1a
4			**A** - Ca-rich plagioclase is replaced by Na-rich plagioclase ✓	1		2.1a
5			**D** - Spearman's Rank ✓	1		2.1b
6			**A** - continental crust ✓	1		1.1a
7			**D** - only one is a marked change in composition ✓	1		1.1c
8			**C** - incompetent rock subjected to compressional stress ✓	1		2.1a
9			**C** - strike-slip faults ✓	1		2.1a
10			**A** - ice flow ✓	1		2.1a
11			**C** - chemical only ✓	1		2.1a
12			**D** - tsunami ✓	1		2.1a
13			**C** - hot desert✓	1		2.1a
14			**A** - inverted and formed by turbidity currents ✓	1		2.1a
15			**B** - electromagnetic survey ✓	1		1.1c
16			**A** - high crystal content ✓	1		1.1a
17			**B** – rock B ✓	1		1.1a
18			**C** - shale ✓	1		1.1a
19			**C** - garnet → chlorite ✓	1		2.1a
20			**B** - phytoremediation ✓	1		1.1c
21			**A** - fracking ✓	1		1.1b
22			**C** - some mammals could fly ✓	1		2.1a
23			**D** - shale → oolitic limestone → coarse sandstone ✓	1		2.1a
24			**B** – an increase in concentration of SO_2 in the atmosphere ✓	1		1.1c
25			**C** - an increase in the proportion of ^{16}O ✓	1		2.1a

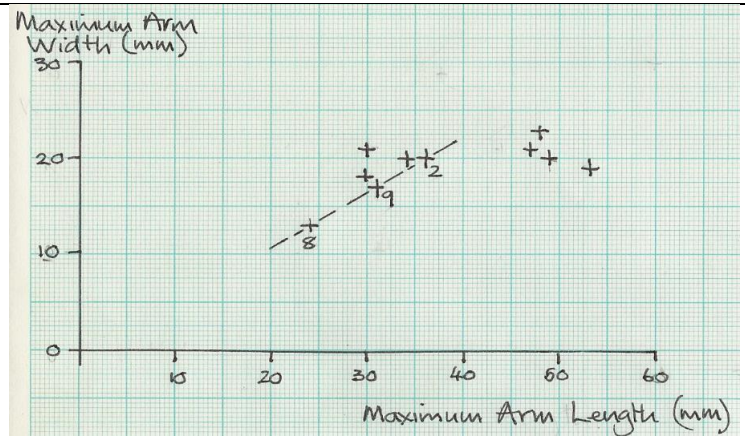
Question			Answer	Mark	Guidance	AO
26	(a)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 3300 (kg m^{-3}) award 2 marks** 14.92 / 4.52 = 3.3008 x 1000 = 3300.88 ✓ 3300 (kg m^{-3}) ✓	2	**ALLOW** 1 mark for answer not given to 2 sig figs e.g. 3300.9 kg m^{-3}	2.1b
	(a)	(ii)	Geological factor: particles of crushed rock may not contain only that mineral – will affect the mass / density of the sample **OR** fractures in the mineral – will affect / lower the mass / density of the mineral **OR** mineral may be weathered / altered / serpentine may be present – will lower mass / density of the mineral ✓ Experimental factor: air trapped in sample - will lower mass/density **OR** splash losing displaced water / failure to catch all displaced water- will lead to lower volume / higher density **OR** can not filled correctly **OR** error zeroing / reading balance – will lead to incorrect mass reading **OR** the balance is inaccurate leading to incorrect mass reading and density **OR** balance resolution is too low **OR** water level reading gives incorrect volume **OR** incorrect identification of the mineral ✓	2	Each marking point **MUST** contain a description and matching explanation **ACCEPT** porous **ALLOW** composition may vary / may form a solid solution series / there may be substitution of elements in mineral lattice / may vary between fayalite and forsterite – mass/density changes with composition **Max 1** for 1 correct geological factor **AND** 1 correct experimental factor but no correct explanations	1.1d 2.1b
26	(a)	(iii)	olivine ✓	1		2.1a
26	(a)	(iv)	pyroxene First Second (Last) opaque mineral (First) Second Last mineral with fractures First (Second) Last ✓	1	**MUST** have all 3 correct for mark	3.1a

26	**(a)**	**(v)**	pyroxene 26% +/- 15% opaque mineral 0.5 to 2% mineral with fractures 73% +/- 15% ✓	1	**MUST** have all 3 correct for mark **DO NOT ALLOW** if total does not add up to 100%	2.1b
26	**(a)**	**(vi)**	peridotite ✓ crystal size is > 5mm / coarse (therefore a plutonic igneous rock) ✓ mafic minerals / olivine and pyroxene / mainly olivine **OR** it is an ultramafic rock ✓	3	**ALLOW** harzburgite, dunite, lherzolite	1.1a 3.1b
26	**(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** The factors resulting in magmatic differentiation due to fractional crystallisation are described and explained along with the resulting change in the chemistry of the magma. Correct named ore mineral example(s) are given and the process is described in logical / time order of events. Technical terminology is used correctly. *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** The processes are described in a logical order with an attempt at explanations and some use of technical terminology. Correct named ore mineral example(s) may be given.	6	Indicative scientific content may include: • only applies to large-scale plutonic magma bodies with slow cooling / cooling over Ma • mafic and ultramafic intrusions • different minerals crystallise at different temperatures • at the highest temperatures metal oxides / ore minerals will form • named ore mineral example: chromite / magnetite / any other correct named ore mineral • platinum group elements (PGE) / platinum /palladium • these crystals / minerals are much denser than the magma and will tend to sink / settle down • these crystals / minerals sink due to gravity settling • these crystals / minerals are removed / separated from the magma • the melt becomes more silicic / less mafic / the chemistry changes • magma saturated in sulfide • sulfur exsolves forming an immiscible liquid • droplets of immiscible sulfide liquid are denser than magma so sinks	1.1a 1.1c 2.1a 3.1b

			There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence. **Level 1 1 – 2 marks** Some of the processes involved are included but not necessarily ordered logically. There is little explanation of the processes or use of technical terminology. Named ore mineral example(s) may not be included. *There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant.* No response or no response worthy of credit **0 marks**.		• PGE, gold and nickel are siderophile and so concentrate with iron • If no iron then behave like chalcophile and bond with sulfur forming sulfides • gathered up by the sinking sulfide droplets • they may form layers at the base of the magma chamber resulting in economic ore deposits • cumulates result • further concentration could result from filter pressing in which the weight of overlying crystals squeezes out the melt remaining between them	
26	**(c)**	**(i)**	dip of descending slab is approximately 45 degrees ✓ at a distance of (150 km) from trench, the slab is deep enough to reach temperatures for partial melting and magma generation ✓ dewatering / water released from the descending slab lowers melting point / generates melt in the mantle wedge / (asthenospheric) mantle above ✓ (low density) magma rises vertically to form the island arc ✓	Max 2	**ALLOW AW** **ACCEPT** flux melting	2.1a
26	**(c)**	**(ii)**	partial melting **OR** magma mixing **OR** magmatic differentiation **OR** assimilation **OR** stoping **OR** contamination ✓	1	**ACCEPT** filter pressing **OR** gravity settling	1.1a
26	**(c)**	**(iii)**	andesite / intermediate magma / lava has a higher / 52 – 66% / silica content ORA ✓ (as the silica % increases) the viscosity increases ✓ higher silica content causes more polymerisation in the magma ✓ the temperature of erupting magma / lava is lower ✓ the crystal content of the magma / lava is higher ✓	Max 3		1.1c

			more difficult for gases / volatiles to exsolve **OR** gas content will be higher **OR** more build-up of gas pressure ✓ lava may crystallise in the vent / block the vent ✓			
			Total	**21**		

Question			Answer	Mark	Guidance	AO
27	(a)		organism becomes buried (in sediment) ✓ replacement of original material by new minerals to form rock **OR** lithification / diagenesis processes described **OR** recrystalisation (aragonite to calcite) ✓	2	**ACCEPT** diagenetic processes such as cementation / pore fluid movement / compaction **ACCEPT** pyritisation / silicification / carbonisation **ACCEPT** casts and mould **OR** encased in amber	1.1c
27	(b)	(i)	the sediment must be fine-grained / mud / clay-rich to allow (soft body) detail to be preserved ✓ low energy conditions are necessary to preserve delicate structures / soft body ✓ rapid burial as no decay / not scavenged ✓ low oxygen / anoxic / anaerobic to reduce scavenging or bacterial action or decay ✓ hypersaline / high pH conditions to reduce scavenging or bacterial action or decay ✓	Max 2	**Max one** if 2 correct descriptions but no explanation	2.1a 3.1b
27	(b)	(ii)	long and thin (worm like) so lived in a burrow / infaunal **OR** no eyes so lived in burrow / infaunal ✓ it was benthonic **OR** lived on the sea floor crawling along the surface ✓ it had complex arms / tentacles so captured / filtered food ✓ tail for swimming / nektonic ✓	Max 1	mode of life conclusion **MUST** be justified by appropriate description of morphology	2.1a 3.1b
27	(b)	(iii)	there was the development of many experimental body plans resulting in many different new species ✓ Cambrian Lagerstatten deposits / sites of exceptional preservation allow us to see evidence of soft bodied preservation not normally preserved ✓ numbers of soft bodied organisms outnumber hard bodied organisms in Lagerstatten desposits suggesting many soft bodied organisms were present at the time ✓ it is an unusual soft bodied animal ✓	Max 1	**DO NOT ALLOW** discussion of hard part evolution in isolation (as *Facivermis* is soft bodied).	2.1b

27	**(c)**	**(i)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = (Width) 40 mm and (Length) 108 mm award 2 marks** Width = 40 mm +/- 3mm **OR** 4.0 cm +/- 0.3 cm ✓ Length = 108 mm +/- 2mm **OR** 10.8 cm +/- 0.2 cm ✓	2	**ALLOW Max** one mark for missing units **OR** more than 3 (width) **OR** 4 (length) sig figs **ACCEPT** 3 significant figures **ACCEPT** 4 significant figures	2.1b
27	**(c)**	**(ii)**	feeding traces show evidence of movement / this trace was from a stationary animal / resting trace ✓	1		2.1a 3.1a
27	**(d)**	**(i)**	appropriate axes maximising plot area and fully labelled ✓ points plotted correctly ✓ ✓	3	 8 or more points correct for 2 marks, 5 to 7 points = 1 mark, <5 = 0 marks	1.1d
27	**(d)**	**(ii)**	Description: the three points have almost identical ratios **OR** the three points fall on a straight line **OR** the three points have a linear relationship **OR** positive correlation **OR** as width increases so does the length ✓ Explanation: they were formed by the same species but at different growth stages / different ages ✓	2	**ACCEPT** increase proportionally	2.1a 3.1a

27	**(d)**	**(iii)**	there are two distinct clusters on the graph ✓ the two groups do not fall on same line of best fit / have different ratios (so have different characteristics) ✓ LH cluster has similar ratios suggesting even growth in length and width ✓ RH cluster's arm width does not increase with length (so animals will be different shapes) ✓ there are too few measurements to make a reliable interpretation ✓ one has a positive correlation and the other does not / has a negative correlation ✓	Max 2		3.1b 3.1c 3.1d 3.1e
27	**(e)**		disarticulation / break up of skeleton prior to burial ✓ decay of soft tissue due to scavenging / bacterial action ✓ dispersal / spread over a large area **OR** broken due to abrasion / attrition ✓ conditions for replacement / silicification / pyritization / carbonisation of original material are rare ✓ alteration / mechanical compaction / break up of material within the sediments after burial ✓ diagenesis may destroy the fossil ✓	Max 4	**ALLOW** any reasonable description of taphonomic processes using correct alternative terms **ALLOW** description of decay processes or effects of scavenging	1.1a 1.1c
			Total	**19**		

Question			Answer	Mark	Guidance	AO
28	(a)	(i)	forecasting gives the probability of an earthquake occuring ✓ prediction attempts to state when and where an earthquake will occur ✓	2	**ALLOW AW** if probability is linked to magnitude, position and time period **ALLOW AW**	2.1c
28	(a)	(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 6.077 award 2 marks** Return period = (n + 1)/m = 79/13 ✓ = 6.07(6923077) **OR** 6.077 **OR** 6.1 **OR** 6 years 1 month **OR** 73 months ✓	2	**ACCEPT** 6 **ACCEPT** any number of significant figures **ACCEPT** 79+1/3 = 6.1538 OR 6.15 OR 6 years and 2 months **Max 1** if no units given	2.1b
28	(a)	(iii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.165 award 1 mark** 1/6.077 = 0.16(45548791) **OR** 0.165 **OR** 16.46% **OR** 16.5% probability that a magnitude 4 event or greater will occur ✓	1	**ALLOW ecf** from **(ii)** for return period **ACCEPT** any number of significant figures **ACCEPT** 1/6.15 **OR** 16.25% **OR** 0.1625 **ACCEPT** 1/6 OR 0.167 **OR** 16.7%	2.1b
28	(a)	(iv)	it would be the same ✓ the probability does not change ✓	Max 1		1.1c
28	(b)	(i)	old workings were supported by wooden pitprops which will rot away ✓ iron and steel supports will rust / oxidise / corrode ✓ the void / stopes / mine provides little support ✓ workings were often supported by pillars of coal which were extracted before shut-down ✓ reference to longwall retreat mining with deliberate collapse ✓ increased load or vibration from developments / reservoirs above ✓	Max 1		1.1a

			earth movements / settling of spoil used to support / infill workings / new mining in the vicinity ✓ fault reactivation ✓			
28	**(b)**	**(ii)**	the surface will sink / subside ✓	1	**ACCEPT** crown holes	1.1a
28	**(b)**	**(iii)**	Explanation of how damage occurs: most damage occurs when structures are differentially affected by subsidence / tilted **OR** when parts of structures suffer from the horizontal movements and subsequent strain ✓ Engineering geology technique: effects can be mitigated by raft type foundations (to ensure structure moves as a unit) **OR** isolating foundations from the surface movement **OR** use of PVC / sand layers in foundations ✓	2	**ACCEPT** backfilling of mine	1.1c
28	**(b)**	**(iv)**	coal is formed in reducing conditions / anoxic conditions **OR** this results in the formation of pyrite **OR** metal / iron sulfides **OR** mining exposes the pyrite / sulfide minerals to water and oxygen ✓ sulfur dioxide **OR** sulfates form **OR** the process creates acid / sulfuric acid / lowers the pH of the water **OR** the acidic waters take toxic metals / iron into solution ✓	2	**ALLOW** correct named metal(s) e.g., aluminium / lead / mercury / arsenic / cadmium	1.1a 2.1a
28	**(b)**	**(v)**	when mining ceases the pumps are switched off **OR** abandoned mines fill up with water ✓ acid mine drainage water escapes and flows into rivers or lakes lowering the pH which has severe environmental impacts ✓ orange / iron precipitates can discolour the water / smother benthonic aquatic life ✓ toxic levels of iron / aluminium / other correct named metal(s) poison aquatic fauna / flora ✓	Max 2	**ALLOW** correct named metal(s) e.g., aluminium / lead / mercury / arsenic / cadmium	1.1c 2.1a

28	**(c)**		Comparisons: compressive always >> shear > tensile strength ✓ dolerite / igneous strength > metaquartzite / metamorphic strength > shale / sedimentary strength ✓ dolerite / igneous rock **AND** metaquartzite / metamorphic rock are much stronger than shale / sedimentary rock ✓ Explanations: tensile strength is lowest as it is easier to pull crystals or grains apart rather than crush them or break them by shear stress ✓ dolerite / igneous rock is strongest as made of interlocking crystals **OR** dolerite / igneous rock **AND** metaquartzite / metamorphic rock are stronger as crystalline ✓ metaquartzite / metamorphic rock is strong as has undergone recrystallisation / crystalline ✓ shale / sedimentary rock is weakest as grains can be pulled apart / fissile / has a weaker cement ✓ shale / sedimentary rock contains weaker minerals such as clay minerals or mica ✓	Max 3	Must have comparison **and** explanation for 3 marks **ACCEPT** dolerite is strongest and shale is weakest **ACCEPT** compressive is highest and tensile is lowest strength **ALLOW** metamorphic rocks may be weaker if they have a foliation / cleavage / fabric ✓	1.1a 1.1c 2.1a
28	**(d)**	**(i)**	condition / roughness / openness / permeability / asperity of discontinuities ✓ orientation of discontinuities ✓ presence / pressure of groundwater in the discontinuities ✓ attitude / dip angle of discontinuity ✓ movement along the discontinuity ✓	Max 1	 **ACCEPT** size / scale of discontinuity	3.1b

28	**(d)**	**(ii)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 99.73 award 2 marks** 6 discontinuities over 8 metres: λ= 0.75 ✓ RQD = <u>99.73</u> ✓	2	**ALLOW** 0.72 to 0.78 **ALLOW** 99.71 to 99.75 **ALLOW 1 mark for correct answer not to 4 sig fig**	2.1b
			Total	**20**		

Question			Answer	Mark	Guidance	AO
29	(a)	(i)	may be triggered by water / hydrostatic / pore fluid pressure lubricating faults / reactivating faults ✓	1		1.1c
29	(a)	(ii)	try to avoid faulted areas for reservoirs / areas of known seismic activity ✓ fill reservoir slowly / in stages to trigger more small events ✓ line / grout / cement reservoirs to prevent water entering faults / joints at base ✓	Max 1	**ALLOW** seismic activity should be expected and is difficult to prevent ✓ **ALLOW** warn and inform inhabitants of the possibility of seismicity ✓ **ALLOW** add less water / reduce water levels ✓	1.1c
29	(b)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2.4 (MPa) award 3 marks** use P = ρ g h ✓ P = 1000 x 10 x 240 Pa = 2400000 Pa ✓ = 2.4 MPa ✓	3		2.1b
29	(b)	(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 6 (MPa) award 1 mark** lithostatic pressure = 2400 x 10 x 250 = 6000000 Pa 6 MPa ✓	1	Do not penalise error in conversion from Pa to MPa twice (check 29bi)	1.1b
29	(b)	(iii)	hydrostatic is 40% lithostatic pressure **OR** ratio stated **OR** lithostatic pressure is 2.5 times that of hydrostatic pressure ✓ hydrostatic pressure (due to filling of the reservoir) was not the most important effect on slope stability **OR** hydrostatic pressure is less important than lithostatic pressure **ORA** ✓ failure surface may be closer to the water surface so pressure would be lower and less effective ✓	Max 2	**ALLOW ecf** from (b)(i) and (b)(ii) **ALLOW** lithostatic pressure 3.6 MPa / 3600000 Pa greater than hydrostatic **ORA**	2.1b

29	**(c)**	**(i)**	bedding dips into the valley **OR** beds dipping NNE **OR** the bedding dip is steep **OR** dipping beds slip due to gravity ✓ clay / marl layers are a weak / incompetent / have low load bearing strength / have low shear strength **OR** clay / marl can absorb water / has a high porosity so stores water **OR** (wet) clay acts as a lubricant ✓ limestone is permeable (allowing water in) **OR** there are alternating layers of permeable and impermeable rock ✓ alternating layers of (competent) limestone and (incompetent) clay ✓ river **OR** glacial erosion has steepened gorge **OR** removed toe support ✓	Max 2		3.1a 2.1a
29	**(c)**	**(ii)**	rainwater percolates into the limestone cavities adding to the load ✓ clay beds lose shear strength when wet ✓ clay becomes saturated / waterlogged / absorbs water / swells ✓ water acts as a lubricant **OR** causes loss of friction **OR** causes loss of cohesion ✓ hydrostatic / pore water pressure increases and reduces the shear strength of discontinuities / joints / bedding planes ✓	Max 2		2.1a

29	**(c)**	**(iii)**	**ANY** two from: drainage of slopes ✓ covering / use of shotcrete to prevent water ingress ✓ grouting of discontinuities ✓ rock bolting / rock anchors ✓ retaining walls / gabions at base to prevent slippage / give toe support ✓ nets to contain the loose material ✓ slope modification / change the slope profile ✓	2	**ALLOW** any correct named discontinuity (fault / joint / bedding plane / unconformity)	1.1a
			Total	**16**		

Question			Answer	Mark	Guidance	AO
30	(a)		**ANY** three from: • volume of the Earth is measurable / known ✓ • mass of the Earth can be found using the acceleration due to gravity measured at the surface ✓ • the density of the whole Earth is 5500 kg m^{-3} ✓ • density of rocks at the surface are 2700-2900 kg m^{-3} ✓ • density of the whole Earth is higher than the density of rocks at the surface **ORA** ✓ • the core and mantle must be higher density than the crust ✓ • density of upper mantle can be measured as occasionally it is thrust up or found as xenoliths at the surface ✓	3	**ALLOW** correct density in g cm^{-3} **ALLOW** any value within this range **Max 1** mark for idea of Earth density – crust density = mantle / core density	1.1c 2.1a
30	(b)*		**Level 3 5 – 6 marks** There is an explanation of how the properties of the outer core result in refraction due to velocity changes and cause the P and S wave shadow zones. The inner and outer cores are correctly described in terms of states and depths. Technical terminology is used correctly. *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** The P and S wave shadow zones are described correctly. Refraction / velocity changes may be referred to. Some correct description of the states and depths of	6	May include: • P wave velocity is controlled by incompressibility, rigidity and density • S wave velocity is controlled by rigidity and density • liquids have no shear strength / zero rigidity • changing wave velocity at a boundary results in refraction • slowing causes waves to be refracted towards the normal /steepened **ORA** • seismic shadow zones are areas on the Earth's surface where seismic waves are not recorded • S waves stop at the outer core boundary / Gutenberg discontinuity • seismic shadow zones are caused by outer core being liquid	1.1a 1.1c 2.1a 3.1b

			the inner and outer cores is included. Some technical terms are used. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 1 – 2 marks** There is an attempt to describe the P and S wave shadow zones with little or no explanation of the reasons for them **OR** there is some correct description of the states and depths of the inner and outer cores. *There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant.* *No response or no response worthy of credit* **0 marks**.		• S wave shadow zone is from epicentral angles of 103° – 103° / beyond 103° (may be shown on a diagram) • P waves can travel through the outer core but slow down • P waves are sharply refracted / focussed at outer core boundary / Gutenberg discontinuity • P wave shadow zone is from epicentral angles of 103° – 142° (may be shown on a diagram) • P waves speed up in the solid inner core **OR** beyond Lehmann discontinuity • P waves are sharply refracted / focussed at inner core boundary / Lehmann discontinuity • S waves occur in the solid inner core • (shadow zones show) outer core is at a depth of 2900 km • inner core starts at 5100 km (+/- 100 km) • outer core is liquid • inner core is solid	
			Total	**9**		

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Though we make every effort to check our resources, there may be contradictions between published support and the specification, so it is important that you always use information in the latest specification. We indicate any specification changes within the document itself, change the version number and provide a summary of the changes. If you do notice a discrepancy between the specification and a resource, please contact us.

Whether you already offer OCR qualifications, are new to OCR or are thinking about switching, you can request more information using our Expression of Interest form.

Please get in touch if you want to discuss the accessibility of resources we offer to support you in delivering our qualifications.

GCE

Geology

H414/01: Fundamentals of geology

A Level

Mark Scheme for June 2023

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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.

Level of response questions on this paper are **28(a)** and **30(b).**

11. **Annotations**

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given

Annotation	Meaning
I	Ignore
BP	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
I	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

13. **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**.

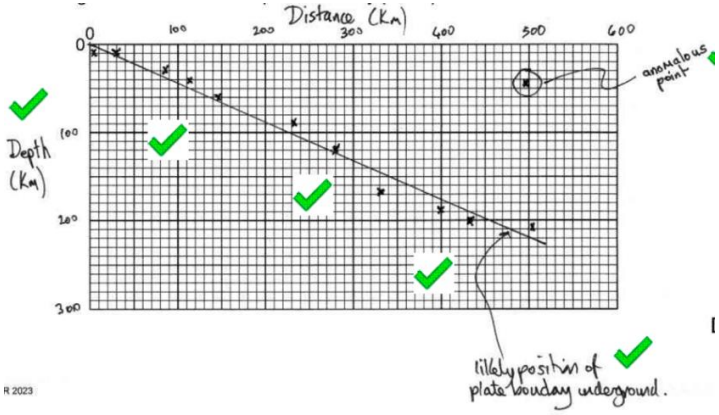
Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question			Answer	Marks	AO Element	Guidance
1			C	1	1.1a	**C –** A naturally occurring element or inorganic compound whose composition can be expressed as a chemical formula
2			D	1	2.1a	**D** – Pyroxenes
3			B	1	2.1a	**B** – Rock **1** = Sedimentary; Rock **2** = Contact Metamorphic; Rock **3** = Regional Metamorphic; Rock **4** = Igneous
4			A	1	1.1c	**A** – Calcite is least soluble and precipitates first
5			B	1	2.1a	**B** - Mafic composition with a porphyritic texture
6			C	1	2.1b	**C** – Lava flows and sills are concordant but only sills have two baked margins
7			C	1	2.1a	**C** – Chlorite → Biotite → Garnet → Kyanite → Sillimanite
8			B	1	2.1a	**B** – Competent rock subjected to tensional stress
9			D	1	2.1a	**D** – Cyclical sedimentation in shallow seas with deposition of shales, limestones, sandstones and ironstones
10			C	1	2.1a	**C** – Only found in high energy marine facies
11			A	1	2.1b	**A** – Cambrian to end Permian
12			D	1	1.1a	**D** – Triassic
13			C	1	2.1a	**C** – Saurischia Sauropoda
14			B	1	2.1a	**B** – Only **1** and **2**
15			B	1	2.1b	**B** – Magnetic anomalies are symmetrical on either side
16			B	1	2.1b	**B** – 2 cm a^{-1}
17			C	1	1.1a	**C** – Has a discontinuous magma chamber and has an axial rift valley
18			A	1	2.1b	**A** – A high velocity zone caused by P-waves travelling through colder and denser material
19			B	1	1.1c	**B** – At divergent plate boundaries
20			D	1	1.1c	**D** – Radioactive particles resulting from nuclear tests in the 1950s found worldwide in deep ocean sediments
21			C	1	2.1a	**C** – Some of the layers 1 to 5 have the same chemistry
22			B	1	2.1a	**B** – Layer **2**
23			C	1	2.1a	**C** – Lithosphere

Question			Answer	Marks	AO Element	Guidance
24			**A**	**1**	2.1a	**A** – Gabions
25			**D**	**1**	1.1a	**D** – Smectite

Question			Answer	Mark	AO Element	Guidance
26	(a)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer =** 1.6 **award 2 marks** 16 mm /10 mm ✓ 1.6 (mm) ✓✓	**2**	2.1b	**ALLOW** +/- 0.1 mm **ALLOW** 1 mark for correct answer not to 2 significant figures
		(ii)	Sandstones / arenaceous **AND** average grain sizes are between 0.0625 / $^{1}/_{16}$ and 2 mm / made of sand grains/ medium grained **OR** siliciclastic **AND** made of quartz / feldspar rich grains / sediment ✓	**1**	1.1a	**MUST** have correct rock group name **AND** matching reason for **1** mark
		(iii)	grains in **B** are angular / subangular / subrounded **AND** grains in **C** are rounded / well rounded ✓ grains in **B** are poorly sorted **AND** grains in **C** are well sorted **OR** grains in **B** have a more varied grain size compared to grains in **C** ✓ **B** is (texturally) immature **AND C** is (texturally) mature ✓	**Max 2**	1.1b	**ALLOW** implicit comparisons, e.g., grains in **C** are **more** rounded
		(iv)	grains in **C** have undergone more / further / longer transport than in **B** ✓ grains in **C** have undergone more erosion / abrasion / attrition than in **B** ✓	**Max 1**	3.1b	**ORA**
	(b)	(i)	correct plotting of composition of **A** on triangular diagram at 65% quartz, 25% feldspar and 10% rock fragments ✓	**1**	1.1d	

Question			Answer	Mark	AO Element	Guidance
		(ii)	**Any one** environment of deposition from: river / alluvial fan / wadi / turbidity flow ✓ Analysis of **Any one** textural characteristic from: immature **OR** poorly sorted **OR** angular / subangular grains **OR** muddy matrix **AND** deposited close to source **OR** transport was of short duration **OR** lack of erosion / abrasion / attrition **OR** rapid deposition **OR** clay settled from suspension **OR** low energy ✓ Analysis of **Any one** composition characteristic from: immature **OR** quartz and feldspar-rich **OR** contains feldspar / rock fragments **AND** softer minerals / minerals with cleavage have not been destroyed by erosion / abrasion / attrition ✓	**3**	3.1d 3.1a 3.1a	
	(c)		evidence from thin section diagram: has a (calcite) cement / has undergone cementation ✓ **Any two** explanations from: • groundwater / pore fluid contains dissolved minerals / calcite ✓ • dissolved calcite / minerals may be products of pressure solution ✓ • solution passes through sediment / pore space ✓ • minerals are precipitated / crystallise in the pore space ✓	**3**	2.1b 1.1a 1.1c	

Question			Answer	Mark	AO Element	Guidance
27	(a)	(i)	axes with correct linear scales, labels and units ✓ Points plotted correctly ✓✓✓	4	1.1d	1 to 5 points plotted correctly = 1 mark 6 to 9 points plotted correctly = 2 marks 10 to 12 points plotted correct = 3 marks 
		(ii)	smooth line through the plotted points **OR** just above the plotted points ✓	1	3.1b	**ALLOW** straight **OR** curved line
		(iii)	subduction **OR** earthquakes occur along the top of the subducted plate **OR** earthquakes mark the Benioff Zone ✓ the plates are prevented from moving by friction and <u>strain energy</u> builds up **OR** stored <u>strain energy</u> is released as seismic waves when the plates move ✓	max 2	2.1b	

Question			Answer	Mark	AO Element	Guidance
		(iv)	anomalous point circled on graph at distance 492 km, depth 45 km ✓	**1**	3.1d	
		(v)	there is movement along a fault ✓ earthquake was triggered by rising magma ✓ an old fault has been reactivated ✓ earthquakes can occur anywhere where sufficient strain has built up ✓	**Max 1**	2.1a	

Question			Answer	Mark	AO Element	Guidance
	(b)	**(i)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer =** 0.85(13986) **award 2 marks** Correct substitution of values into equation: $r_s = 1 - ((6\sum d^2) / (n^3-n)) = 1 - ((6 \times 42.5) / (12^3 - 12))$ ✓ $= 0.85$ ✓	**2**	2.1b	
		(ii)	the critical value is less than the calculated correlation coefficient (r_s) value (0.8514) ✓ the critical value is 0.6485 at the 0.05 / 95% significance level **OR** 0.7939 at the 0.01 / 99% significance level ✓ can be 95% confident that the null hypothesis can be rejected as the Spearman's rank correlation coefficient (r_s) value is above 0.6485 ✓ (can be 99% confident that) the null hypothesis can be rejected as the Spearman's rank correlation coefficient (r_s) value is above 0.7939 ✓ can be 99% confident that the result did not occur by chance / there is correlation ✓ there is a statistically significant correlation between the distance from the plate boundary and the depth of foci of the earthquakes ✓	**max 2**	3.1d 3.1e	**ALLOW ECF** for Spearman's rank correlation coefficient from **28(b)(i)** E.g., • If **ECF** r_s value lower than 0.5636 there is no statistically significant correlation / null hypothesis cannot be rejected • If **ECF** r_s value between 0.5636 and 0.6485 can only be 95% confident that the null hypothesis can be rejected • If **ECF** r_s value above 0.7939 can be 99% confident that the null hypothesis can be rejected **ORA**

Question			Answer	Mark	AO Element	Guidance
28	(a)*		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)** Describes all stages of the Wilson cycle model for ocean basin evolution **AND** Fully explains the plate tectonic processes involved. *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)** Describes an outline of the Wilson cycle model **AND** Explains some of the plate tectonic processes involved. *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)** Attempts to give some stages of the Wilson cycle **OR** Attempts to explain some of the plate tectonic processes involved. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*	**6**	3 x 1.1a 3 x 2.1a	**Indicative points may include:** **AO1.1a Demonstrates knowledge of the Wilson cycle:** • occurs on a 300 - 500 Ma year cycle. • starts with rifting / rift valleys / graben / embryonic oceans forming in continental areas • continents then drift / move apart to form a new / young ocean basin • passive margins on either side • ocean basin becomes mature • ocean basin then begins to close / decline • terminal stage / collision of continents and final closure / suturing of ocean basin occurs • may give present day examples, e.g., East Africa for rifting **OR** Red Sea / Atlantic Ocean for drifting apart **OR** Pacific Ocean for closure **OR** Himalayas for final closure / suturing **AO2.1a Applies knowledge and understanding of plate tectonic processes:** • continents rift apart due to tensional stresses / crustal extension / continental hot spots / mantle plumes • driven by convection currents in the mantle • ocean widens / new oceanic lithosphere is created by seafloor spreading at divergent plate margin / mid-ocean ridge • ridge push occurs

Question			Answer	Mark	AO Element	Guidance
			0 marks *No response or no response worthy of credit.*			• ocean starts to close due to subduction of ocean lithosphere at convergent plate margins / trenches / island arcs • slab pull occurs • compressional stress results in collision of continents / formation of orogenic belts • obduction may occur / ophiolites may be preserved in continental areas • idea that oceans open and close due to balance between formation by seafloor spreading and destruction by subduction
	(b)	**(i)**	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer =** 9 **award 2 marks** temperature change = -50 - +40 = 90 °C time = 720 - 710 = 10 Ma working showing temperature change ÷ time period ✓ = 90 / 10 = <u>9</u> +/- 0.5 (°C Ma^{-1}) ✓	**2**	2.1b	1 mark for correct working 1 mark for correct answer **ACCEPT** 8.5 – 9.5 (°C Ma^{-1})
		(ii)	arrow at 710Ma – rapid increase in temperature ✓	**1**	3.1a	
	(c)	**(i)**	lava / magma / rock contains magnetic minerals / iron minerals / magnetite ✓ iron minerals align with the Earth's magnetic field (at the time) **OR** iron minerals align in direction of the	**max 2**	1.1b 2.1a	**ALLOW** correct named rock containing iron minerals, e.g. mafic rock / basalt

Question			Answer	Mark	AO Element	Guidance
			Earth's magnetic field **OR** iron minerals show alignment with respect to the poles (at the time) ✓ magnetism is preserved (as remnant magnetism) when minerals cool below Curie point ✓			
		(ii)	magnetic inclination / dip of the Earth's magnetic field (from the horizontal) **AND** varies with latitude **OR** gives palaeolatitude ✓ (magnetic inclination / dip of the Earth's magnetic field preserved in rock) would be horizontal / 0° / parallel to the Earth's surface ✓	**1** **1**	1.1b 1.1c	
		(iii)	(rocks formed at the Equator at this time) would contain glacial deposits / tillite / boulder clay / glacial striations ✓	**1**	2.1a	**ALLOW** any correct named glacially formed deposit, e.g., varves / dropstones / glacial till
	(d)	**(i)**	hydrolysis **OR** carbonation **OR** oxidation occur ✓ water and carbon dioxide react to form carbonic acid ✓ soluble ions are formed ✓ residue of clay minerals / unreactive minerals / quartz is left behind ✓	**max 3**	1.1a 1.1c	**ACCEPT** hydrolysed **ALLOW** any correct named ion, e.g., K^+ / Na^+ / Ca^{2+} / HCO^{3-}
		(ii)	chemical weathering removes carbon dioxide from the atmosphere **AND** stored as carbonate ions / hydrogen carbonate ions in solution / in rivers / the sea / carbonate sediments / carbonate rocks ✓	**2**	2.1a	**ALLOW AW**

Question			Answer	Mark	AO Element	Guidance
			carbon dioxide is a greenhouse gas so its removal from the atmosphere leads to global cooling ✓			
		(iii)	deposition of carbonate rocks / limestone / chalk (in marine areas) ✓	**1**	2.1a	**ALLOW** any correct named carbonate rock / limestone
		(iv)	snow / ice cover has a high albedo / albedo is 80-95% **OR** has high reflectivity ✓ high albedo reflects solar energy / heat back into space making it colder ✓ as it gets colder, more precipitation falls as snow / ice **AND** causes it to become even colder ✓ causes a positive feedback loop **OR** runaway global cooling effect ✓	**max 2**	1.1c	
	(e)		heat from volcanic eruptions (under the snow / ice cap) caused melting of the ice ✓ volcanic eruptions release carbon dioxide / greenhouse gases into the atmosphere causing global warming ✓ melting of methane hydrates / methane gas locked in frozen sediment releases methane into the atmosphere which is another powerful greenhouse gas / causes more global warming ✓ volcanic ash / lava/ basalt covers the ice / snow and absorbs more solar energy ✓	**max 2**	1.1a 1.1c	

Question			Answer	Mark	AO Element	Guidance
29	(a)		there are many convergent plate boundaries around the Pacific Ocean which have the potential to generate large submarine earthquakes / underwater slides of volcanic debris ✓ there are no / few convergent plate boundaries around the Atlantic Ocean **OR** most of the Atlantic Ocean is aseismic **OR** Atlantic Ocean has divergent plate margins with smaller earthquakes **OR** the Atlantic Ocean has many passive plate margins with no earthquakes ✓	**2**	1.1c	
	(b)		tsunamis occur more often in the Pacific Ocean so expected **OR** tsunamis in the Indian Ocean are rare so was not expected ✓ the Pacific Ocean had a tsunami warning system in place at the time, the Indian Ocean did not ✓ many people live in low-lying coastal areas / islands around the Indian Ocean ✓ Japan had tsunami defences / tsunami evacuation routes / raised buildings / development-free coastal zones / better emergency planning / preparation / building construction ✓	**max 3**	2 x 1.1c 2.1b	**ALLOW AW** **ALLOW** specific detail of Pacific Ocean tsunami warning system **ORA** **ALLOW** any correctly described tsunami defence, e.g., sea walls / embankments **ALLOW** impact of deforestation in Indian Ocean
	(c)	**(i)**	seismometers / seismographs had not been invented ✓	**1**	3.1b	

Question			Answer	Mark	AO Element	Guidance
		(ii)	3 (hours) ✓	1	3.1a	
		(iii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer =** 139 **OR** 138.9 **OR** 138.$\dot{8}$ **award 2 marks** distance = 1500 x 1000 m = 1500000 m time = 3 x 60 x 60 s = 10800 s working showing speed = distance ÷ time ✓ 139 **OR** 138.9 (m s^{-1}) ✓	2	1.1b	**ALLOW ECF** **Max 1** mark if correct but more than 1 decimal place
	(d)		tsunamites / tsunami deposits have been found in land areas / onshore ✓ marine diatoms / fossils found in terrestrial sediments ✓ rip-up clasts in finer sediments ✓ marine sediments within terrestrial deposits ✓ marine deposits found (9 m) above current sea level / coastline ✓ anomalous high energy / coarse sediments in finer sediments✓	max 2	1.1a	

Question			Answer	Mark	AO Element	Guidance
	(e)		**Any one** description of the Storegga Slide from: • submarine / underwater slide (off the coast of Norway) ✓ • sudden collapse of the continental shelf near Norway ✓ • submarine slide displaced about 3,000 km^3 of sediment ✓ • submarine slide may have been triggered by an earthquake **OR** by deposition of a large volume of sediment from melting glaciers on the continental shelf ✓ **Any one** explanation of how a tsunami was generated from: • large volume of sediment displaced a large volume of water (upwards) ✓ • sudden movement of seafloor sets up a large wave ✓ • forms a broad swell out to sea, height increases in coastal waters when the wave slows down and breaks ✓	**2**	1.1a 1.1c	**MUST** include idea submarine event **OR AW** for submarine

Question			Answer	Mark	AO Element	Guidance
	(f)		non-specialists lack technical / scientific knowledge **AND** understanding of probability / return periods / degree of ground shaking ✓ geologists are unable to predict exact time / location / magnitude of future earthquakes ✓ difficult to decide if a public warning is appropriate ✓ earthquakes of the same magnitude can have very different consequences ✓ public perception of risk **OR** what a person believes the risk to be **AND** is different to the actual / true risk established by collecting and analysing data ✓ geoscientists may be sued / prosecuted for attempting predictions **OR** for giving false alarms ✓	**max 2**	1.1c	**DO NOT ALLOW** general discussion of risk as given in question **ALLOW** reference to the 2009 L'Aquila earthquake, Italy, after which seismologists were prosecuted / jailed for manslaughter for giving 'falsely reassuring statements' before the earthquake

Question			Answer	Mark	AO Element	Guidance
30	**(a)**	**(i)**	labelled arrow at the boundary between the copper oxide and carbonate minerals and the copper sulfide minerals ✓	**1**	2.1b	

Question			Answer	Mark	AO Element	Guidance
		(ii)	**Any two** processes above the water table from: • above the water table conditions are oxidising / oxidation occurs ✓ • chemical weathering / chemical reactions convert insoluble copper sulfides into soluble copper sulfates / carbonates / oxides ✓ • correct example of a chemical reaction, e.g., chalcopyrite + water + oxygen → copper sulfate + iron (III) hydroxide ✓ • infiltrating / percolating (rain)water dissolves copper / takes copper into solution / copper is leached downwards ✓ **Any two** processes below the water table from: • below the water table conditions are reducing / anoxic / reduction occurs **OR** the water table is the redox boundary ✓ • chemical reactions convert (soluble) copper sulfates / carbonates / oxides into (insoluble) copper sulfides ✓ • copper / ore is (re)precipitated immediately below the water table ✓ • copper is concentrated into a smaller volume, so the grade is higher ✓	**4**	1.1a 2.1a 1.1a 2.1a	**ALLOW** use of correct named copper ore minerals in explanations **ALLOW** spelling sulphide / sulphate **ALLOW** the gossan capping is a barren / leached zone of insoluble iron oxides **DO NOT ALLOW** use of the term deposition
		(iii)	the area is now hot and arid **OR** a desert so there is no water available for chemical reactions / chemical weathering	**1**	2.1a	

Question			Answer	Mark	AO Element	Guidance
			OR all the available copper has already been leached from the rocks above the water table ✓			
	(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)** Uses numerical data from the table to compare the geophysical signatures of the host rocks and copper ore minerals to evaluate which geophysical techniques are likely to be most successful in locating copper ore deposits. *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)** Attempts to evaluate which geophysical techniques are likely to be successful in locating copper ore deposits. *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)** May list or give a basic outline of one or more geophysical exploration techniques **AND / OR**	**6**	3 x 1.1b 3 x 3.1c	**Indicative points may include:** **AO1.1b Demonstrates knowledge of geophysical techniques** **general points** • can be land or air-based (except resistivity surveys) • may be done as a grid or transect survey • looking for geophysical anomalies **OR** departures from normal values • results are plotted on anomaly / isoline maps **gravity survey** • use of a gravimeter **OR** detecting variations in Earth's gravitational field strength • gravity survey gives information about density of underlying rocks / minerals • data is corrected for latitude **OR** altitude **OR** topography **electrical resistivity survey** • electrical resistivity is measured using metal electrodes / probes • an electric current is passed through rock **magnetic survey** • use of a magnetometer **OR** detects variations in Earth's magnetic field strength **electromagnetic (EM) survey**

Question			Answer	Mark	AO Element	Guidance
			Some relevant information is lifted from the table in an attempt to evaluate the use of geophysical techniques in locating copper ore deposits. *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.*			• measures ground conductivity • uses the process of electromagnetic induction **OR** may use VLF transmitters • values are given as percentage of the induced secondary field relative to the primary field **AO3.1c Evaluates which geophysical techniques are likely to be successful in locating copper ore deposits** **general points** • finding a geophysical anomaly does not guarantee the presence of an economic copper ore deposit • geophysical surveys do not give precise information about mineral content / grade / depth • only one part of an exploration programme / geochemical surveys / exploration drilling will also be needed **gravity survey** • copper ore minerals will give positive gravity anomaly • likely to be successful **AND** copper ore minerals have a much higher density than host rocks **OR** density of ore minerals 5090 – 4200 kg m^{-1} compared to 2500 – 2990 kg m^{-1} for host rocks • most successful if host rock is granite

Question			Answer	Mark	AO Element	Guidance
						electrical resistivity survey • copper ore minerals are good conductors **OR** copper ore minerals will give negative resistivity anomaly • likely to be successful **AND** copper ore minerals have a much lower resistivity / higher conductivity than host rocks **OR** resistivity of ore minerals 10^{-5} – 10^{-4} compared to 10^{3} – 10^{6} for host rocks • most successful if host rock is granite **magnetic survey** • not likely / may be successful **AND** magnetic susceptibility of copper ore minerals overlaps with that of the host rocks **OR** magnetic susceptibility of copper ore minerals 0-13 compared to 0-4400 for host rocks • most successful if host rock is diorite **electromagnetic (EM) survey** • copper ore minerals are good conductors **OR** copper ore minerals will give positive EM anomaly • likely to be successful **AND** copper ore minerals have a much higher conductivity than host rocks • most successful if host rock is granite
	(c)		decision needs to be made about the type and design of the mine, e.g., open cast or underground ✓	**max 3**	1.1a	**ALLOW** any correct named mining method

Question			Answer	Mark	AO Element	Guidance
			planning for / design of infrastructure **OR** access roads **OR** extraction facilities **OR** processing facilities **OR** ventilation ✓ checking that the mine is economically viable ✓ planning for environmental management **OR** environmental impact assessment must be done **OR** plans for restoration / reclamation must be made in advance ✓ involving the local community in decisions and plans ✓ planning must include health / safety considerations ✓ phased development may be planned to mine highest grade ore first to offset costs of exploration / development ✓			
	(d)	**(i)**	ore is broken / crushed / reworked mine waste is piled up on an impermeable liner ✓ a solvent is applied to the ore by spraying / pumping / using a drip system ✓ copper is <u>dissolved / taken into solution</u> and the leach solution is collected (in a pond) ✓ only 60-70% of the copper can be recovered **OR** the process takes two months to two years to complete ✓	**max 2**	1.1b	**ALLOW AW**
		(ii)	the electricity used for electrolysis can be generated using renewable methods **OR** no requirement to use coal as the fuel **OR** lower energy requirements **OR** lower energy costs ✓	**max 3**	3.1d	

Question			Answer	Mark	AO Element	Guidance
			smelting causes atmospheric pollution / acid rain / releases sulphur dioxide / releases carbon dioxide / releases greenhouse gases ✓ can be used to extract copper from very low-grade ore / reworked mine waste ✓ can be operated economically on a small scale ✓ copper produced by smelting has to be further purified by electrolysis ✓ other precious metals / valuable metals / gold / silver can be recovered as by-products from electrolysis ✓			**ORA**

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GCE

Geology

H414/01: Fundamentals of geology

A Level

Mark Scheme for June 2024

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

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

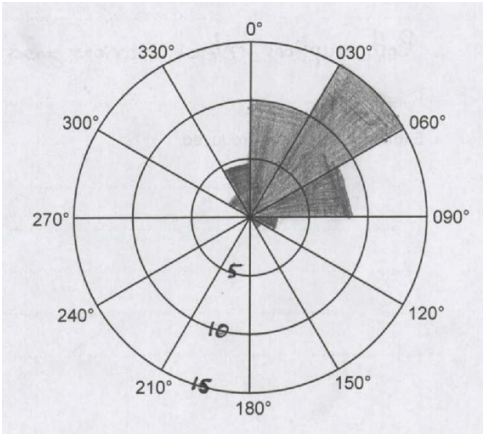
Question			Answer	Marks	AO Element	Guidance
26	(a)	(i)	Volcano **A** = Shield ✓ Volcano **B** = Strato(volcano) / Composite (cone) ✓	2	1 x 1.1a 1 x 2.1a	**ALLOW** mafic / basaltic for **A** **ALLOW** intermediate / andesitic / silicic / rhyolitic for **B** **DO NOT ALLOW** Strata for **B**
26	(a)	(ii)	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

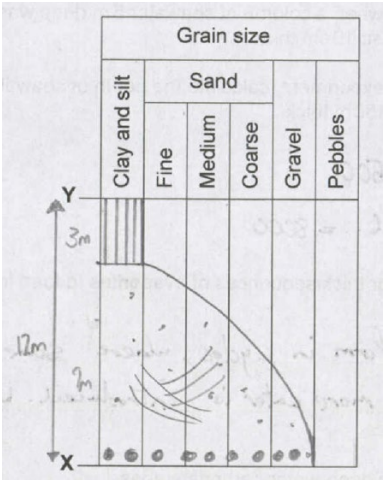
Question			Answer	Marks	AO Element	Guidance
26	(c)	(ii)	• Drop a heavy object / ball bearing through the liquid ✓ • Measure the time taken for the object to fall a known distance ✓ **OR** • Place the liquid in a stoppered test-tube and tilt the tube **OR** place the liquid on a slope ✓ • Measure the 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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