Oxford Cambridge and RSA

GCE

Geology

H414/02: Scientific literacy in geology

Advanced GCE

Mark Scheme for November 2020

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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.

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.

Question			Answer	Mark	AO element	Guidance
1	(a)	(i)	subsiding / low lying areas of Earth's crust / rift valley / graben / geosyncline / depression **AND** where sediments accumulate ✓	1	1.1a	**ALLOW** if faulting is discussed at basin margins
1	(a)	(ii)	**ANY two** from: • use of mapping to deduce vertical and lateral changes in sediments / rocks ✓ • drill boreholes ✓ • analyse / correlate type of sediments / rocks / microfossils present in drill core ✓ • use of seismic surveys ✓ • seismic profiles show subsurface layering / geometry ✓ • use of well log subsurface techniques to show geometry of basin ✓ • coarse sediments / conglomerates indicate high energy / shallow water / marginal areas / edge of basin ✓ • identification of sedimentary structures (e.g. ripple marks) **OR** fossils (e.g. corals) linked to water depth / energy levels / position in basin ✓	2	1.1b 1.1d	**MAX 1 for** general discussion of different sedimentary rock types / sedimentary structures / fossils not linked to specific environmental conditions **ORA** **ALLOW** discussion of **ANY** correct sedimentary structures / fossils to indicate water depth / energy levels / conditions
1	(b)	(i)	magnification = size of image / size of real object = 38mm / 1.26mm magnification = x 30 +/- 1 ✓✓	2	2.1b	
1	(b)	(ii)	rock is an oolitic limestone **OR** oolitic ironstone ✓ **ANY 1** from: • concentric ooliths indicate high energy / currents **AND** shallow water ✓ • (chamosite / siderite / iron) minerals are precipitated from seawater ✓ • precipitation around a nucleus builds up concentric layers as grains roll back and forth ✓	1 1	2.1a	**ALLOW** wackestone **OR** oo-micrite

Question			Answer	Mark	AO element	Guidance
1	(c)	(i)	water depth shallow **AND** energy levels low ✓ **ANY 1** from: • (evaporites indicate) high rates of evaporation / higher evaporation than recharge **OR** a hot / arid climate **OR** periods of drying out **OR** marine regression ✓ • (thin limestones indicate) a warm / tropical environment ✓ • (bivalves and ostracods indicate) conditions suitable for life ✓	1 1	3.1b	
1	(c)	(ii)	description: cycle is limestones, overlain by clay and then sandstone ✓ **OR** ichnofauna of *Rhizocorallium* and *Arenicolites*, then *Thalassinoides* repeat (in different rocks / environments) ✓ **OR** cycle is marine limestone to terrestrial sandstone ✓ reason: each cycle is caused by changing sea level / regression ✓ **OR** subsidence / transgression allows cycle to repeat ✓	1 1	2.1a 3.1d	**ALLOW** any starting rock in correct cycle order
1	(c)	(iii)	for beds 1, 4 and 6 (in that order) *Gryphaea* 5 : 3 : 18 5/3 3/3 18/3 **1.66 : 1 : 6** ✓✓ **OR** *Pecten* 4 : 12 : 7 4/4 12/4 7/4 **1 : 3 : 1.75** ✓✓	2	2.1b	1 mark for a correct ratio 1 mark for reducing the ratio **DO NOT ALLOW** if more than 3 sig figs are used
			Total	13		

Question			Answer	Mark	AO element	Guidance
2	(a)*		*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)** Sedimentary conditions and the geological setting of the Solnhofen Limestone is discussed in detail with good links to theory regarding exceptional preservation. Evidence is given as part of the narrative. *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)** Sedimentary conditions and the geological setting of the Solnhofen Limestone is addressed with some links to exceptional preservation. **OR** Preservation potential in different parts of the basin is discussed. *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 either the sedimentary conditions **OR** the geological setting of the Solnhofen Limestone without attempting to link to exceptional preservation. **OR** Describes the sedimentary conditions leading to exceptional preservation, but is not linked explicitly to the Solnhofen Limestone and may be linked to other sites of exceptional preservation. *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 3.1b 3.1e	**AO2.1a Apply knowledge and understanding of geological ideas** may include: • exceptional preservation occurs when organisms are not transported / scavenged / decayed • fine detail preserved when energy levels are low / particle size is small • diagenesis needs to occur quickly **AO3.1b Interprets geological information, ideas and evidence** may include: • shallow lagoon/basin with coral and microbial reefs may be cut off from recharge • inland basin with no sea / limited rivers feeding basin • contain highs which have allowed for shallow water communities to form as reefs (corals/algae) • may describe areas of map where preservation potential is highest with reasons **AO3.1e Draws conclusions** may include: • reefs cut off areas of the basin allowing salinity to toxic levels (for life) • organisms in high salinity basins will be preserved once covered due to lack of scavengers / lack of oxygenation for decay • explains why preservation is good linked to the context of Solnhofen

Question			Answer	Mark	AO element	Guidance
2	(b)		gives clear conclusion that the specimens are unlikely to be the same species ✓	1	3.1b	**MUST** consider both time **AND** space for max marks
			ANY 2 from: • a species is a group of morphologically similar individuals that can interbreed to produce fertile offspring – it is not possible to know this as they are fossils ✓ • anatomical differences between number 12 and the other specimens suggest that it may be a different species **OR** morphology must be very similar to be considered a species, but several anatomical differences have been found ✓ • over a time span of 7 million years evolution is likely to have occurred so it is unlikely for them all to be the same species ✓ • specimen 12 is lowest in the sequence and may display fewer characteristics of birds / is least evolved ✓ • only two specimens have been found in the lowest strata, more would be needed to make a judgement **OR** most of the specimens found are in two members of one formation ✓ • no other specimens have been found in the east / most of the specimens have been found in the west / centre of the basin which may support a different species theory **OR** isolation between west / centre and east sides may have allowed different species to evolve ✓	2	3.1e	**ORA**
2	(c)		**ANY 2** similarities for 1 mark from: • furcula / wishbone • reversed first toe • have long forelimbs / wings ✓	1	2.1a	
			ANY 2 differences for 1 mark from: • *Archaeopteryx* has teeth, chicken no teeth • *Archaeopteryx* has long bony tail, chicken has a short tail • *Archaeopteryx* does not have breastbone, chicken has large breastbone • pubis pointing different ways (forwards in *Archaeopteryx* and backwards in chickens)	1		**ALLOW** two implicit differences for 1 mark

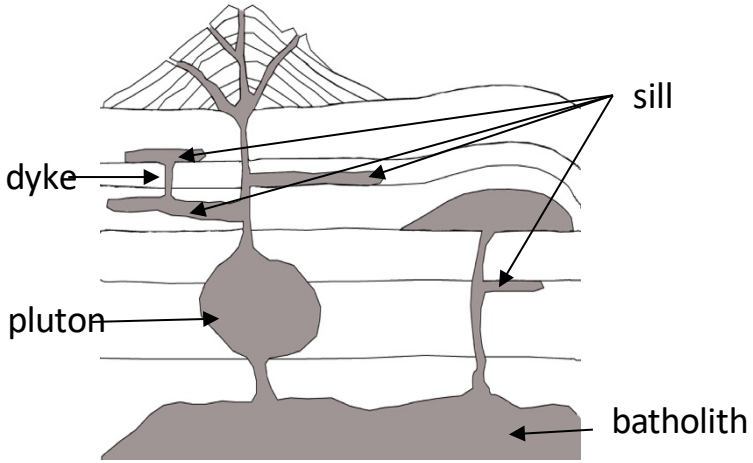
Question			Answer	Mark	AO element	Guidance
			• metatarsals not fused in *Archaeopteryx*, fused in chickens • *Archaeopteryx* has claws on wings, chicken does not ✓ •			
2	**(d)**		**ANY 2** descriptions **AND** matching explanations from: • evolved quickly **AND** (each species) had a short stratigraphic range / occupy a short time frame in geological history ✓ • abundant **AND** can find enough specimens to date a rock ✓ • easily identifiable morphology **AND** to be sure of assignation ✓ • can be found in many types of sediments and across different environments **AND** because a fossil restricted to one environment would be useless for zonation ✓ • had nektonic / pelagic mode of life **AND** is not confined to one rock type / is widespread geographically ✓ • can be found over a wide geographical area **AND** areas far apart can be zoned / correlated ✓ • strong skeletons / preservable hard parts **AND** is commonly preserved ✓	**2**	**1.1d**	each marking point **MUST** contain a description **AND** a matching explanation **ALLOW AW** **ALLOW MAX 1** for two correct descriptions with no / incorrect explanations
2	**(e)**		95m / 5.3 million years 95 / 5300 000 = 0.00001792 1.792×10^{-5} ✓✓	**2**	**2.1b**	**ALLOW** one mark if answer not in standard form
			Total	**15**		

Question			Answer	Mark	AO element	Guidance
3	(a)	(i)	(bulk) composition stays the same **OR** changes (that involve heat and pressure) without addition or subtraction of materials / elements / atoms ✓	1	1.1c	
3	(a)	(ii)	rock formed is a <u>metaquartzite</u> ✓	1	1.1c	
			ANY 1 textural change **AND ANY 1** mineralogical change for 1 mark from: textural change: • texture changes from clastic / grains to crystalline • adjacent grains exert pressure and quartz goes into solution at boundaries / pressure solution occurs • the grains are fused together (to form crystals) • recrystallisation results in uneven grain boundaries / granoblastic / sugary / saccharoidal texture / crystals with 120° triple point intersections / an unfoliated rock • crystal size increases with grade / as temperature increases mineralogical change: • mineralogy remains as quartz • impure sandstone may from additional metamorphic minerals ✓	1	2.1a	**DO NOT ALLOW** use of igneous terminology **ALLOW** metaquartzite as indicating mineralogy remains as quartz

Question			Answer	Mark	AO element	Guidance
3	(b)*		*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)** Identifies more than one phase of metamorphism / deformation, and may attribute the garnets to the earlier phase of metamorphism / deformation **AND** Correctly identifies the parent rock **AND** the resultant metamorphic rock, linked to medium metamorphic grade and regional metamorphism. *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)** Identifies a main foliation (which surrounds the porphyroblasts) and describes the formation of the foliation as part of the metamorphic history **AND** Correctly identifies the parent rock **AND / OR** the resultant metamorphic rock. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1-2 marks)** Correctly identifies the rock as a schist due to mineralogy / fabric, without attempting to link to metamorphic history. **OR** Correctly identifies the rock as either a regional **OR** a medium grade metamorphic rock and gives some idea of the conditions in which it formed **OR**	6	3.1a 3.1b 3.1d	**AO3.1a Analyse geological information, ideas and evidence** • identifies the mineralogy/texture as medium grade metamorphism • rock regionally metamorphosed • rock has two clear foliations and contains porphyroblasts • describes the formation of a foliation **AO3.1b Interprets geological information, ideas and evidence** • identifies that the garnets show inclusions which mean that they formed at the same time as the first foliation (early formed minerals) • main foliation developed at the same time as the garnets • garnets have been rotated in response to the pressure / temperature regime as they grew • a secondary / later foliation cross cuts the first • less recrystallisation in the secondary foliation suggests metamorphism was less intense **AO3.1d Make judgements** • there are a minimum of two phases of metamorphism / deformation which cross cut each other • parent rock must have contained some aluminosilicates / clay minerals to enable the formation of large amounts of mica / garnet / new aluminosilicate minerals • parent rock was a shale / mudstone / clay or other suitable named rock (to produce a schist)

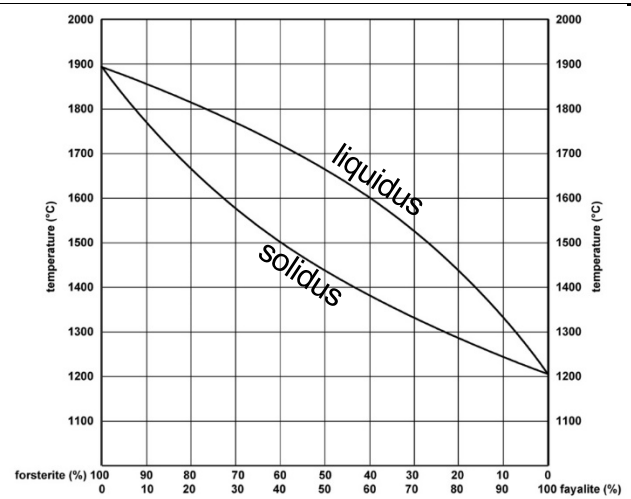
Question			Answer	Mark	AO element	Guidance
			Correctly identifies the parent rock as a shale / mudstone / clay. *There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant.* *No response or no response worthy of credit* **0 marks**.			
3	**(c)**	**(i)**	isograds drawn correctly ✓ ✓	**2**	**2.1b**	three lines drawn correctly for 2 marks two lines drawn correctly for 1 mark **ALLOW MAX 1** if 2+ correct lines are not completed across the entire map **OR** if lines continued around the edges of the map **DO NOT ALLOW** if lines are drawn through the letters
3	**(c)**	**(ii)**	area labelled **C** shaded on chart ✓	**1**	**3.1b**	
3	**(c)**	**(iii)**	Barrovian zones ✓	**1**	**1.1a**	
3	**(d)**		$CaCO_3 + SiO_2 \rightarrow CaSiO_3 + CO_2$ ✓ ✓	**2**	**2.1a [M1.4]**	**1 MARK** for each half of the equation **ALLOW** correct reactants and products in either order **MAX 1** if the symbol equation does not balance
3	**(e)**	**(i)**	both axes labelled correctly: temperature (°C) **AND** pressure (MPa) ✓ data plotted correctly ✓ appropriate line drawn ✓	**3**	**2.1a [M2.9]**	axes can be plotted either way round 5 or 6 points plotted correctly **ALLOW** a line joining point to point **OR** a suitable line of best fit
3	**(e)**	**(ii)**	kyanite = higher pressure / lower temperature mineral ✓ andalusite = higher temperature / lower pressure mineral ✓	**1** **1**	**2.1a**	
			Total	**20**		

Question			Answer	Mark	AO element	Guidance
4	(a)	(i)	**ANY 2** stability problems for 1 mark from: • sandstone may be poorly consolidated / uncemented and lack strength • sandstone may contain joints / bedding planes which are zones of weakness / allow slippage • dipping beds may slip • clay and sandstone interface may not be stable • clay is weak / incompetent and may collapse / slump • sandstone is permeable allowing water ingress leading to slippage / collapse • clay may absorb water / undergo swelling leading to failure • overbreak / underbreak may occur due to differing rock strengths ✓ **ANY** 1 suitable stabilisation method from: • concrete <u>lining</u> / steel ribs ✓ • use <u>shotcrete</u> (to stabilise rocks) ✓ • grouting (to reduce permeability) ✓ • rock bolt the sandstones (to prevent slippage / rock falls) ✓ • install rock drains ✓ • use fill to stabilise tunnel if overbreak has occurred ✓	**1** **1**	**1.1a** **1.1d**	
4	(a)	(ii)	**ANY 1** from: smectite / montmorillonite / bentonite / saponite ✓	**1**	**1.1a**	
4	(b)		*K* = **<u>0.908</u>** ✓✓✓ evidence of correct working **ANY** two from: • calculation of cross-sectional area A = (20 x 500) = 10000 • calculation of (h2-h1) / L = (55 - 50) / 1000 = 0.005 • correct substitution of values into formula: 45.5 = *K* x 10000 x ((55 – 50) / 1000) • correct rearranging of formula to find *K*: *K* = Q / A ((h2-h1) / L) **OR** = 45.4 / (10000 ((55 – 50) / 1000)) **OR** = 45.4 / (10000 x 0.005) **OR** = 45.4 / 50	**3**	**2.1a**	**MAX 2** if answer is not to 3 significant figures **MAX 2** for evidence of correct working if calculated answer is incorrect
			Total	**6**		

Question			Answer	Mark	AO element	Guidance
5	(a)	(i)	✓✓  	2	1.1a 1.1c	**ANY 2 OR 3** correct for 1 mark **4** correct for 2 marks **ALLOW** any vertical / discordant linear intrusion as dyke **ALLOW** any concordant linear intrusion as sill
5	(a)	(ii)	**ANY 1** from: • emplacement of the laccolith will dome the crust above ✓ • geodetic surveying will measure the movement of the ground / change in shape ✓ • the positive gravity anomaly will be detected ✓	1	2.1a	**ALLOW AW**
5	(a)	(iii)	intrusions at depth are classified as plutonic **AND** shallow level intrusions are classified as hypabyssal ✓	1	1.1a	

Question			Answer	Mark	AO element	Guidance
5	(b)		description and explanation of magma / lava composition: mafic / low silica content lava / magma **AND** has low viscosity **/** has low gas content **AND** silicic **/** high silica content lava / magma **AND** has high viscosity **/** has high gas content ✓	1	1.1d	**ALLOW** implicit comparisons
			ANY 1 comparison of volcanic landscapes for mafic and silicic volcanoes from: • mafic magma forms fissure / shield volcanoes / flattened features / plateaus / mafic volcanoes have shallow sides / slopes less than 10° **AND** silicic magma form stratovolcanoes / (composite) cones / domes / elevated features / calderas / silicic volcanoes have steep sides / slopes ~ 30° ✓ • mafic volcanoes have a roughly circular shape **AND** silicic volcanoes have an irregular shape ✓ • mafic volcanoes are made up of successive lava flows **AND** silicic volcanoes are composite **OR** made up of alternating layers of ash / tuff and lava ✓ • mafic lava flows extend long distances **AND** silicic lava flows are close to the vent ✓	1		
			ANY 1 comparison of volcanic hazards for mafic and silicic volcanoes from: • mafic volcanoes are effusive / have low explosivity **AND** silicic volcanoes are explosive / have high explosivity ✓ • main hazards for mafic volcanoes are lava flows **AND** main hazards for silicic volcanoes are pyroclastics / pyroclastic flows / lahars ✓ • lava flows from mafic volcanoes tend to be at higher temperatures / flow faster **AND** lava flows from silicic volcanoes tend to be at lower temperatures / flow slower ✓	1		**ALLOW** any correct named hazard of a mafic volcano and any correct named hazard of a silicic volcano
5	(c)	(i)	1. pyroxene / augite ✓ 2. amphibole / hornblende ✓ 3. biotite (mica) ✓	3	1.1a	
5	(c)	(ii)	olivine to biotite (mica) circled ✓	1	1.1a	

Question			Answer	Mark	AO element	Guidance
5	(c)	(iii)	early formed / high temperature minerals usually react with the magma to form the next mineral down in the series ✓ if the reaction is not complete **OR** if cooling is too rapid **AND** the early mineral will be preserved **OR** a rim of the next mineral down will be formed around the edge of the crystal **OR** a corona texture forms ✓	**1** **1**	**2.1a**	**ALLOW** correct named examples, e.g. olivine reacts with the magma to produce pyroxene
5	(c)	(iv)	fractional crystallisation: as chromite / early-formed / high temperature minerals crystallise the composition of the remaining magma changes **OR** minerals crystallise in order of melting point **OR** different minerals crystallise at different temperatures ✓ gravity settling: chromite / ore minerals / metallic minerals have a high density (compared with the density of the magma) **AND** sink / settle out to the bottom of the magma chamber (as cumulate layer) ✓ filter pressing: if a liquid-crystal magma mixture is subjected to pressure the liquid is squeezed out / layers form ✓	**1** **1** **1**	**1.1a** **2.1a**	

Question			Answer	Mark	AO element	Guidance
5	(d)	(i)	 ✓	1	2.1a	both lines labelled correctly for 1 mark
5	(d)	(ii)	temperature: 1600°C ✓ composition: 72% forsterite **OR** 28% fayalite ✓	1 1	2.1b 3.1a	**MUST** include correct units **ALLOW** + or – 2% of given values
5	(d)	(iii)	composition: 60% forsterite **OR** 40% fayalite ✓	1	3.1a	**ALLOW** + or – 2% of given values
5	(d)	(iv)	temperature: 1380°C ✓	1	3.1a	**MUST** include correct units
			Total	21		

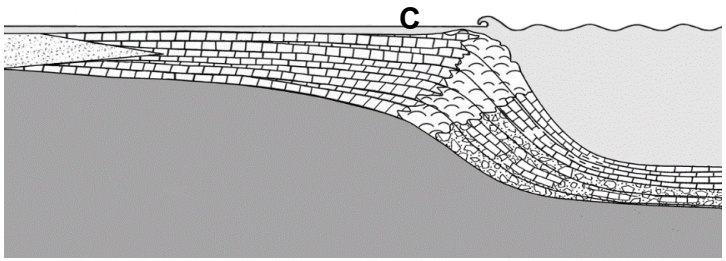
Question			Answer	Mark	AO element	Guidance
6	(a)		**ANY 2** from: • the iron in seawater originated from volcanism at the mid-ocean-ridges / hydrothermal vents ✓ • Fe^{2+} / ferrous iron is soluble / dissolved in seawater **OR** Fe^{3+} / ferric iron is insoluble ✓ • oxygen was produced by photoferrotrophs / photosynthesis (by bacteria) ✓ • oxidation caused iron minerals to come out of solution **OR** caused the iron minerals to be precipitated ✓ • form interbedded iron oxide and chert layers (suggesting cyclic variations) ✓	**2**	**3.1c** **3.1e**	**ALLOW** transport of iron in solution from rivers **ALLOW** cyanobacteria
	(b)		**ANY 2** from: • coral reefs form in shallow marine / continental shelf environments ✓ • oceans open by seafloor spreading and close due to subduction, forming and destroying these continental shelf environments ✓ • formation of supercontinents reduces shallow marine environments / coastlines and destroys coral reefs ✓ • break-up of supercontinents increases shallow marine environments / coastlines creating suitable environments for coral reef formation ✓ • the movement of continents affects the area of shallow marine environments between 30° N and S of the equator where coral reefs form ✓	**2**	**2.1a**	**ORA**
	(c)		coral skeletons enriched in ^{18}O indicate a cold palaeoclimate and low sea levels **AND** coral skeletons enriched in ^{13}C indicate a warm palaeoclimate and high sea levels ✓ **ANY 1** explanation from: • in colder periods / periods of low sea level ^{16}O is locked in glaciers / ice caps and not returned to the ocean so seawater / coral skeletons are enriched in ^{18}O **OR** depleted in ^{16}O ✓	**1** **1**	**1.1d**	**ORA** for valid alternative description relating to ^{16}O **OR** ^{12}C

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO element</th><th>Guidance</th></tr>
<tr><td></td><td></td><td></td><td>• in warmer periods / periods of high sea level ^{12}C is locked in plants / vegetation and not returned to the ocean so seawater / coral skeletons are enriched in ^{13}C OR depleted in ^{12}C ✓</td><td></td><td></td><td></td></tr>
<tr><td></td><td>(d)</td><td>(i)</td><td>
<table>
<tr><td colspan="4">mass in g</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td>114.00</td><td>114.00</td><td>114.00</td><td>114.00</td></tr>
<tr><td>2.00</td><td>2.00</td><td>2.00</td><td>2.00</td></tr>
<tr><td>116.00</td><td>116.00</td><td>116.00</td><td>116.00</td></tr>
<tr><td>115.12</td><td>115.26</td><td>115.41</td><td>115.19</td></tr>
<tr><td>0.88</td><td>0.74</td><td>0.59</td><td>0.81</td></tr>
<tr><td>2.00</td><td><u>1.68</u></td><td>1.34</td><td><u>1.84</u></td><td>✓</td></tr>
<tr><td>100%</td><td><u>84</u>%</td><td>67%</td><td><u>92</u>%</td><td>✓</td></tr>
</table>
</td><td>2</td><td>3.1a</td><td>1 mark for mass of $CaCO_3$
1 mark for % $CaCO_3$
OR
1 mark for B correct
1 mark for D correct

e.g. (0.81 x 100) / 44 = 1.84g
1.84 / 2 x 100 = 92%</td></tr>
<tr><td></td><td>(d)</td><td>(ii)</td><td>ANY 1 from:
• the experiment should have been repeated multiple times for each sample to allow for any erroneous results ✓
• the limestones (from each age group) may not be homogeneous / there may be lateral variation in beds ✓
• there could be experimental errors, e.g. electronic balance variation, loss of sample during transfer to beaker, etc. ✓
• the temperature could affect the rate of reaction ✓
• the reaction might not be complete after 6 minutes ✓</td><td>1</td><td>3.1f</td><td>DO NOT ALLOW experimental error without a specific example
ALLOW any valid example of experimental error</td></tr>
<tr><td></td><td>(d)</td><td>(iii)</td><td>student is partly correct as purity increases with time for samples C to A (Cretaceous to Neogene) ✓

student is partly incorrect as sample D (Permian) is older than C or B but has a higher purity ✓</td><td>2</td><td>3.1e</td><td>ALLOW ECF from (d)(i)</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>11</td><td></td><td></td></tr>
</table>

Question			Answer	Mark	AO element	Guidance
7	(a)	(i)	**ANY 2** descriptions from: • domed corals are found in all locations **OR** dish corals are only found on the lower slope **OR** branching corals are not found on the lower slope ✓ • the number of domed coral colonies increases with depth **AND** the number of branching coral colonies decreases with depth ✓ • branching corals dominate the upper slope **AND** dish corals dominate the lower slope ✓ **ANY 1** reason for distribution of dish corals from: • the plate-like form is an adaptation to low light levels **OR** maximises surface area for photosynthesis (of algae) ✓ • the dish corals are fragile and cannot survive currents / wave action / higher energy at shallower depths ✓ • large surface area allows dish corals to catch organic matter fallout from the reef above ✓	**2** **1**	**3.1b** **3.1c**	**MUST** make a comparison to get **MAX** marks for description
7	(a)	(ii)	(cementing) algae / Zooxanthellae thrive in warmer sea temperatures / temperatures of 23 to 27°C ✓	**1**	**3.1a**	**ALLOW** where sea temperature does not fall below 18°C for extended periods of time
7	(b)	(i)	grainstone ✓	**1**	**2.1a**	**ALLOW** bio-sparite
7	(b)	(ii)	**ANY 1** characteristic from: • rock is made of reef talus / reef debris ✓ • rock is bioclastic / composed of fossil / skeleton / coral fragments (from the reef / reef slope) ✓ • rock contains carbonate mud / micrite ✓ **ANY 1** geological process from: • wave action / currents / high energy (on fore-reef) ✓ • fragments / material transported down the reef slope ✓ • deposition occurs to form beds ✓ • rock will be cemented with carbonate mud / micrite ✓	**1** **1**	**2.1a**	

Question			Answer	Mark	AO element	Guidance
7	(b)	(iii)	✓  	1	2.1a	**ALLOW** area immediately behind reef crest up to half-way along reef flat
7	(b)	(iv)	a group of sedimentary facies / rocks that represent one depositional environment ✓	1	2.1a	
7	(c)	(i)	**ANY 1** description of weathering from: chemical weathering **OR** rainwater is acidic due to dissolved carbon dioxide from the atmosphere **OR** hydrolysis breaks down feldspar / silicate minerals releasing Ca^{2+} **OR** carbonation breaks down carbonates releasing Ca^{2+} ✓ **ANY 1** description of transport from: Ca^{2+} / calcium ions / carbonate ions are transported **OR** dissolved calcium is removed in solution **OR** rivers / surface run-off transport the material to the sea / ocean ✓	1 1	2.1a	

Question			Answer	Mark	AO element	Guidance
7	(c)	(ii)	**ANY 3** from: • 4.5 km is approximately the Carbonate Compensation Depth / CCD ✓ • below the CCD calcite goes into solution **OR** calcareous ooze will not form **OR** increasing pressure with depth increases the solubility of $CaCO_3$ ✓ • (above this depth) carbonate tests / calcareous microorganisms / calcareous nanofossils / foraminifera / coccoliths fall to the sea floor **OR** form a calcareous ooze ✓ • below the CCD only siliceous microorganisms / radiolaria fall to the sea floor **OR** form a siliceous ooze ✓ • rates of deposition are very low / slow **OR** mm /1000 years **OR** deposition requires low energy conditions ✓	**3**	**1.1a**	**ALLOW** 1 mark for general discussion of planktonic microorganisms sinking to the sea floor **ALLOW** any other correct named example of calcareous microorganism **ALLOW** any other correct named example of siliceous microorganism
			Total	**14**		

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GCE

Geology

H414/02: Scientific literacy in geology

Advanced GCE

Mark Scheme for Autumn 2021

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.

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
I	Ignore
BP	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

Question			Answer	Marks	AO element	Guidance
1	(a)	(i)	removal of sediment **AND** its transport **OR** the wearing away of the land surface (during transport) **OR** the wearing away of sediment by abrasion / attrition (during transport) ✓	1	1.1a	
	(a)	(ii)	**ANY** two from: • grains become more texturally mature with transport as corners get removed / due to attrition / abrasion ✓ • grains get finer with transport as corners get removed **/** due to attrition / abrasion ✓ • grains get rounder with transport as corners get removed / due to attrition / abrasion ✓ • grains get better sorted with transport as corners get removed / due to attrition / abrasion ✓ • grains become more quartz rich / more compositionally mature as other minerals decompose / fracture / are eroded away during transport ✓	2	1.1a	
	(b)	(i)	**ANY** two from: • clay minerals may be formed from breakdown of feldspars ✓ • hematite may form as an oxidation product in deserts ✓ • minerals are in solution / dissolved in groundwater ✓ • dissolved minerals may be products of pressure solution elsewhere ✓ • groundwater / pore fluid passes through sediment / pore space ✓ • minerals are precipitated / crystallise in the pore space ✓ • cement binds the grains together ✓	2	1.1c	**ALLOW** correct named clay mineral
	(b)	(ii)	any correct named cement, e.g., quartz / calcite ✓	1	1.1a	**ALLOW** limonite / siderite / glauconite

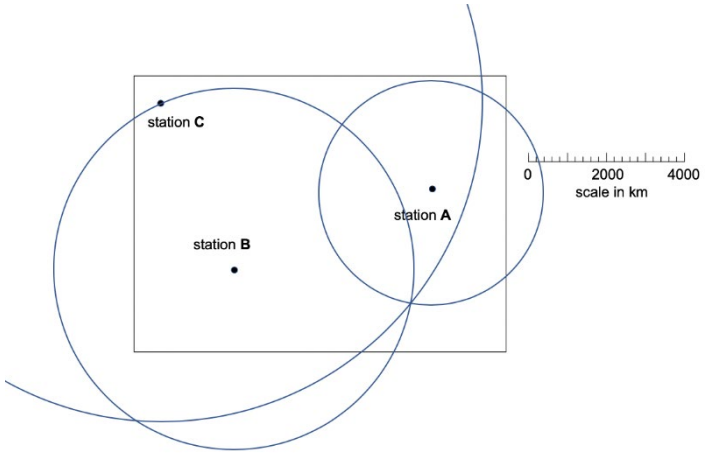
Question			Answer	Marks	AO element	Guidance
	(b)	(iii)	gas evolution from peat (whilst under pressure / compaction) **OR** CH_4 / CO_2 / SO_2 evolved **OR** loss of water occurs ✓ resulting in a (relative) increase in carbon content ✓	2	1.1a 2.1a	**DO NOT ALLOW** ideas that are not chemically based **ALLOW** loss of any correct named gas
	(c)	(i)	**ANY** two from: • compaction / load pressure / weight of overlying sediment / overburden causes dis(solution) ✓ • occurs at contacts points between grains ✓ • (large quantities of $CaCO_3$ are) taken into solution ✓ • clay is concentrated in layers as it is insoluble / does not go into solution / forms a residue ✓ • (re)crystallisation / precipitation from fluids occurs where stable ✓	2	3.1a	**ALLOW** compression
	(c)	(ii)	porosity **AND** permeability decrease ✓	1	3.1b	
	(c)	(iii)	clay originally disseminated in the limestone is now concentrated in layers **OR** clay is the insoluble residue **OR** the clay results from impurities in the limestone ✓	1	3.1b	
	(c)	(iv)	**ANY** one from: • easy to cut into thin layers due to composition ✓ • lacks porosity, so resistant to wear / does not crumble / is impermeable ✓ • recrystallised / hard(er), so stays polished / is hard wearing ✓ • mechanically strong, so durable ✓ • stylolites make the appearance of the rock more attractive ✓	1	2.1a	**ALLOW AW** **DO NOT ALLOW** non geological ideas
	(d)	(i)	**A** desiccation cracks ✓ **B** imbrication ✓ **C** cross-bedding ✓	3	3.1b	1 mark for each correct answer. **A – ALLOW** mud cracks **C – ALLOW** ripple marks
	(d)	(ii)	**A AND C** ✓	1	1.1d	

Question			Answer	Marks	AO element	Guidance
	(e)		**beach – ANY** one from: • composed of sand and gravel with rounded grains ✓ • medium - coarse grained / may include pebbles ✓ • orthoquartzites / quartz-rich sediment ✓ • may contain shell fragments / symmetrical ripple marks / burrows ✓ **shallow sea / wave influenced – ANY** one from: • form crossed-bedded sands / bioturbated sands / offshore sandbars ✓ • may contain glauconite ✓ • may contain asymmetrical ripples / burrows ✓ **below wave base – ANY** one from: • fine grained / muds and silts ✓ • many marine organisms / burrows ✓	3	2.1a	must have one marking point from each section. mark annotated diagram(s) as text

Question			Answer	Mark	AO element	Guidance
2	(a)	(i)	<table><tr><td>260</td><td>**080**</td></tr><tr><td>222</td><td>**042**</td></tr><tr><td>012</td><td>**012**</td></tr><tr><td>328</td><td>**148**</td></tr><tr><td>055</td><td>**055**</td></tr><tr><td>355</td><td>**175**</td></tr></table> ✓✓	2	2.1b	6 or 5 correct for 2 marks 3 or 4 correct for 1 mark Less than 3 correct 0 marks
	(a)	(ii)	experiment 1 = 069.5 / 070° **AND** experiment 2 = 085.3 / 085° ✓	1	2.1b	Must have both values **ALLOW ECF** from 2(a)(i)

Question			Answer	Mark	AO element	Guidance
	(a)	(iii)	**ANY** two from: • shells may be different sizes / shapes ✓ • differences in water pressure / speed / volume ✓ • tubing may have moved from centre ✓ • water left on tray / shells wet from first experiment ✓ • shells placed in slightly different places ✓ • iron in bench / lab interfering with compass readings ✓ • conducted in different parts of the lab so trends different ✓	2	3.1d	**ALLOW AW**
	(a)	(iv)	**ANY** one from: • control the flow rate / direction of the water ✓ • use more linear shells, such as *Solen* ✓ • create a drain hole for excess water ✓ • reduce the incline to less than 10° ✓ • conduct experiment away from sources of iron ✓ • dry the tray / shells between experiments ✓ • mark the position of the shells on the tray so they are placed in the same position each time ✓ • add sediment to the tray to make it more realistic ✓	1	3.1f	**ALLOW AW**
	(a)	(v)	**ANY** three from: • could be used to model if there was a current when a sedimentary rock formed ✓ • could be used to model the direction of current flow ✓ • shows shells tend to align in the direction of flow **OR** at right angles to flow ✓ • could compare to trends of fossils (on bedding planes) ✓ • the experiment only models a unidirectional current / river, (but mussels are marine organisms) ✓ • reality is more complex, e.g., there is sediment present **OR** interactions between currents **OR** in the ocean **OR** results in shell concentrations **OR** winnowing / sorting / rip currents / longshore drift / tides occur ✓	3	3.1c	

Question			Answer	Mark	AO element	Guidance
	(b)		**ANY** four from: • selection of suitable shell types ✓ • use the same number / mass of shells in each repeat ✓ • place shells in suitable container (with lid) • agitate / shake for set time period ✓ • masses / sediment (of known mass) could be placed (in container) with shells ✓ • describes way of separating different fragment sizes, e.g., using sieves **OR** measuring maximum diameter of fragments **OR** finding the mass of fragments over a particular size ✓ • measures mass of size fractions **OR** calculates percentage attrition ✓	**4**	**2.1b**	

Question			Answer	Mark	AO element	Guidance
3	(a)	(i)	**B** = 6 ✓ **C** = 9 ✓	2	1.1b 3.1b	
	(a)	(ii)	**B** = 4700 +/- 300 km ✓ **C** = 8000 +/- 300 km ✓	2	2.1b	**ALLOW ECF** from 3(a)(i)
	(a)	(iii)	 ✓ ✓ ✓	3	2.1b	1 mark for 1 correct arc 2 marks for 3 correct arcs 1 mark for locating the epicentre / can be in the centre of a triangle of error **ALLOW ECF** from 3(a)(ii)
	(b)	(i)	subduction zone **OR** subducted slab / plate **OR** subducted oceanic lithosphere ✓	1	3.1c	**ALLOW** convergent plate margin **DO NOT ALLOW** partial melting or low velocity zone alone
	(b)	(ii)	**ANY** two from: • P-waves travel faster through subducted slab **AND** P-waves travel slower where there is rising magma / partial melting ✓ • P-waves travel faster through the colder / denser material **OR** P-waves travel slower through hotter / less dense material ✓	2	1.1c	

Question			Answer	Mark	AO element	Guidance
			• the subducted slab is more rigid / more incompressible **OR** areas of rising magma / partial melting are less rigid / less incompressible ✓			
	(b)	**(iii)**	**ANY** one from: • a low velocity zone marks the asthenosphere as P / S waves slow down as they enter 5% partial melt ✓ • tomographic imaging shows the top of the asthenosphere at 75-100 km depth **OR** the base of the asthenosphere at approximately 250 km depth **OR** the asthenosphere is between 75-100 to 250 km depth ✓ • there is an increase in P / S wave speed at the base of the asthenosphere as the mantle becomes solid / as zone of 5% partial melt ends ✓	**1**	**2.1a**	
	(b)	**(iv)**	**ANY** one from: • oceanic crust is too thin for intermediate / deep focus earthquakes ✓ • shallow focus earthquakes are triggered by rising magma at the rift ✓ • shallow focus earthquakes occur due to lateral movement of transform faults ✓	**1**	**2.1a**	

Question			Answer	Mark	AO element	Guidance
4	(a)	(i)	**ANY** one from: mass extinction events **OR** asteroid impacts **OR** large-scale flood events **OR** large-scale volcanism ✓	1	1.1c	**ALLOW** bedding planes in **Fig. 4.1** are at different angles suggesting violent tectonic forces / upheaval / earthquakes **OR** angular clasts of Silurian rock in **Fig. 4.1** suggest a flash flood event
	(a)	(ii)	theory: Uniformitarianism **OR** Gradualism ✓ physical process: The Rock Cycle ✓	1 1	1.1a	
	(a)	(iii)	geological processes observable now / today acted the same way in the past ✓	1	1.1a	
	(a)	(iv)	**ANY** two from: • superposition ✓ • law of included fragments ✓ • cross-cutting relationships ✓ • original horizontality ✓	2	1.1a	**ALLOW** correct descriptions of these relative dating principles **ALLOW** unconformity for cross-cutting relationship
	(a)	(v)	**ANY** one from: • superposition: oldest rocks at base of sequence as deposited first **OR** rocks get successively younger upwards **OR** youngest rocks at top of sequence as deposited last ✓ • included fragments: fragments must be older than the rock in which they are contained **OR** older included fragments have been eroded and redeposited **OR** fragments in Devonian rocks have come from Silurian rocks ✓ • cross-cutting relationships: angular unconformity must be younger than the rocks it cuts across **OR** folded rocks were eroded then horizontal rocks deposited on top of them **OR** younger rocks cut across older rocks ✓	1	1.1a	**ALLOW** any valid explanation

Question			Answer	Mark	AO element	Guidance
			• original horizontality: beds were deposited horizontally **OR** if not horizontal, beds have been uplifted and tilted ✓			
	(a)	**(vi)**	beds containing the same fossils are the same age **OR** uses the first and last appearance of fossils / stratigraphic range ✓	**1**	**1.1a**	
	(a)	**(vii)**	fragments of older rock / fossils found in a younger rock ✓ allows the relative ages of units to be deduced as included fragments have come from older rock units **OR** (older fossils in the rock) make the rock appear to be older than it is ✓	**1** **1**	**2.1a**	
	(a)	**(viii)**	**ANY** one from: • he recognised faunal succession **OR** fossil faunas succeed one another in a definite age order ✓ • he suggested that rocks containing the same fossil assemblages are the same age **OR** rocks could be correlated on the basis of their fossil assemblages ✓ • William Smith found other unconformities ✓ • excavations of the canals allowed William Smith to collect large numbers of fossils from rock strata across the country ✓	**1**	**1.1c**	**ALLOW AW**
	(b)	**(i)**	**ANY** two from: • rates of sedimentation vary over time in the same location ✓ • rates of sedimentation vary geographically / laterally ✓ • rates of sedimentation vary between different rock types / depositional environments, e.g., mudstone & sandstone / deep marine & terrestrial ✓ • there may have been periods of erosion removing sediments leading to errors in rate calculation ✓ • there are no surviving sedimentary rocks from the early Earth **OR** ancient sedimentary rocks have been recycled by plate tectonic processes ✓	**2**	**1.1c**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO element</th><th>Guidance</th></tr>
<tr><td></td><td>(b)</td><td>(ii)</td><td>FIRST CHECK ANSWER ON ANSWER LINE
if answer = 0.0196 (mm per year) award 2 marks

working showing thickness of sediment ÷ time period over which the sediments were deposited

= <u>0.0196</u> (mm per year) ✓✓</td><td>2</td><td>2.1b</td><td>1 mark for correct working

1 mark for correct answer to 3 significant figures</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td><table><tr><th>Structural Events</th><th>Number</th></tr><tr><td>Youngest</td><td>6</td></tr><tr><td></td><td>2</td></tr><tr><td></td><td>4</td></tr><tr><td>Oldest</td><td>8</td></tr></table>✓</td><td>1</td><td>3.1b</td><td>ALL correct for 1 mark</td></tr>
<tr><td></td><td>(c)</td><td>(ii)</td><td><table><tr><th>Sedimentary Events</th><th>Number</th></tr><tr><td>Youngest</td><td>3</td></tr><tr><td></td><td>7</td></tr><tr><td></td><td>1</td></tr><tr><td>Oldest</td><td>5</td></tr></table>✓</td><td>1</td><td>3.1b</td><td>ALL correct for 1 mark</td></tr>
</table>

Question			Answer	Mark	AO element	Guidance
5	(a)	(i)	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 55.68 (kN m^{-2}) award 3 marks** σ = (18 x 1) + (19 x 0.7) + (2 x 22) = 75.3 ✓ μ = 9.81 x 2 = 19.62 ✓ σ^1 = 75.3 – 19.62 = <u>55.68</u> kN m^{-2} ✓	**3**	**2.1b**	
	(a)	**(ii)**	**ANY** one from: (rock) drains to remove water (and reduce pore fluid pressure) ✓ grouting / shotcrete to reduce permeability ✓ vegetation as plants reduce infiltration of water / 'fix' soil in place ✓	**1**	**1.1d**	
	(b)	**(i)***	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)** Uses a good balance of the general **AND** geological information / evidence from the text **AND** knowledge of the properties of smectite and illite clays **AND** makes judgements on the causation of the landslide. *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)** **EITHER** Uses some of the general **AND** geological information / evidence **AND** makes judgements on the causation of the landslide. **OR**	**6**	**3.1c** **2.1a** **3.1d**	**Indicative points may include:** **AO3.1c Evaluates information and evidence** **general information** • excessive rainfall may be final trigger • low-cost housing with shallow foundations • quarrying / deforestation • housing built on 25° slope • area susceptible to flash floods • drainage trenches retained water • cracks and fissures in walls & pavements **geological information** • bedrock heavily fractured & interbedded so weak • clay is weak / incompetent • beds dip from mountains above area making them unstable • area had high concentration of smectite and suffered slope failure • surrounding area had low concentration of smectite and did not fail

Question			Answer	Mark	AO element	Guidance
			Uses detailed geological information / evidence from the text **AND** makes judgements on the causation of the landslide. *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)** Some relevant information / evidence is lifted from the question **AND** there is an attempt at a judgement on the causation of the landslide. Answer may be unbalanced. *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.*			**AO2.1a Applies knowledge and understanding of the changing properties of clay** • soil containing as little as 5% clay minerals can be subject to shrink-swell • illite is a non-expanding / low shrink-swell (2:1) clay • smectite is an expanding / high shrink-swell (2:1) clay • smectite can expand up to 1500% of original volume when saturated • clay slopes are generally only stable below 10° angle • evidence of shrink-swell are cracks and fissures in walls and pavements **AO 3.1d Makes judgements on causation based on evidence provided** • fractured bed rock allows percolation of water • water adds weight making a failure more likely • fractured bed rock is weak • deforestation reduces hillside cohesion and allows rise of water table • over-quarrying increases run-off • hydrostatic pressure breaks grain-to-grain cohesion • hydrostatic pressure forces apart bedding planes / lubricates bedding planes • bedding planes likely to fail down dip • 25° slopes too steep for clay
	(b)	**(ii)**	lime **OR** calcium oxide treatment ✓ changes Na-smectite to Ca-smectite **OR** Ca-smectite expansion is only 100% **OR** Na-smectite expansion is 1500% ✓	**1** **1**	**2.1b**	**ALLOW** use of cement **ALLOW** alters the composition / structure of clay(s) to prevent shrinking and swelling

Question			Answer	Mark	AO element	Guidance
	(b)	(iii)	**ANY** two from: • study of aerial / satellite photographs **OR** desk study ✓ • surface mapping (folds / faults / joints / dip of beds) **OR** mapping fracture density **OR** slope mapping ✓ • sub-surface mapping, e.g., test pits / boreholes / drilled cores ✓ • geophysical survey, e.g., seismic refraction / resistivity ✓ • soil mechanics measurements **OR** laboratory testing of rock / soil samples **OR** measurements of rock strength (compressive / shear) ✓ • integration of data into GIS ✓	**2**	**3.1c**	**ALLOW** one mark for list of two correct techniques **ALLOW** any correct named appropriate geophysical surveying technique, e.g., ground penetrating radar

Question			Answer	Mark	AO element	Guidance
6	(a)	(i)	lower flow rate / less aquifer recharge / less water in the aquifer **AND** increases bromate concentration in groundwater **OR** there is less dilution of the bromate in groundwater ✓	1	2.1a	**ORA**
	(a)	(ii)	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 25.2 (µg/l) award 2 marks** 1200 m^3 x 1000 = 1200000 litres **AND** 1820 m^3 x 1000 = 1820000 litres ✓ ((1200000 + 1820000) x 10) ÷ 1200000 = 25.2 (µg/l) **OR** ((1200 + 1820)) x 10) ÷ 1200 = <u>25.2</u> (µg/l) ✓	2	3.1a	**ALLOW** 25.17 **OR** 25
	(a)	(iii)	**ANY** two from: • remove contaminated substrate ✓ • pump (and treat) bromate contaminated water from a borehole closer to the contamination source ✓ • phytoremediation – use of plants to remove bromate ✓ • use ion exchange process to remove bromate ✓	2	2.1a	
	(b)		(dis)solution of chalk / $CaCO_3$ / calcite / carbonate by groundwater creating a void space / caves ✓	1	2.1a	**ALLOW** compaction of aquifer due to over extraction / abstraction of water from wells

Question			Answer	Mark	AO element	Guidance
7	(a)	(i)	an animal with four limbs **OR** an animal that largely walked on four limbs ✓	1	1.1a	
	(a)	(ii)	**ANY** two from: • amniotic egg increased survival of young / protection of embryo ✓ • eggs could be laid away from a water source / increase in niches ✓ • less bones / more muscle and tendons ✓ • increased flexibility / manoeuvrability of animal ✓	2	1.1c	
	(a)	(iii)	**ANY** one from: amniote eggs have a hard shell (e.g., like chicken eggs) (so can lay eggs on land) **AND** anamniote eggs have no shells (e.g., like frog spawn) (so eggs need to be laid in water) ✓	1	1.1a	**MUST** give a morphological difference **ALLOW** amniote eggs have a membrane **AND** anamniote eggs do not
	(a)	(iv)	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)** Uses a good balance of the information / evidence from the text **AND** knowledge of the modes of life of different groups of named Archosaurs **AND** Makes links between bone structure and potential modes of life of some of the different Ornithosuchia with reasons. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*	6	2.1a 3.1c	**Indicative points may include:** **AO3.1c Evaluates information and evidence** • compares position of bones in the two types of Archosaurs • links bone structure to mode of life / locomotion with examples • Pseudosuchia / crocodilian ankle structure mostly used whilst swimming, with limited movement on land • Ornithosuchia ankle structure linked to life on land • Ornithosuchia have diverse members which walk, run, hunt, graze or fly **AO2.1a Applies knowledge and understanding** • Ornithosuchia ankles adapted to the need for additional weight bearing on land • Pseudosuchia / crocodilian skeletons supported by water so less need for weight-bearing

Question			Answer	Mark	AO element	Guidance
			Level 2 (3–4 marks) **Either** Uses some of the information / evidence from the text **AND** links this the modes of life of different groups of named Archosaurs. **OR** Uses more detailed ideas and evidence about Ornithosuchia to link morphology to specific examples of their modes of life. Answer may be unbalanced. *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)** Some relevant information / evidence is lifted from the question about some of the different groups of Archosaurs **AND** there may be an attempt to link to their modes of life **OR** Discusses Ornithosuchia / dinosaur mode of life, largely ignoring the content in the article. Answer may be unbalanced. *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.*			• describes how Ornithosuchia ankle structure supports grazing, running and hunting – both herbivorous and carnivorous modes of life • describes purpose of reversed big toe in birds / *Archaeopteryx* allowing perching • discusses changes in bone density / hollow bones in birds to allow flying • Compares morphology / modes of life of Ornithischian and Saurischian dinosaurs within the Ornithosuchia

Question			Answer	Mark	AO element	Guidance
	(b)	(v)	short and flattened peg shaped teeth = **SS** ✓ large olfactory lobes = **ST** ✓ hinged jaw containing teeth suitable for grinding = **O** ✓ primitive hips with pubis bone which points forward = **SS AND ST** ✓	4	2.1a	
	(c)		**ANY** four from: • definition of convergent evolution – independent evolution of same / similar features in unrelated / distantly related species ✓ • birds and pterosaurs do show convergent evolution as they have similar (morphological) features ✓ • both birds and pterosaurs evolved wings (for flight) ✓ • both evolved a stabilising tail ✓ • but structures for flight are different in pterosaurs and birds ✓ • but pterosaurs had teeth / had skin-like membranes held up by wing fingers ✓ • but birds have complex flight feathers ✓	4	3.1c	

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GCE

Geology

H414/02: Scientific literacy in geology

A Level

Mark Scheme for June 2022

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

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

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

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

MARKING

1. Mark strictly to the mark scheme.

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

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

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

5. Work crossed out:

   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 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 **1ci** and **3e.**

11. Annotations available in RM Assessor

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
I	Ignore
BP	Blank page

12. 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

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.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>A Desiccation cracks ✓

B Ripples / ripple marks ✓

C Salt / halite <u>pseudomorphs</u> ✓</td><td>3</td><td>AO2.1a</td><td>1 mark for each correct answer

DO NOT ALLOW mudcracks for A

ALLOW symmetrical OR asymmetrical ripple marks OR cross laminations for B</td></tr>
<tr><td>1</td><td>(a)</td><td>(ii)</td><td><table><tr><th>Sedimentary structure</th><th>Way up
✓ or X</th><th>Palaeocurrent direction
✓ or X</th></tr><tr><td>A</td><td>✓</td><td>X</td></tr><tr><td>B</td><td>✓</td><td>✓</td></tr><tr><td>C</td><td>✓ OR X</td><td>X</td></tr></table>✓ ✓ ✓</td><td>3</td><td>AO1.1d</td><td>1 mark for each correct row</td></tr>
</table>

Question			Answer	Marks	AO element	Guidance
1	(a)	(iii)	**Any one from:** • Offshore transition from coarse to fine sediment ✓ • Coarse-grained sediments / pebbles / gravel / sand **AND** on beach / near shore / in shallow water / high energy ✓ • Fine-grained sediment / mud / clay **AND** offshore / in deep water / low energy ✓ • Pebbles / gravel / sand on beach may contain shell lags / wood fragments (due to high energy storms) ✓ • Sediment type are usually rounded sand grains with high quartz content / may contain glauconite ✓ **Any one from:** • (Symmetrical) ripples formed in sands / on beach / in shallow water / from bi-directional currents ✓ • Laminations in muds / below wave base / in deep water / low energy ✓ • Bioturbation / burrows ✓	**2**	**AO1.1c**	1 mark for discussion regarding sediments **AND** 1 mark for sedimentary structures **ALLOW** correct named rocks for sediment **ALLOW** asymmetrical ripples if associated with rip current or longshore drift **OR** herringbone cross bedding **OR** subaqueous dunes **ALLOW** correct any correct named burrow
1	(b)	(i)	• Braided river facies described as (wide shallow) channels and islands / bars / eyots ✓ • States a (conformable) vertical sequence is produced by lateral facies changes / lateral environments **OR** uses Walther's Law to explain that 3D geometry results from sediments deposited at the same time in different places ✓ • Deposition occurs on inside of bends / bars / islands / eyots **AND** where current velocity is low / reduces ✓ • Erosion occurs on outside of bends **OR** where current velocity is high ✓ • Deposition / erosion causes channel migration **OR** deposition may block channels **OR** deposition may divert channels ✓	**max 3**	**AO2.1a**	Mark diagrams as text **MAX 2** if describes meandering river system **ALLOW** any correct named subenvironment where velocity is low for deposition **ALLOW** any correct named subenvironment where velocity is high for erosion

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>1</td><td>(b)</td><td>(ii)</td><td>FIRST CHECK THE ANSWER ON ANSWER LINE
If answer = 15.8 award 4 marks

<table>
<tr><td></td><td>Angular</td><td>Sub angular</td><td>Sub rounded</td><td>Rounded</td></tr>
<tr><td>Observed (O)</td><td>20</td><td>10</td><td>7</td><td>3</td></tr>
<tr><td>Expected (E)</td><td>10</td><td>10</td><td>10</td><td>10</td></tr>
<tr><td>O – E</td><td>10</td><td>0</td><td>-3</td><td>-7</td></tr>
<tr><td>$(O – E)^2$</td><td>100</td><td>0</td><td>9</td><td>49</td></tr>
<tr><td>$\frac{(O – E)^2}{E}$</td><td>10.0</td><td>0.0</td><td>0.9</td><td>4.9</td></tr>
</table>
✓✓✓

$\Sigma \frac{(O – E)^2}{E}$ = 15.8 ✓</td><td>4</td><td>AO2.1b</td><td>1 mark for expected row 10,10,10,10
1 mark for O – E row
1 mark for correctly completing rest of table
1 mark for correct calculation</td></tr>
<tr><td>1</td><td>(b)</td><td>(iii)</td><td>Degrees of freedom = n – 1 OR 4 - 1 = 3 ✓

Value is greater than the critical value
AND (Result is) statistically not due to chance OR the hypothesis can be rejected OR the shape of the pebbles is not random ✓</td><td>2</td><td>AO3.1c
AO3.1b</td><td>ECF on calculated chi square value</td></tr>
</table>

Question			Answer	Marks	AO element	Guidance
1	(c)	(i)*	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)** Uses detailed evidence from the table and knowledge of deltaic sequences to correctly link different beds to all parts of a delta. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Uses evidence from the table to interpret the sequence as a deltaic environment **OR** Identifies cyclical deposition where the coal indicates swamp / land and the mudstone is a return to marine environments. *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)** Some relevant information / evidence used from the table is correctly linked to an environment for at least one bed, but the sequence is not recognised as a deltaic environment **OR** Discusses changes in depth of water or energy levels correctly linked to different beds in the sequence.	**6**	**AO3.1b, AO3.1c AO3.1e**	**Indicative points may include:** <u>AO3.1b Interpret geological information ideas and evidence</u> • Describes cyclical sedimentation • Describes coarsening upwards sequence • Links beds / rock types / evidence to different positions on a delta • Discusses evidence of changing energy levels • Discusses fossil evidence <u>AO3.1c Evaluate geological information, ideas and evidence</u> • Links erosional channel fills with meandering rivers / distributary channels / channel switching on delta top / topset beds • Links coal formation and rootlets to land and swamp on delta top / topset beds • Links the cross bedded sandstone to the delta front / delta slope / foreset beds • Recognises that mudstone containing bivalves is marine / prodelta / bottomset beds • Subsidence / sea level change linked to cyclicity <u>AO3.1e Draws conclusions</u> • Identifies a prograding delta front • Identifies a deltaic sequence • Identifies changing sea level

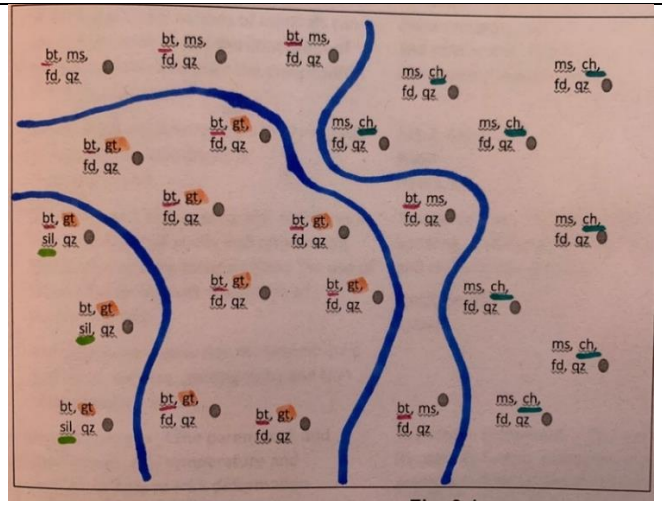
Question			Answer	Marks	AO element	Guidance
			There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. **0 marks** *No response or no response worthy of credit.*			
1	**(c)**	**(ii)**	Cement / Matrix ✓ Grain size ✓ Textural maturity ✓ Sorting ✓ Grain shape / Roundness ✓	**max 2**	**AO2.1b**	**ALLOW** friability / description of how rock breaks **ALLOW** fossil content **ALLOW** grain sphericity
1	**(c)**	**(iii)**	Measure thickness of a bed at the base / a bed that can be reached (using a tape measure) and use this to visually determine bed thicknesses up the cliff face **OR** Makes comment about estimating true thicknesses from apparent thicknesses due to dip ✓ **OR** Place a (fiduciary) scale or an object of known size next to the cliff ✓	**1**	**AO3.1f**	**ALLOW** use of photography to estimate thickness of higher beds **DO NOT ALLOW** a suggestion that would be unsafe
1	**(c)**	**(iv)**	• Danger of falling rocks from rock face **AND** must wear a hard hat / keep away from loose areas ✓ • Slip / trip hazards on uneven / slippery rock surfaces **AND** must wear stout footwear ✓ • Cut off by the tide **AND** check tide times / plan in advance ✓ • Inclement weather conditions where safety is compromised **AND** check weather conditions / wear suitable clothing for weather conditions / describes appropriate precautions for the weather ✓	**max 2**	**AO3.1f**	**DO NOT ALLOW** general health and safety issues not relevant to sedimentary logging **ALLOW** 1 mark for a list of 2 safety issues without mitigations suggested **ALLOW** use of acid to test rocks **OR** use of geological hammer to take specimens **OR** sharp rocks cutting hand with correct mitigation for 1 mark

Question			Answer	Marks	AO element	Guidance
2	(a)	(i)	Fit of continents' coastlines / edge of continental shelf / jigsaw fit, e.g., South America and Africa ✓ Rock types of the same age **AND** same type **OR** matching rocks on different continents **OR** matching Precambrian cratons **OR** matching continent flood basalts ✓ Matching mountain chains / orogenic belts on different continents **OR** have same age and trend **OR** that can be joined, e.g., Precambrian aged mountain ranges on South America and Africa ✓ Matching fossils which lived on land / shallow sea / freshwater / couldn't cross a wide ocean found on different continents, e.g., *Mesosaurus* / *Glossopteris* for Gondwanaland **OR** trilobites of Scotland and England / Wales **OR** fossil corals / plants suggesting continent was at the Equator at the time so must have moved to present day position ✓ Matching deposits from glaciation (tillites) / glacial striations suggesting continents were joined, e.g., those found in South Africa and parts of South America ✓ (Palaeoclimatic) evidence in sedimentary rocks suggesting a continent was in a different climatic zone / latitude than it is today so must have moved to present day position, e.g. coal / tillites / evaporites / red sandstone / limestones ✓	**max 4**	**AO1.1a** **AO1.1c**	**MAX 3** if specific named example is not included as evidence **IGNORE** discussion of radiometric dating or palaeomagnetism **ALLOW** any correct named land-dwelling fossil, e.g., plants / ferns **ALLOW ANY** correct named example of a sedimentary rock linked to correct latitude of deposition

Question			Answer	Marks	AO element	Guidance
2	(a)	(ii)	Ridge push (divergent margins) **AND** (sea floor cools and thickens causing) gravitational sliding away from the MOR **OR** rising magma pushes the plates apart ✓ Slab pull (convergent margins) **AND** (cold / dense) lithosphere sinks into ocean trenches ✓ Convection currents in the mantle **OR** mantle plumes act as the active / rising limb at divergent margins / transfer energy to spreading centres ✓	**max 2**	**AO1.1c**	**ALLOW** 1 mark if sea floor spreading is discussed **ALLOW** 1 mark if ridge push **AND** slab pull listed **DO NOT ALLOW** statement of tensional / compressional forces as only explanation
2	(a)	(iii)	Density of oceanic plate is greater than continental (which explains why oceanic plates are subducted) **OR** Density of oceanic plate is 2.9 gcm^{-3} whilst continental plate is 2.7 gcm^{-3} ✓ Oceanic composition is basaltic / mafic / contains more mafic minerals **AND** continental composition is granitic / silicic / intermediate / contains more felsic / silicic minerals **OR** Oceanic crust is almost entirely igneous **AND** continental crust can be igneous, sedimentary and metamorphic / more varied composition **OR** Oceanic bulk composition contains less SiO_2 than continental crust ✓	**2**	**AO1.1c**	1 mark for density and 1 mark for composition **ORA** **ALLOW** correct named minerals in each **ORA**

Question			Answer	Marks	AO element	Guidance
2	(b)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 47% award 2 marks** Indicates maximum value is 280 **AND** minimum value is 190 ✓ Change = $\frac{\text{max value – min value}}{\text{min value}}$ x 100 = $\frac{280 – 190}{190}$ x 100 = 47% (increase) ✓	**2**	**AO2.1b**	**ALLOW ANY** correctly rounded number, e.g., 47.4 or 47.37
2	(b)	(ii)	• Contribution of vulcanicity / volcanic gases ✓ • No organisms able to photosynthesise to take out CO_2 from atmosphere ✓ • Great Oxygenation Event had not occurred ✓ • No ozone layer so no life on land / plants had not evolved ✓	**max 2**	**AO1.1b** **AO2.1a**	
2	(b)	(iii)	Cycles of volcanic activity **OR** Icehouse / Greenhouse cycles / cycles of Snowball Earth **OR** Changes in Earth's tilt / orbit / Milankovitch Cycles ✓	**max 1**	**AO3.1d**	**MUST** have idea of periodicity **ALLOW** changes in obliquity / eccentricity / precession **ALLOW** changes in the distribution of continents / changes in ocean circulation
2	(c)	(i)	Anthropocene ✓	**1**	**AO1.1a**	

Question			Answer	Marks	AO element	Guidance
2	(c)	(ii)	• Rate of biological change is high / (mass) extinction is occurring ✓ • Rate of environmental change is high / increased global warming / increased greenhouse effect due to Human activity **OR** increased levels of anthropogenic carbon dioxide / anthropogenic greenhouse gases in atmosphere **OR** CO_2 has risen to over 400 ppm ✓ • Man-made chemicals, e.g., plastics, are widely distributed in the environment ✓ • Mass extinctions / environmental changes were used to draw boundaries between geological periods ✓ • A global marker horizon / GSSP / golden spike can be identified ✓	**max 3**	**AO2.1b**	**ALLOW** agriculture changing soils **ALLOW** widely spread chicken bones (in landfill) **ALLOW** suggestion of a specific named marker, e.g.,1950s – Atomic age / global increase in radionuclides

Question			Answer	Marks	AO element	Guidance
3	(a)	(i)	• Metamorphic rock has same (bulk) composition as the original / parent rock ✓ • No gases / elements / ions / atoms lost **OR** gained ✓ • No melting **OR** stays solid ✓	**max 2**	**AO1.1a**	**DO NOT ALLOW** no change in minerals
3	(a)	(ii)	Metamorphism that occurs as temperature / pressure / grade decreases (over time) ✓ Provides a suitable example of changing rocks such as gneiss metamorphosed / recrystallised into a schist **OR** discusses correct higher grade index mineral being replaced by lower grade index mineral **OR** olivine is changed to serpentine / chlorite **OR** provides suitable example of a retrograde metamorphic reaction such as hydration / carbonation / oxidation ✓	**max 2**	**AO1.1d**	**ALLOW** metamorphism caused by uplift / removal of overlying rock **DO NOT ALLOW** reference to different zones in a metamorphic aureole / Barrovian zones
3	(b)		 ✓✓	**2**	**AO2.1b**	2 marks if all three isograds are correct 1 mark if one **OR** two isograds are correct isograds should not cross

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO element</th><th>Guidance</th></tr>
<tr><td>3</td><td>(c)</td><td>(i)</td><td>
<table>
<tr><th>Rock Identification</th><th>Parent rock</th><th>Metamorphic rock</th></tr>
<tr><td>A</td><td>Sandstone / Orthoquartzite</td><td>Metaquartzite</td></tr>
<tr><td>B</td><td>Shale / Mudstone / Clay / Argillite / Argillaceous rock</td><td>Gneiss</td></tr>
</table>
✓✓✓✓</td><td>4</td><td>AO3. 1b</td><td>1 mark for each correct box

ALLOW slate / schist as parent rock for gneiss</td></tr>
<tr><td>3</td><td>(c)</td><td>(ii)</td><td>• Equidimensional texture shown / labelled ✓
• Interlocking crystals shown / labelled ✓
• Correct scale drawn and labelled to match crystal size ✓</td><td>3</td><td>AO2.1b</td><td>MAX 2 if no labels

IGNORE reference to mineralogy / composition</td></tr>
<tr><td>3</td><td>(d)</td><td>(i)</td><td>Labelled line sloping gently downwards through hornfels ✓</td><td>1</td><td>AO2.1a</td><td>MUST be mostly in hornfels facies
MUST be shown as a path not a zone</td></tr>
<tr><td>3</td><td>(d)</td><td>(ii)</td><td>Amphibolite ✓</td><td>1</td><td>AO3.1b</td><td></td></tr>
<tr><td>3</td><td>(d)</td><td>(iii)</td><td>from 200-300 to 800-900 MPa ✓</td><td>1</td><td>AO3.1b</td><td>MUST include units for mark</td></tr>
</table>

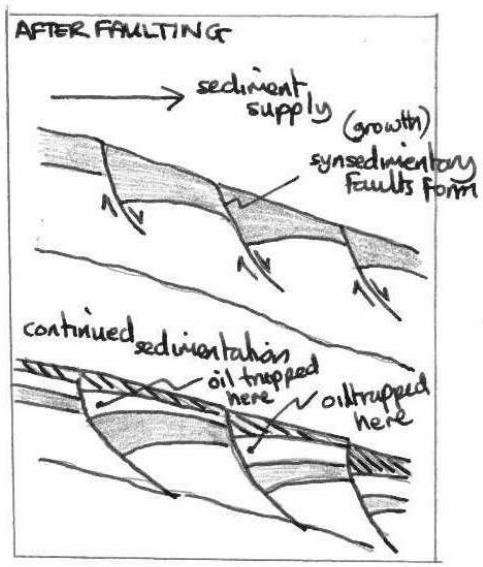
Question			Answer	Marks	AO element	Guidance
3	(e)		Refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Gives detailed description and explanation of prograde regional metamorphism, using correct textural terms linked to correct regional metamorphic rock types (slate / phyllite, schist, gneiss) at all grades **AND** Describes correct index minerals that recrystallise and become stable at the different temperatures and pressures. *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)** Good description of prograde regional metamorphism, using correct textural terms and mineralogical changes in some named regional metamorphic rocks linked to correct grades *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)** Describes prograde regional metamorphism as a change in texture or foliation using some correct terminology such as foliation, cleavage, schistosity or gneissose banding **OR** Describes a correct rock name or index mineral that forms	**6**	**AO2.1a** **AO1.1c**	**Indicative points may include:** AO1.1c Demonstrate understanding of geological ideas AO2.1a Apply knowledge and understanding of geological ideas • Increased pressure and temperatures enable recrystallisation to occur • New minerals recrystallise at specific temperature and pressure regimes as old minerals leave their stability fields • Slate / phyllite, schist and gneiss are order of metamorphism • Increased movement of ions / particles / atoms during recrystallisation / due to higher temperatures results in wider bands of like minerals • Presence of water accelerates the process • Coarser crystals = higher grade metamorphism • Porphyroblasts described, e.g., garnet in schist • Foliation / cleavage formed by preferred alignment of recrystallised minerals perpendicular to applied pressure • Cleavage only forms in platy minerals / at low grade • Crenulation cleavage may be evident if stress directions change / commonly occurs in phyllite

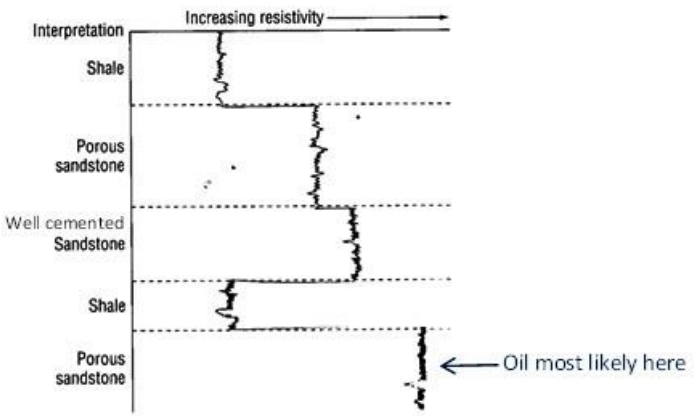
Question			Answer	Marks	AO element	Guidance
			during regional metamorphism *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*			• Schistosity and gneissose banding occur due to increasing separation of mafic and silicic minerals / at higher grades • Stable minerals include chlorite / biotite mica in slate / muscovite mica in slate or phyllite / garnet and micas in schist / kyanite and sillimanite in gneiss
3	**(f)**		Competent rocks / rocks containing equidimensional / hard minerals such as quartz in sandstone don't easily deform **OR** are more likely to fail in a brittle manner / fault / joint (than fold) **OR** bed thickness will stay the same (during folding) **OR** tension joints will develop **OR** boudinage may form ✓ Incompetent rocks / rocks containing platy minerals / clay minerals / mica deform easily **OR** will undergo ductile / plastic deformation / will fold **OR** bed thickness will change (during folding) **OR** cleavage will develop (during folding) ✓	**2**	**AO2.1a**	**ALLOW** if suitable correct named rock examples have been explained **MUST** use correct technical terms

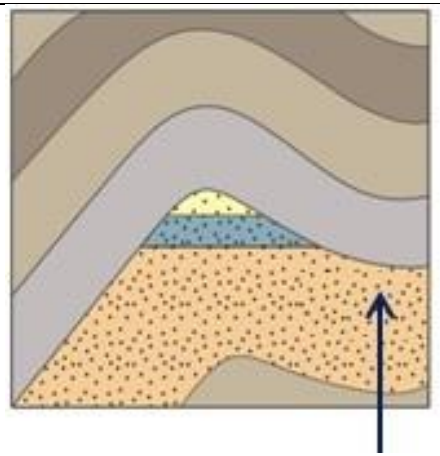
Question			Answer	Marks	AO element	Guidance
4	(a)	(i)	**Any two from:** • Pannotia was a supercontinent (which formed during the Precambrian) ✓ • Break up of supercontinent / Pannotia formed smaller / microcontinents **OR** led to the formation of Gondwana ✓ • Gondwana remained around the South Pole ✓ • Laurentia, Baltica and Siberia separated from each other ✓ • Iapetus Ocean opened between Laurentia and Gondwana / Avalonia **OR** Scotland and England / Wales were separated by Iapetus **OR** Scotland was located in Laurentia, whilst England and Wales were in Avalonia / close to Gondwana ✓ **Any one tectonic event from:** Rifting **OR** mantle plume **OR** formation of mid-ocean ridge **OR** ridge push **OR** Wilson Cycle described ✓	**max 3**	**AO2.1a**	**MAX 2** for descriptions with no tectonic event described **MUST** give at least two for marking point 4 **DO NOT ALLOW** tensional forces with no discussion
4	(a)	(ii)	Centre of basin / deep marine during Cambrian ✓ Turbidites / greywacke / (dark) shales / (dark) mudstones / clay deposited ✓ **OR** Margins of basin / shallow marine / platform / shelf during Cambrian ✓ Conglomerates / (ortho)quartzites / glauconitic sandstones / green feldspar-rich sandstones / pebbly sandstones / medium-coarse grained clastic rocks / gritstones / reef or thin limestones / red shales deposited ✓	**2**	**AO1.1a**	**1 + 1** for correct sediment type linked to correct palaeoenvironment **DO NOT ALLOW** sandstone or limestone without correct descriptor

Question			Answer	Marks	AO element	Guidance
4	(b)	(i)	• Lots of thoracic segments / pleurae (means many limbs / gills / appendages) **AND** for walking on seafloor / swimming / (nekto-)benthonic lifestyle **OR** allowed trilobite to enrol for protection ✓ • Elongate / streamlined body **AND** for crawling on seafloor / swimming / (nekto-)benthonic lifestyle ✓ • Crescent-shaped / compound / complex eyes **AND** for good vision suggesting a hunter **OR** allowed it to see predators / prey **OR** gave it good all round 360° vision for benthonic lifestyle **OR** allowed it to see forwards and upwards suggesting benthonic lifestyle ✓ • Long genal spines **AND** spreads mass on seafloor **OR** for stability in water column ✓ • (Dorsal) exoskeleton / exoskeleton (made of chitin) / genal spines / thoracic spines **AND** protected it (from predators in water column above) ✓	**max 3**	**AO3.1b** **AO3.1e**	Mark labelled diagram as text **MUST** use correct morphological terms for marks
4	(b)	(ii)	Graptolites **OR** corals ✓	**1**	**AO1.1b**	**ALLOW** brachiopods **OR** correct named reef-building organism **OR** hyolithids

Question			Answer	Marks	AO element	Guidance
5	(a)	(i)	Sapropel ✓	1	AO1.1a	
5	(a)	(ii)	Kerogen ✓	1	AO1.1a	
5	(a)	(iii)	50 to 200 °C ✓	1	AO1.1c	**MUST** include units for mark **ALLOW** range from 50-70 to 180-200 °C
5	(a)	(iv)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 1.7 (km) to 6.7 (km) award 2 marks** 50°C = 50/30 = 1.7 km ✓ 200°C = 200/30 = 6.7 km ✓	2	AO2.1b	**ALLOW** maximum 1 mark if correct answers not to 2 sig. fig. **ALLOW** ECF from part (iii) **ALLOW** 1.6 recurring and 6.6 recurring if clearly shown
5	(a)	(v)	Biogenic gas normally escapes / seeps to the surface due to shallow burial ✓	1	AO2.1a	**MUST** recognise biogenic gas is very shallow
5	(b)	(i)	(High) porosity / large volume of pore space / well rounded / well sorted grains **AND** can store significant quantities of oil ✓ (High) permeability / lack of matrix / lack of cement / good interconnections between the pore spaces / jointing / faulting / bedding planes **AND** allows oil to migrate in / allows oil to be extracted / yields oil ✓	2	A02.1a	**MAX 1** if state porous **AND** permeable not explicitly linked to matching explanations
5	(b)	(ii)	• Permeable rocks / joints / faults provide a pathway between source and reservoir rocks ✓ • Oil migrates down the pressure gradient from high to low pressure (usually upwards) ✓	max 2	A02.1a	

Question			Answer	Marks	AO element	Guidance
			• Oil is less dense than the water in the pore spaces **OR** oil is under hydrostatic pressure (so percolates upwards above the water) ✓ • At higher temperatures, the viscosity of the oil is lower so it flows more easily ✓			**DO NOT ALLOW** less dense than rock
5	**(b)**	**(iii)**	Diagram(s) showing: • growth / development of fault **OR** shows fault becoming curved / listric / detached at base **OR** shows increasing throw with depth ✓ • correct indication of oil trapped in dipping beds adjacent to fault **OR** in roll-over anticline adjacent to fault ✓ • correct labelling of the source rock / reservoir rock / cap rock ✓ • correct directional arrows on fault(s) to indicate direction of movement ✓	**max 3**	**A02.1b**	**DO NOT ALLOW** if no fault(s) shown **MAX 2** if diagram does not show synsedimentary fault(s) **OR** the development / growth of fault(s) 

Question			Answer	Marks	AO element	Guidance
5	(c)	(i)	 Lowermost porous sandstone bed indicated ✓	1	A03.1d	
5	(c)	(ii)	(Presence of oil in the pores spaces leads to a) high resistivity ✓	1	A03.1b	
5	(c)	(iii)	Seismic (reflection) survey / seismic tomography **AND** waves are reflected at layer boundaries **OR** oil traps / correct named trap / folds / faults / unconformities can be identified **OR** depth to reservoir rock identified **OR** seismic wave velocities can be used to identify reservoir rock (containing oil) **OR** Gravity survey **AND** positive anomaly due to excess of mass / anticline trap / uplifted block **OR** negative anomaly due to deficit of mass / a salt dome trap ✓	max 1	A01.b	**MUST** have technique **AND** description of how presence of oil / a trap is identified **ALLOW** fold

Question			Answer	Marks	AO element	Guidance
5	(d)	(i)	**B** – Anticline / antiform trap **AND** **C** – Salt dome trap ✓	1	A02.1a	
5	(d)	(ii)	 Spill point correctly labelled on **B** ✓	1	A03.1d	

Question			Answer	Marks	AO element	Guidance
5	(e)		**Max three from:** • Microfossils can be extracted from drill core / drill chips / recovered during exploration drilling / mud logging can be used ✓ • Microfossils are abundant / small / have hard parts so are found in large numbers / intact in drill core / drill chips ✓ • Many microfossils were planktonic so are geographically widespread / found in all rock types ✓ • Microfossils can be used for biostratigraphy / can be used as zone fossils / same microfossils are found in the same aged rocks / allow rocks to be dated and correlated ✓ • Microfossils show rapid evolution **OR** each genus has a short stratigraphic range ✓ • First appearance / last appearance / stratigraphic range of a microfossil species / genus can be used to identify specific time zones / date rocks ✓ • Different microfossil assemblages will be found in the reservoir rock compared to the source rock / Kimmeridge Clay **OR** allow us to find rocks of the correct age for reservoir rocks ✓ **MAX two microfossils from:** Foraminifera / coccolith(ophores) / radiolaria / dinoflagellates / pollen grains / spores can be used ✓	**max 4**	**A02.1b** **A03.1a** **A03.1e**	**MAX 3** if no correct microfossil group named **ALLOW** any valid Jurassic microfossil **ALLOW** palynomorphs / conodonts / ostracods / diatoms / acritarchs

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GCE

Geology

H414/02: Scientific literacy in 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 **3(c)** and **6(a).**

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

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

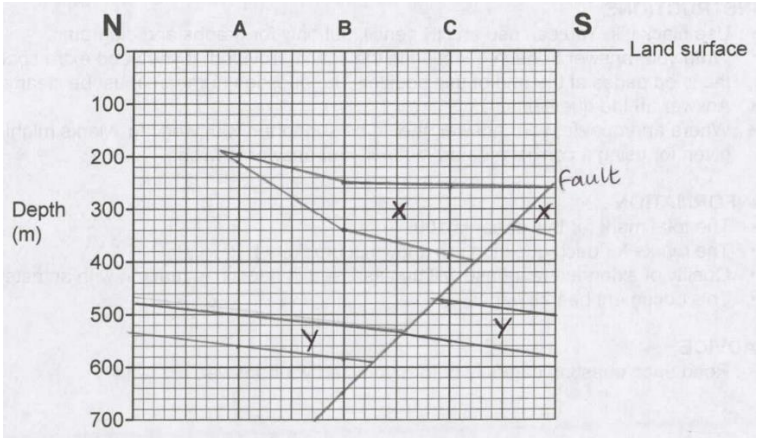
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- 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	Mark	AO Element	Guidance
1	(a)		**Any two** from: • Land which has been built upon **OR** modified by human activity ✓ • Land that has been used for industrial / commercial processes ✓ • Has abandoned factories **OR** has disused buildings / structures **OR** has old infrastructure ✓ • Is derelict / disused land ✓ • May have ground contamination / pollution ✓	2	1.1a	**ALLOW** old landfill site **DO NOT ALLOW** waste disposal / mining unqualified **ALLOW** any correct named contaminant, e.g., asbestos / lead / hydrocarbons / solvents / pesticides
1	(b)	(i)	 ✓✓✓	3	2.1a	Fault plotted correctly for **1 mark** Coal seam **X** plotted widening to the south for **1 mark** Coal seam **Y** plotted displaced by fault for **1 mark**

Question			Answer	Mark	AO Element	Guidance
1	(b)	(ii)	**Any two** from: • Good access to seam **X** using the shaft close to **A** (where seam is close to surface) ✓ • Seam is dipping gently so will be able to construct transport system / machinery will have easy access ✓ • Seam **X** is wide so room to store waste ✓ • Seam **X** is shallow so easily accessible from surface / less likely to suffer roof collapse ✓ • Rocks will absorb radiation ✓ • Ready-made void will reduce costs of excavation ✓ • Stope extraction means unstable roof / may collapse ✓ • Pillars / supports may be in the way (meaning poor access) ✓ • Likelihood of fault reactivation (due to increased load) ✓ • Possibility of leakage / groundwater contamination • Would need lining to contain waste **OR** surrounding rocks need to be impermeable ✓ • Seam **Y** is too deep **OR** is offset by fault so would not be suitable ✓	**2**	**3.1c, 3.1e**	
1	(b)	(iii)	**Any one** description of method from: • Horizontal levels / roadways / trackways are driven out from the shaft ✓ • Coal is removed from the stopes using a shearing / cutting machine **OR** leaves a cavity / void / cavern ✓ • Pillars of coal **OR** supports **OR** props **OR** chocks are left to support the roof ✓	**1**	**1.1d, 3.1d**	

Question			Answer	Mark	AO Element	Guidance
			Any one problem from: • Not all the coal is removed ✓ • Supports fail / wooden supports rot ✓ • Unstable roof / rocks leads to collapse ✓ • Subsidence may occur at the surface ✓	**1**		
1	**(c)**	**(i)**	**Any three** from: • Acid water contaminates drinking water supplies / groundwater / aquifers / surface water ✓ • Free H^+ ions / acidic / low pH water is corrosive **OR** dissolves compounds (as it moves through old mines) ✓ • (Acidified water) contains poisonous / toxic compounds ✓ • (Acidified water) may contain heavy metals / lead / arsenic / mercury / cyanide ✓ • Poisons wildlife / aquatic species in streams / rivers **OR** damages habitats / ecosystems / reduces biodiversity ✓	**3**	**2.1a, 2.1b**	**ALLOW** kills / harms animals / plants
	(c)	**(ii)**	**Any one** from: • Continue pumping out / dewater mine and treat water (after mine closure) ✓ • Seal old mine (concrete or clay) to prevent water leakage ✓ • Use active treatment **OR** add calcium carbonate / limestone / lime / sodium carbonate / sodium hydroxide to increase pH ✓ • Add agents / oxidants to cause precipitation of metals from water ✓ • Use passive treatment / wetlands / shallow ponds / reed beds / phytoremediation ✓	**1**	**2.1a**	**ALLOW** use of (bentonite) clay

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO Element</th><th>Guidance</th></tr>
<tr><td>2</td><td>(a)</td><td>(i)</td><td>
<table>
<tr><th>Morphological feature</th><th>Brachiopod
✓ or X</th><th>Bivalve
✓ or X</th></tr>
<tr><td>Pedicle foramen</td><td>✓</td><td>X</td></tr>
<tr><td>A line of symmetry along the hinge line</td><td>X</td><td>✓</td></tr>
<tr><td>Pallial line</td><td>X</td><td>✓</td></tr>
</table>
</td><td>3</td><td>1.1b</td><td>1 mark for each correct row</td></tr>
<tr><td>2</td><td>(a)</td><td>(ii)</td><td>Any three from:
• (Large) pedicle opening / foramen AND supports (large) pedicle for attachment OR pedicle / fleshy stalk AND to attach to substrate ✓
• Strongly ribbed valves AND strengthens shell ✓
• Zigzag / folded margin / commissure AND reduces sediment moving into valves ✓
• Robust / thick / heavy / strong valves AND stable on the substrate / strengthens shell ✓
• Valves may be streamlined AND to prevent damage in high energy OR to align in current ✓</td><td>3</td><td>1.1a</td><td>MAX 1 mark if three adaptations are given with no / incorrect explanations

DO NOT ALLOW attached by pedicle <u>foramen</u> OR attached by pedicle <u>opening</u></td></tr>
</table>

Question			Answer	Mark	AO Element	Guidance
2	(a)	(iii)	**Any two** from: • Only thick shelled fossils preserved **OR** shells show evidence of abrasion ✓ • Broken / disarticulated shells **OR** death assemblage ✓ • (Broken) shells concentrated in layers ✓ • Alignment of shells ✓ • Sorting by size ✓ • Burrowing / infaunal fossils **OR** burrows / trace fossils suggesting burrowing ✓	2	2.1b	**ALLOW** Presence of corals
2	(b)	(i)	Cnidaria **OR** coral ✓	1	2.1a	**ALLOW** Anthozoa
2	(b)	(ii)	**Any three** from: • Fossil **D** has mural pores and **E** does not ✓ • Fossil **E** has a columella and **D** does not ✓ • Fossil **E** has dissepiments / septa and **D** does not ✓ • Both fossils have tabulae ✓ • Both fossils had individual spaces for polyps ✓ • Both fossils are colonial / compound / made of corallites ✓ • Both have radial symmetry in transverse section ✓	3	2.1b	**ALLOW E** is branching and **D** is not **ALLOW AW** **ALLOW** implicit comparisons
2	(b)	(iii)	Palaeozoic ✓	1	2.1b	
2	(b)	(iv)	Brachiopods **OR** bivalves **OR** algal mats ✓	1	2.1a	**ALLOW** any correct named reef-building or reef-dwelling fossil, e.g., crinoid

Question			Answer	Mark	AO Element	Guidance
2	(b)	(v)	**Any four** from: • At or just below sea level / < 30 metres depth ✓ • Clear waters / minimal sediment / low turbidity ✓ • In photic zone / abundant sunlight / have symbiotic algae ✓ • High energy / (well) oxygenated water / nutrient upwelling ✓ • Fully marine / salinity of 30 to 40 parts per thousand ✓ • Temperature between 23 and 29°C / tropical waters ✓ • Sessile / attached / epifaunal / benthonic mode of life ✓ • Filter feeders / have nematoblasts / stinging cells / tentacles to catch food ✓ • May be solitary or colonial / compound ✓	4	2.1a, 3.1b	**ALLOW** any range between 23 and 29°C **OR** optimum temperature 25 / 26 / 27°C
2	(c)	(i)	Pterosaurs **OR** some groups of plants / insects ✓	1	1.1a	
2	(c)	(ii)	Mammals ✓ **Any one** explanation from: • Allowed <u>diversification / radiation</u> into new niches / niches previously occupied by dinosaurs ✓ • Allowed increase in size ✓ • Allowed increase in number of species ✓ • Burrowing / aquatic mammals were not affected as much ✓ • Mammals had a more varied diet ✓	1 1	2.1a	**ALLOW** birds Explanation marking point is dependent on **MP1** **ALLOW** <u>rapid</u> evolution of mammals occurred

Question			Answer	Mark	AO Element	Guidance
2	(c)	(iii)	**Any two** from: • Large crater (offshore) at Chicxulub **AND** is 66 Ma / right age **OR** is site of impact ✓ • Impact site **AND** identified by gravity surveys / inverted sequences / brecciated rock ✓ • Iridium (concentrated in clays at boundary) **AND** originated from outside the Earth / found in meteorites / asteroids ✓ • (Widespread) clay layer **AND** fallout of pulverised meteorite / asteroid / rock from impact ✓ • Shocked quartz grains found at boundary **AND** evidence of impact due to stress / high pressure / shock metamorphism ✓ • Spherules / tektites found near crater **AND** result from melting of rock on impact ✓ • (Widespread) tsunami deposits **AND** as impact caused a tsunami **OR** as a result of impact in ocean ✓ • Soot layer **AND** caused by wildfires triggered by the impact ✓	2	2.1a	**MAX 1** if **two** pieces of evidence listed without explanations **ALLOW** Yucatan Peninsula / Mexico for Chicxulub

Question			Answer	Mark	AO Element	Guidance
3	(a)	(i)	**Any two** from: • Positions of continents have changed <u>over time</u> ✓ • Continents have moved together **OR** have moved apart **OR** supercontinents have existed in past ✓ • Jigsaw fit of continents is evidence ✓ • Wegener's other evidence included matching rocks / fossils / geological structures / evidence of glaciation on different continents ✓ • No explanation **OR** no mechanism was given at the time ✓	2	1.1a	**ALLOW AW**
3	(a)	(ii)	**Any two** from: • Active mantle convection relies on a <u>conveyer belt</u> model where convection cells move plates ✓ • Active convection cells in mantle are not large enough / do not have enough energy to move plates ✓ • No correlation between movement of mantle and movement of plates ✓ • No correlation between plate area and velocity of plate movement ✓ • Good correlation between the edge of the subducting plate and the velocity of plate movement ✓ • Drag of mantle may slow the movement of plates ✓ • Asthenosphere is too plastic / flexible / not enough friction to move the plates along ✓	2	1.1c, 2.1a	

Question			Answer	Mark	AO Element	Guidance
3	(a)	(iii)	Ridge push ✓ Buoyant upwelling of mantle elevates lithosphere at MOR **OR** gravity sliding acts on MOR moving lithosphere away **OR** lithosphere is pushed apart by rising magma at MOR / divergent plate boundaries ✓ **OR** Slab pull ✓ Negative buoyancy pulls subducting oceanic plate into the mantle (at convergent plate boundaries) **OR** cold / dense lithosphere sinks down at ocean trenches / convergent plate boundaries / subduction zones **OR** subducting plate is pulled down by gravity ✓	**2**	**1.1c**	
3	(b)	(i)	Low velocity zone labelled where P and S wave velocities drop close to Earth's surface (approximately 75-250 km depth) ✓ Gutenberg discontinuity labelled at 2900 km, where S waves stop and P wave velocity drops ✓ Outer core marked in area of 2900 – 5100 km depth, where there are no S waves, and the velocity of P waves drops ✓	**1** **1** **1**	**2.1b**	

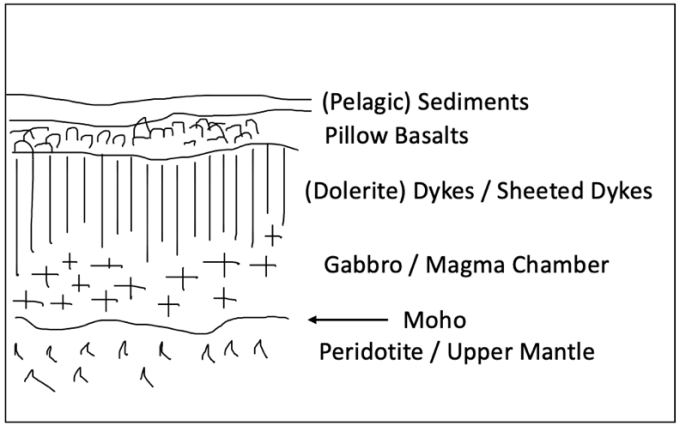
Question			Answer	Mark	AO Element	Guidance
3	(b)	(ii)	**Any one** description from: • S wave velocities generally get faster with depth in mantle ✓ • No S waves are transmitted through outer core **OR** S wave velocity drops to zero at outer core / Gutenberg discontinuity ✓ • S waves reappear in inner core / at inner - outer core boundary / at Lehmann discontinuity ✓ **Any one** explanation from: • S wave velocities are dependent on the rigidity / density of the rock ✓ • Liquids have zero rigidity so S waves cannot be transmitted through liquids / through the outer core ✓ • S waves are generated by P waves in the inner core ✓	**1** **1**	**3.1a**	
3	(b)	(iii)	Correctly read off graph: P wave velocity at 1000km = any value between 11.3 to 11.7 km s^{-1} P wave velocity at 2900km = any value between 13.4 to 13.8 km s^{-1} % change = $\frac{\text{final value – initial value}}{\text{Initial value}}$ x 100 ✓ Correct answer based on correct values used ✓	**2**	**2.1b**	**ALLOW MAX 1** for correct calculation based on incorrect P wave velocities

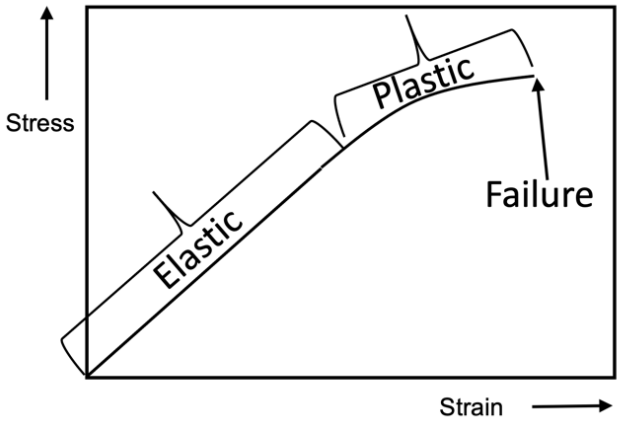
Question			Answer	Mark	AO Element	Guidance
3	(c)*		Refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Uses a good balance of detailed evidence for the structure and composition of the Earth including density **AND** gravity or magnetism *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)** Good evidence for the structure and composition of the Earth is described including density **OR** gravity **OR** magnetism. *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)** Some evidence for the structure or composition of the Earth is described. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*	**6**	**1.1b, 2.1a, 2.1b**	**AO1.1b Demonstrate knowledge and geological skills and techniques** – geophysical surveying **AO2.1a Apply knowledge and understanding of geological ideas** – inferring direct evidence for structure and composition **AO2.1b Apply knowledge and understanding of geological skills and techniques** – inferring indirect evidence for structure and composition **Density** • Gained from rock samples from deep mines / boreholes / deep ocean drilling / ophiolites / mantle xenoliths • Gives density of oceanic crust average 2.9 g cm^{-3} / continental crust average 2.7 g cm^{-3} / Mantle xenoliths average 3.3 g cm^{-3} • Meteorites give evidence for the density of the mantle / core • Mass / density of whole Earth is 5.5 g cm^{-3} / too great to be composed of only crust and mantle rocks, so the core must be higher density or Fe / Ni have correct density

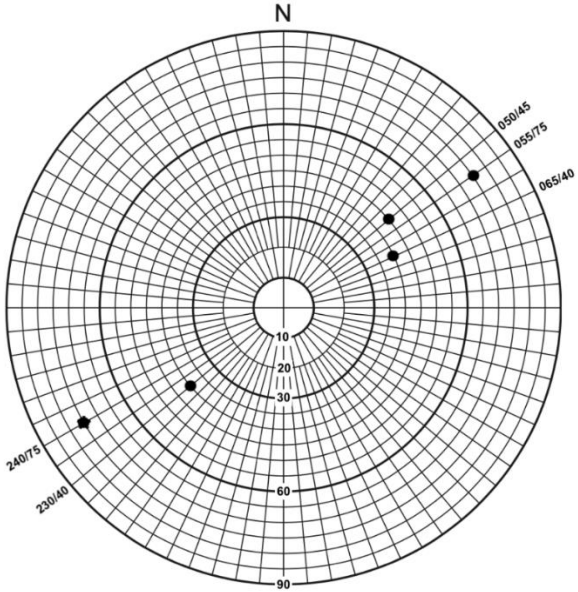
Question			Answer	Mark	AO Element	Guidance
			0 marks *No response or no response worthy of credit.*			**Gravity** • Positive gravity anomalies are produced by high density mafic / ultramafic intrusions • Negative gravity anomalies are produced by low density silicic intrusions • Strong negative gravity anomalies occur across mountain ranges giving evidence that roots of mountains are less dense than mantle • Bouguer gravity anomalies shows less dense continental crust pushes down into mantle / forms roots of mountains • Evidence asthenosphere is a rheid **Magnetism** • Existence of Earth's magnetic field is evidence that part of the core is liquid / Fe / metal / convecting • Electromagnetic (EM) surveys can detect partial melt in upper mantle / below MORs / in the asthenosphere **Other evidence** • Rocks from deep mines and boreholes give evidence continental crust is granitic / silicic / intermediate • Mantle xenoliths / kimberlite pipes give evidence mantle is peridotite / ultramafic

Question			Answer	Mark	AO Element	Guidance
						• Ophiolite complexes / deep ocean drilling give evidence for the layered structure of oceanic crust / oceanic crust is mafic / oceanic core complexes • Iron meteorites contain Fe-Ni / siderophiles and match the core • Stony meteorites contain peridotite / ultramafic rock / olivine and match the mantle / lithosphere
4	**(a)**		Crystal size description: Sills have medium crystals **AND** lava flows have fine crystals **OR** sills have coarser crystals **OR** lava flows have finer crystals ✓ **Any one** crystal size explanation from: Sills cooled (more) slowly / more time for crystals to grow / cooled below the surface **OR** lava flows cooled (more) rapidly / less time for crystals to grow / cooled on the surface ✓ Xenoliths description: Xenoliths found in top and base of sill **AND** xenoliths are only found at base of lava flow ✓ **Any one** xenoliths explanation from: Sills had country rock above and below **OR** lava flows had air / no country rock above **OR** lava flows only had country rock below **OR** xenoliths are older country rock (incorporated into igneous bodies) **OR** country rock above a lava flow is younger ✓	**1** **1** **1** **1**	**1.1a, 1.1c**	

Question			Answer	Mark	AO Element	Guidance
4	(b)		Cuts across / through / not parallel to the original beds ✓	1	1.1a	
4	(c)	(i)	**X** – Olivine ✓ **Y** – Pyroxene / Augite ✓ **Z** – Plagioclase / Feldspar ✓	3	2.1a	**DO NOT ALLOW** Orthoclase **OR** K feldspar
4	(c)	(ii)	(Olivine) Basalt ✓	1	3.1b	
4	(d)	(i)	**FIRST CHECK ANSWER ON THE ANSWER LINE. If answer is T = 28.46 and S = 69.66 award 2 marks** Correct calculation method **OR** formula recall ✓ **T** = 28.46 **AND S** = 69.66 ✓	2	1.1d, 2.1b	**ALLOW** correct answers written on answer lines or in table **ALLOW 1 mark** for one correct answer given to 2 decimal places **ALLOW 1 mark** for 2 correct answers not given to 2 correct decimal places **ALLOW 1 mark** for 2 correct answers to 2 decimal places if distance has not been converted to mm
4	(d)	(ii)	Velocity increases as temperature increases **OR** has a positive correlation ✓	1	3.1e	
4	(d)	(iii)	**V** / vegetable oil **AND any one** reason from: Fast flowing as composed of mafic lava **OR** fast flowing as composed of ferromagnesian minerals **OR** low viscosity so forms shield volcano **OR** low viscosity as low silica content (45-52% SiO_2) ✓	1	3.1c	**ALLOW** basic for mafic

Question			Answer	Mark	AO Element	Guidance
4	(d)	(iv)	**Any two for one mark** from: • Risks of glassware breakage • Scalding / burns from hot water **OR** hot substances **OR** hot glassware • Spilled substances / slipping on substances • Bungs flying out when heated • Danger of electricity (hot water bath) and water mixing ✓	1	3.1f	**ANY two** for **1 mark** **ALLOW** any reasonable answer **DO NOT ALLOW** goggles, lab coats, hair, bags
4	(d)	(v)	**V** flows too fast to time when hot **OR** viscosity too low when hot **OR** unable to start timer before liquid reaches bung ✓	1	3.1c	**ALLOW** any reasonable answer
5	(a)	(i)	Obducted <u>oceanic</u> crust / lithosphere **OR** sections of <u>oceanic</u> crust / <u>oceanic</u> rocks that have been tectonically moved onto continental crust ✓	1	1.1a	**ALLOW AW**
5	(a)	(ii)	 ✓✓✓	3	2.1a, 2.1b	Recognisable sketch showing layered structure through an ophiolite for **1 mark** Any 2 labels for **1 mark** Any 3 **OR** 4 labels for **2 marks** **ALLOW AW** for layer names **MAX 1** for cross-section showing emplacement of an ophiolite complex

Question			Answer	Mark	AO Element	Guidance
5	(b)	(i)	 ✓✓✓	3	3.1b	**1 mark** for each correct label Elastic deformation labelled within bracketed area Plastic deformation labelled within bracketed area Failure point labelled correctly
5	(b)	(ii)	Any **two** from: • Movement along faults is prevented by friction and rock is put under strain / deforms ✓ • Stored stress exceeds the strength of the rock, and it fails ✓ • Energy is released as rock fractures (breaks) and moves **OR** energy released as seismic waves **OR** energy released as vibrations **OR** energy released causes ground movement ✓ • (Elastic) rebound occurs when ground / rocks move back / return to undeformed state ✓	2	1.1c	**ALLOW** stress / pressure instead of energy **DO NOT ALLOW** tension **ALLOW AW** **MAX 1** if explanation uses plates rather than rocks / faults **ALLOW** general statement about stress becomes too much and rocks break releasing energy for **1 mark** **MARK** diagrams as text

Question			Answer	Mark	AO Element	Guidance
5	(c)	(i)	 ✓✓✓	3	2.1b	**ALLOW** ±half a division on stereonet **DO NOT ALLOW** kite plot / rose diagram / circular bar graph 4 points accurate for **3 marks** 2 **OR** 3 points accurate for **2 marks** 1 point accurate for **1 mark**
5	(c)	(ii)	NW to SE ✓	1	3.1b	**ALLOW** correct maximum compressional stress stated from one direction
5	(c)	(iii)	No **AND** Stereonet does not show dip direction **OR** no dip direction information was provided **OR** does not show if the limbs are dipping towards each other or dipping away from each other ✓	1	3.1e	

Question			Answer	Mark	AO Element	Guidance
6	(a)*		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 a good balance of information / evidence given in the text, map and tables to evaluate and make detailed judgements of the pros / cons of retrofitting. Includes seismic hazards / risk **AND** civil engineering / building code factors. Gives a clear decision as to whether retrofitting existing buildings should be mandatory. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Uses some of the information / evidence given in the text, map and tables to evaluate and make judgements of some of the pros / cons of retrofitting. Includes seismic hazards / risk **OR** civil engineering / building code factors. The decision as to whether retrofitting existing buildings should be mandatory may not be explicit. *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)**	**6**	**3.1c, 3.1d, 3.1e**	**Indicative points include:** **AO3.1c Evaluates information from tables and maps for evidence to help in decision and AO3.1d Makes judgements in terms of pros and cons, and AO3.1e Draws a conclusion. (HSW 9, 10 and 11)** **Seismic hazards / risk** • A hazard exists if there is danger to people or property or Salt Lake City is densely populated • Homes, schools and businesses are at risk • Faults underlie the basin / relative motion on the faults creates a hazard / fault sections underlie most densely urbanised areas • Young / unconsolidated rocks underlie the basin, these absorb (more) energy / amplify seismic waves / ground shaking • Liquefaction hazard is likely in saturated / unconsolidated sediments • Mass movements / landslides may be triggered in mountainous areas • An earthquake prediction could cause a panic evacuation of the city **Civil engineering / building codes** • Earthquakes don't kill people, buildings do

Question			Answer	Mark	AO Element	Guidance
			Some information / evidence is lifted from the text, map and tables to identify some of the pros / cons of retrofitting. A judgement as to whether retrofitting existing buildings should be mandatory may be attempted. *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.*			• Old part / downtown Salt Lake City has many unreinforced / brick buildings • Unreinforced masonry / brick / block buildings are most at risk of damage • Damage to unreinforced buildings will be 40% at intensity VIII / 80% at IX / 100% at X • Damage to reinforced buildings could be as low as 5% at intensity VIII / 13% at IX / 25% at X • Natural frequency of tall buildings can put even modern ones at risk • A retrofitting programme could include cross-bracing to buildings / base isolators • Foundations may be reinforced by pumping in liquid cement • Services (gas, electricity, water) can be earthquake proofed **Retrofitting of existing buildings** **Pros – should be mandatory** • There has been much urban development since 1934 / the last 6.0+ M_W earthquake • A retrofitting programme would significantly reduce the seismic risk • The return period is only an average and a 6.5 to 7.5 M_W earthquake could occur much sooner than predicted

Question			Answer	Mark	AO Element	Guidance
						• Retrofitting does not have to be very expensive • Risk to human life is significant so a retrofit programme is urgently needed **Cons – should not be mandatory** • Return period for a 5.0 M_W or greater is 15 years, but these are not destructive • 6.0 M_W are destructive but only two have occurred in the last 120 years • 6.5 to 7.5 M_W very destructive, but return period is 270 years, there may not be another for well over 100 years • Who is going to pay for retrofitting / people may not be able to afford retrofitting
6	**(b)**		**FIRST CHECK ANSWER ON THE ANSWER LINE. If answer is 15 award 2 marks** Recall of formula: (*n* + 1) / *m (*where *n* is number of years on record and *m* is number of recorded occurrences) **OR** correct method of working ✓ Correct answer: 15 ✓	**2**	**3.1a**	**DO NOT ALLOW** 15.12

Question			Answer	Mark	AO Element	Guidance
6	(c)		Any **three** from: • Epicentre likely to have highest intensity **OR** will be located within the IX isoseismal line ✓ • As energy is absorbed further from epicentre there are concentric successively lower intensities ✓ • Older / unreinforced masonry / brick and block buildings in downtown Salt Lake City are more likely to be damaged / suffer higher intensity ✓ • Highest intensity in downtown Salt Lake City as it is most densely urbanised / has highest population density **OR** undeveloped land has lower intensity ✓ • Newer / reinforced / built to a tighter building code buildings in West Lake City are less likely to be damaged / suffer lower intensity ✓ • Higher intensities above faults **OR** (Buildings in) downtown Salt Lake City have a section of Wasatch fault running below so higher intensity / closer to epicentre ✓ • Higher intensity where there are unconsolidated sediments / gravel / sand / clay / lakebed deposits ✓ • Mass movements / landslides may occur along margins of mountains ✓ • Higher VII zone (within V zone) in the S/SE as the urban area extends to there / there is fault present / landslides may occur ✓	**3**	**3.1b, 3.1d**	**ALLOW AW**
6	(d)	(i)	Resonance amplifies oscillations **OR** sway increases at natural frequency **OR** at natural frequency sway occurs ✓	**1**	**2.1a**	**ALLOW AW**

Question			Answer	Mark	AO Element	Guidance
6	(d)	(ii)	$k = (\boldsymbol{f} \times 2\pi)^2 \times m$ **OR** $(\boldsymbol{f} / 1 / 2\pi)^2 \times m$ **OR** $4\pi^2 \times m \times \boldsymbol{f}^2$ ✓	1	2.1b	**ALLOW** any correct formula rearrangement to give k
6	(d)	(iii)	Any **two** from: • Greater stiffness results in higher natural frequency **OR** greater mass results in a lower natural frequency ✓ • **A** could have most structural integrity as it has greatest stiffness **OR B** could have least structural integrity because it has the lowest stiffness ✓ • **B** has natural frequency furthest away from the earthquake frequency so could have most structural integrity **OR A** could have least structural integrity because its frequency is closest to the earthquake frequency ✓ • **C** could have most structural integrity as it has the greatest mass **OR B** could have least structural integrity because it has the lowest mass ✓	2	3.1c	
6	(d)	(iv)	Taller buildings tend to be more flexible / less stiff / less rigid **OR** taller buildings are likely to have a larger mass (which reduces the natural frequency) ✓	1	1.1c	**ORA** for shorter buildings

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GCE

Geology

H414/02: Scientific literacy in 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 **2(c)** and **5(a)(v)**.

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

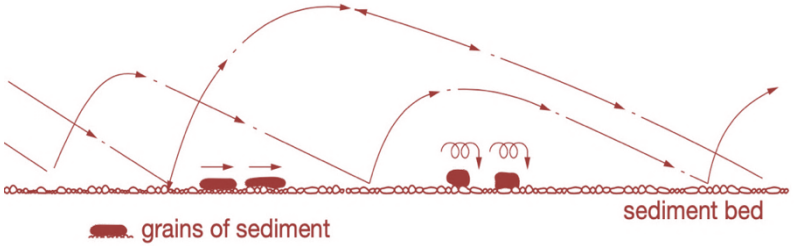
Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- 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)	(i)	Grain labelled saltating (bouncing or hopping) ✓ Grain labelled in traction (rolling or sliding) ✓  	1 1	1.1a	**MAX 1** if river bed is not drawn **MAX 1** if two correct diagrams not labelled saltation and traction **MUST** label or indicate movement of grains **IGNORE** reference to grain size
1	(a)	(ii)	Different grain shapes (could allow the same size grains to be transported by either saltation or suspension) ✓ Different densities / weights (could allow the same size grains to be transported by either saltation or suspension) ✓ Turbulence during transport could hold a grain in suspension whereas laminar flow would cause the grain to saltate ✓	**Max 1**	2.1a	**ALLOW AW** for density / weight **ALLOW** different compositions
1	(b)		**MAX any two** descriptions of differences from: Texturally mature sediment will have: • More / well rounded **OR** more spherical / high sphericity grains ✓ • Better / well sorted **OR** has grains all the same size ✓ • Finer (average) grain size ✓ **MAX any two** explanations from: • During transport / higher energy (transport) ✓ • Undergoes erosion / abrasion / attrition ✓	**Max 3**	2.1a	**ORA** for texturally immature **MUST** use correct descriptive terminology **IGNORE** weathering

Question			Answer	Marks	AO Element	Guidance
1	(c)	(i)	36 cm s^{-1} (Allow 33 to 39) ✓	1	3.1a M3.11	**MUST** include units for the mark **ALLOW** cm/s for units
1	(c)	(ii)	0.3 mm (Allow 0.27 to 0.33) ✓	1	3.1a M3.11	**MUST** include units for the mark
1	(c)	(iii)	• Allows for a wide range of velocities / grain sizes **OR** the range of velocities / sizes is too large ✓ • The axes would be too large if linear scales were used **OR** to fit on a suitable graph size ✓ • Can present data over a very large range ✓ • Shows data as a straight line when values increase exponentially ✓	Max 1	2.1b M3.6	**ALLOW** AW
1	(d)	(i)	Name: Compaction / compacted ✓ Explanation: During burial **OR** overlying sediment accumulates **OR** weight from overburden **OR** caused by (load) pressure **OR** grains move closer / fuse together **OR** beds become thinner **OR** dewatering occurs ✓	1 1	1.1a	**ALLOW** burial as named process **MARK first** process and explanation only
1	(d)	(ii)	Name: Pressure solution **OR** (pressure) dissolution ✓ Explanation: (Load pressure creates stress) at contact between grains **AND** quartz / grain dissolves **OR** dissolved minerals move laterally **OR** minerals are (re)precipitated / (re)crystallised **OR** grains become fused together ✓	1 1	1.1c 3.1c	**ALLOW** stylolitisation / stylolite **DO NOT ALLOW** melting **DO NOT ALLOW** discussion of sediment movement / deposition

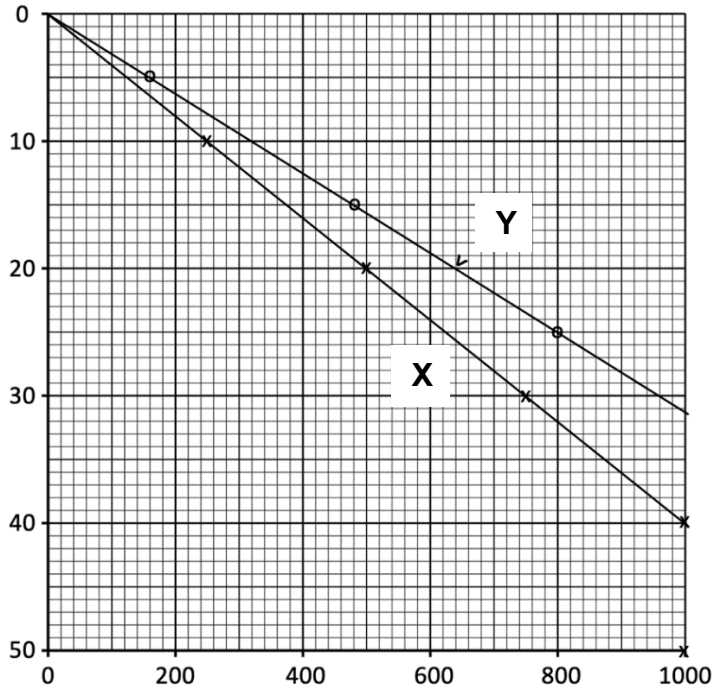
Question			Answer	Marks	AO Element	Guidance
1	(d)	(iii)	Name: Precipitation / precipitate ✓ Explanation: Dissolved minerals / minerals in solution / minerals in groundwater move through sediment **OR** dissolved minerals form in pore spaces between grains ✓	**1** **1**	1.1c 3.1c	**ALLOW** crystallisation / recrystallisation / cementation **ALLOW** correct named mineral **DO NOT ALLOW** discussion of sediment movement / deposition
1	(d)	(iv)	• Less water can be stored **OR** capacity of aquifer reduces ✓ • Porosity reduces **OR** volume of pore space reduces ✓ • Cement fills the pores **OR** grains are closer together **OR** interconnections between pores reduces ✓ • Permeability reduces **OR** less water can pass through **OR** flow of water reduces ✓ • Takes longer for aquifer to recharge **OR** takes longer to extract the water ✓ • Dolomitisation **OR** atomic substitution of Mg^{2+} for Ca^{2+} **OR** any valid atomic substitution may have occurred ✓	**Max 3**	2.1a 3.1e	**ALLOW** Porosity / permeability can increase due to further solution **OR** dolomitisation **OR** any valid atomic substitution for 1 mark

Question			Answer	Mark	AO Element	Guidance
2	(a)	(i)	Rigid / brittle / broken into (tectonic) plates ✓	1	1.1c	**ALLOW** solid
2	(a)	(ii)	Seismic waves / seismic surveys / seismic tomography / EM surveys ✓	1	1.1a	**ALLOW** crosses 1300°C isotherm
2	(a)	(iii)	Description: Rheid **OR** plastic layer **OR** is 1-5% melted **OR** partially / partly melted ✓ Explanation: Allows (lithospheric / tectonic) plates to float / move / slide (over asthenosphere) **OR** the asthenosphere can flow ✓	1 1	2.1a	**ALLOW** convection cells / convection currents **OR** allows ridge push or slab pull for explanation mark
2	(b)	(i)	• State of equilibrium / balance between Earth's lithosphere and asthenosphere ✓ • The lithosphere is buoyant / floats at a height that depends upon its thickness / density / weight / mass **OR** less dense continents rise to a higher elevation than more dense ocean floors ✓ • Pressure exerted by the lithosphere on the underlying asthenosphere is the same everywhere (irrespective of elevation) ✓ • Isostatic adjustment / isostatic rebound occurs where the lithosphere and asthenosphere are out of equilibrium **OR** the asthenosphere flows sideways to compensate for any extra weight / mass of the lithosphere above ✓	**Max 2**	1.1a 1.1c	**ALLOW** discussion of crust and mantle **ALLOW** named example of where this occurs, e.g., ice sheets

Question			Answer	Mark	AO Element	Guidance
2	(b)	(ii)	• (Gravity anomalies) result from density differences in crustal rocks **OR** roots of mountains / continental crust is less dense **OR** oceanic crust is denser **OR** MOR can have an excess or mass / are hot and less dense ✓ • Negative gravity anomalies show rocks are less dense (than expected) **OR** positive gravity anomalies show rocks are denser (than expected) ✓ • (Strong) negative gravity anomalies occur across mountain ranges **OR** positive gravity anomalies occur over ocean basins **OR** gravity anomalies over MORs can be positive or negative ✓ • (Gravity anomalies) show where the crust and mantle are not in equilibrium **OR** show where isostatic adjustment / isostatic rebound is occurring ✓ • Negative gravity anomalies occur over areas where isostatic rebound is occurring **OR** show continental crust extends further into mantle than expected (because isostatic rebound hasn't occurred) ✓	**Max 2**	2.1b 3.1c	**ALLOW** discussion of lithosphere and asthenosphere

Question			Answer	Mark	AO Element	Guidance
2	(c)	*	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 the geodynamo theory in a detailed and well understood way **AND** explains the indirect evidence for processes operating within the Earth's core. *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 the geodynamo theory in a moderate level of detail **AND** explains some of the indirect evidence for processes operating within the Earth's core. *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)** Describes the geodynamo theory in a basic way **OR** describes a property / process operating within the Earth's core. *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 2.1a 3.1c HSW1	AO2.1a Apply knowledge and understanding of geological ideas AO3.1c Evaluate geological information ideas and evidence **Indicative points may include:** Geodynamo theory: • The Earth's core is made of iron / nickel • Outer core is liquid and inner core is solid • Forms a permanent magnet • Has the appearance of a bar magnet / magnetic field lines are oriented N-S • The outer core acts like an electromagnet / self-exciting (dynamo) • Flow of molten iron produces electrical currents • The electrical currents generate magnetic field lines (perpendicular to them) • Variations in magnetic field strength / magnetic reversals occur • Reversals occur approx. every 100,000 to 400,000 years • The position of magnetic north changes over time • Magnetic inclination preserved in rocks provides evidence for the Earth's magnetic field in the past

Question			Answer	Mark	AO Element	Guidance
						<u>Evidence for processes:</u> • Inner / solid part of core is above the Curie point / too hot to be a permanent magnet • Without a liquid outer core movement / convection would not be possible • Changes in Earth's magnetic field strength / magnetic reversals are evidence that convection in the core changes / the self-exciting dynamo runs down • Movement is caused / energy comes from formational heat / radioactive decay • Heat moves outward in all directions from centre of the Earth • The temperature difference between the hot inner and cooler outer core creates convection currents • The Coriolis force / the Earth's spin twists the convection currents or aligns the magnetic field N-S • Reversals are recorded as remanent magnetism in rocks • Magnetic anomalies on the seafloor provide evidence the Earth's magnetic field has changed over time

Question			Answer	Mark	AO Element	Guidance
2	(d)	(i)	 Region **X** data plotted correctly ✓ Region **Y** data plotted correctly ✓ Lines drawn through both sets of points ✓	3	1.1b 2.1b M3.8	**IGNORE** extrapolation beyond 800°C for Region **Y**
2	(d)	(ii)	640 (°C) ✓	1	3.1a M3.8	
2	(d)	(iii)	32 ✓ °C km^{-1} ✓	2	3.1a M3.10	**ALLOW** °C/km for units **ALLOW** ratio for 1 mark

Question			Answer	Mark	AO Element	Guidance
3	(a)	(i)	Loss of energy **OR** transfer of energy from seismic waves to rock **OR** reduction in amplitude (of a wave as it propagates / travels through a material) ✓	1	1.1a	**ALLOW** AW
3	(a)	(ii)	Higher frequency waves have more oscillations (per second) **OR** energy is dissipated / transferred / absorbed faster ✓	1	2.1a	**ORA**
3	(a)	(iii)	<u>Description:</u> Competent / strong rocks have lower intensity / less ground shaking / less damage occurs ✓ <u>**Any one** explanation from:</u> Competent rocks allow vibrations to pass through easily **OR** attenuation is low / negligible **OR** absorb less energy (per unit area) ✓ Incompetent rocks absorb some / more energy ✓ Unconsolidated rocks / sediments vibrate more easily **OR** have high attenuation **OR** amplify ground shaking **OR** undergo liquefaction ✓	1 1	2.1a 3.1b	**ORA** for incompetent / weak rocks **OR** unconsolidated rocks / sediments

Question			Answer	Mark	AO Element	Guidance
3	(b)		**Any two** limitations from: • Shows what happened in the past, not what will happen in future **OR** does not allow prediction of where next earthquake will happen ✓ • Next earthquake could occur on a different fault / different section of fault / different depth / not all faults are known / stress can move position after each earthquake ✓ • Next earthquake / event could be a different magnitude **OR** does not allow prediction of magnitude ✓ • Information may not be understood by non-specialists / members of the public ✓ **Any two** strengths from: • Shows geological features, e.g., faults / rock type / soil type / steep ground ✓ • Areas where earthquakes have happened in the past can be matched up with similar areas where they have not, so can expect similar impact ✓ • Shows areas likely to suffer high intensity / landslides / liquefaction / tsunamis ✓ • Show areas unsuitable for building **OR** where building codes need to be enforced **OR** where built structures need strengthening **OR** where earthquake-proofing of buildings / infrastructure is needed ✓ • Show areas suitable for locating emergency services **OR** evacuation routes **OR** places of safety (muster points) ✓ • Visual / easy to understand **OR** helps non-specialists prepare **OR** helps decision making of government bodies **OR** allows non-specialists to decide whether to get earthquake insurance / earthquake-proofing ✓	**2** **2**	1.1b 2.1b	**ALLOW** reference to other specific named geological hazard(s), e.g., landslide **ALLOW** reference to other specific named geological hazard(s)

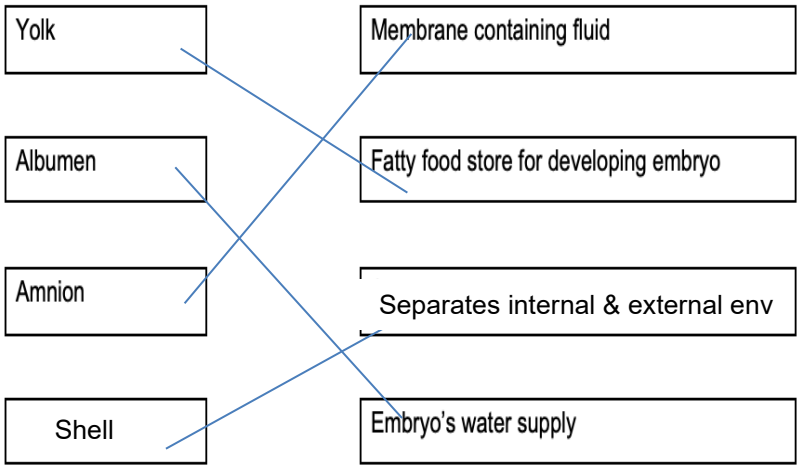
Question			Answer	Mark	AO Element	Guidance
3	(c)		• Lacks a physical **OR** mathematical basis **OR** based on probabilities so may not happen ✓ • Social consequences can be positive, e.g., saves lives / allows people to prepare themselves / prepare their property ✓ • Social consequences can be negative, e.g., panic / stress / unnecessary evacuations / loss of business / falling house prices ✓ • Some people will ignore forecast due to false alarms / apathy / complacency ✓ • Seismologists need to work without fear of retribution / litigation (if they get it wrong) ✓ • Can lead to unsafe engineering / building design (not strong enough) ✓ • Can lead to overly conservative / expensive engineering / building design ✓ • Involves a degree of subjectivity / may lead to different interpretations of the same data by different seismologists ✓ • Problems of misunderstandings between civil engineers / non-specialists / the public **AND** seismologists / geologists / scientists ✓	**Max 3**	3.1c 3.1e	

Question			Answer	Mark	AO Element	Guidance
3	(d)	(i)	Kaolinite is 1:1 ✓ Smectite is 2:1 ✓	2	1.1a	
3	(d)	(ii)	<u>Description one:</u> Treat clay with calcium oxide / lime / chloride salt ✓ <u>Explanation one:</u> Reduces ability to expand **OR** substitutes Ca^{2+} in place of Na^{+} **OR** addition of Ca^{2+} reduces the amount of swelling **OR** clays containing Na^{+} can expand up to 1500% compared to ones containing Ca^{2+} which expand to 100% **OR** stops clays becoming hydrated ✓ **OR** <u>Description two:</u> Use bacteria to change chemistry ✓ <u>Explanation two:</u> Reduces ferric / Fe^{3+} to ferrous / Fe^{2+} **OR** increases the negative surface charge **OR** increases interlayer cation fixation **OR** makes the clay retain K^{+} ✓	2	2.1b	**ALLOW any one** description and **one** matching explanation for **1 + 1** **ALLOW** cement

Question			Answer	Mark	AO Element	Guidance
4	(a)	(i)	Both had four fins / limbs ✓ Fins / limbs were in the same position on the body ✓ Skulls / jaws / teeth (morphology) very similar ✓ Early amphibians had some smally bony scales similar to fish ✓	1	1.1c	**ALLOW** both lack claws or nails **ALLOW** both laid eggs in water
4	(a)	(ii)	(Late) Devonian **OR** (early) Carboniferous ✓	1	1.1a	
4	(b)		**Any** descriptions from: • Fossil **A** has longer tail **OR** fossil **B** has a shorter tail • Fossil **A** has longer / thinner body / is more streamlined **OR B** has a shorter / wider body • Fossil **B** has a large girdle (and **A** does not / is smaller) • Fossil **B** has a robust skeleton (and **A** does not) • Fossil **A** has an elongated / narrower skull **OR B** has wider skull • Fossil **B** has longer limbs **OR** Fossil **A** has shorter limbs ✓✓ **Any one** explanation for fossil **A** to support aquatic environment from: • Long tail used for swimming ✓ • Long thin / streamlined body / narrow skull for swimming / gliding through water ✓ • Short limbs reduce drag in water ✓	2 1	2.1a 2.1b	**ANY 2** correct descriptions for **1 MARK** **ANY 3** or more correct descriptions for **2 MARKS** **ALLOW** implicit comparisons **ALLOW** thicker as **AW** for robust / wider **IGNORE** reference to bony tarsals / foot size

Question			Answer	Mark	AO Element	Guidance
			Any one explanation for fossil **B** to support terrestrial environment from: • Short tail used for balance on land ✓ • Short / wide body for stability walking on land **OR** doesn't need to be streamlined ✓ • Wide girdle for strong attachment of limb bones for walking ✓ • Longer limbs for locomotion on land ✓	**1**		
4	**(c)**	**(i)**	Ischium points backwards in both dinosaurs ✓ Ischium is longer in Iguanodon than Tyrannosaurs ✓ Ilium much larger / wider in Tyrannosaurus than Iguanodon **OR** thicker pubis in Tyrannosaurus than Iguanodon **OR** bones more robust in Tyrannosaurus than Iguanodon ✓ Pubis points forward in Tyrannosaurs **OR** is near vertical (reptile hipped) **OR** Pubis slopes backward / is fore-aft (bird hipped) in Iguanodon ✓	**Max 3**	2.1a	**ORA** **ALLOW** implicit comparisons between the dinosaurs, e.g. longer ischium
4	**(c)**	**(ii)**	Ornithischian ✓ Pubis points backwards **OR** is 'bird hipped' ✓	**1** **1**	2.1b	**ALLOW** Ornithipods

Question			Answer	Mark	AO Element	Guidance
4	(c)	(iii)	Horny (toothless) beak / no predatory teeth / lacks teeth in front of jaw ✓ Used to crop vegetation / unable to tear up meat ✓ **OR** Had leaf shaped cheek teeth ✓ For mincing vegetation ✓ **OR** Hinged jaw / jaw moved from side to side ✓ To chew / grind vegetation ✓ **OR** Limbs ending in hooves ✓ Not a feature of a predator **OR** for steady movement ✓ **OR** Thumb spikes ✓ For gathering vegetation ✓ **OR** Heavy skeleton **OR** (mainly) quadrupedal **OR** able to rear up / become bipedal ✓ Able to run from predators **OR** (rear up to) reach vegetation ✓	**2**	1.1c	**ALLOW any one** morphological adaptation and **one** matching explanation for **1 + 1** **MARK first** adaptation and explanation only **ALLOW** Pleurokinetic jaw **OR** lateral movement of maxilla **ALLOW** (thumb spike) used for defence **ALLOW** walked / moved on 4 legs as **AW** for quadrupedal **ALLOW** (bipedal to) rear up for defence
4	(c)	(iv)	Convergent ✓	**1**	2.1a	

Question			Answer	Mark	AO Element	Guidance
4	(d)	(i)	 ✓✓✓✓	4	2.1a	
4	(d)	(ii)	(Amniotic egg) provided an aquatic / watery environment (for development of embryo) **OR** can be laid out of water **OR** did not have to return to water to breed ✓ (Hard shell) provided protection (to the developing embryo) **OR** prevented desiccation / drying out on land ✓ (Porous shell) allowed for diffusion of (respiratory) gases **OR** gaseous exchange **OR** oxygen in **OR** carbon dioxide out ✓ Contained everything the embryo needed to develop into a miniature adult (able to fend for itself on land) **OR** didn't need to go through a larval stage ✓	**Max 2**	1.1d	

Question			Answer	Mark	AO Element	Guidance
5	(a)	(i)	**MAX any two** descriptions from: Clay / **C** always had the lowest % transmission **OR** medium sand / **M** always had the highest % transmission **OR** the finer the sediment, the lower the % transmission ✓ Silt / **S** showed the biggest change in % transmission during the experiment ✓ Clay particles settle out the slowest **OR** medium sand grains settle out the fastest **OR** the coarser the grain size the faster the grains settled out ✓ Medium sand grains had high % transmission even at the start of the experiment ✓ **MAX any two** explanations from: Clay particles are the lightest / most buoyant **OR** medium sand particles are the heaviest **OR** description of Stoke's Law ✓ Clay particles remain in suspension ✓ Most medium sand particles had already settled out prior to the start of measuring ✓ Silt has a mixture of particle sizes between the other two, so settle out at different rates ✓	**Max 3**	2.1b	**ORA** **ALLOW** clay flocculates so blocks out light / has lower % transmission

Question			Answer	Mark	AO Element	Guidance
5	(a)	(ii)	**FIRST CHECK ANSWER ON THE ANSWER LINE. If answer is 8.78 (%) award 3 marks** Recall of percentage change formula **OR** $\frac{80.5 - 74.0}{74.0}$ X 100 ✓ = 8.783 ✓ = 8.78 (%) Answer to 3 sig figs. ✓	**3**	3.1b	% Change = $\frac{\text{final} - \text{initial}}{\text{Initial}}$ X 100 **MAX 2** if answer not given to 3 sig. fig.
5	(a)	(iii)	**M** **AND** Largest / coarsest sediment size **OR** energy is high ✓	**1**	3.1b	**ALLOW C OR S** if justified that grains would be held in suspension
5	(a)	(iv)	Care with electrical equipment and water in experiment (electrocution) **OR** electrical burns ✓ Care with glass breakage and cuts ✓ Care taken with breathing in particulates of sediment (at start of experiment) **OR** risk to asthma sufferers ✓ Slip hazard from water / sand spillage ✓	**Max 1**	2.1b	

Question			Answer	Mark	AO Element	Guidance
5	(a)	(v)*	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)** Analyses and evaluates (implicitly or explicitly) the experimental procedures in detail **AND** suggests some improvements with clarity. *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)** Analyses and evaluates (implicitly or explicitly) the experimental procedures **OR** suggests some improvements. *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)** Analyses at least one experimental procedure in a basic way **OR** suggests at least one improvement giving basic reason(s). *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**	3.1a 3.1c 3.1.f M2.4 HSW6	AO3.1a Analyse geological information ideas and evidence AO3.1c Evaluate geological information ideas and evidence **Indicative points may include:** Analysis and evaluation of the experimental procedures • More accurate than estimating transmission by eye • Made 5 measurements of each – allows plotting of line graph • Colorimeter was calibrated at start • Used a colour filter to make the sediment easier to see • Used regular time intervals • Not realistic / representative of environments of deposition • Samples **C**, **S** and **M** will be different masses for the same volume - may influence results • No information if samples have been graded / sieved - may influence results • Does not state if sample **C** has been crushed (if in lumps will not stay in suspension) • Boiling tubes may not all have the same volume (may differ between **C**, **S** and **M**)

Question			Answer	Mark	AO Element	Guidance
						• Sampling (by pipette) at centre of tube is not specific enough • No information about shaking time • Sampling (by pipette) does not specify volume to sample • Any delay in moving cuvette to colorimeter will affect results • Human error starting stopwatch • No evidence that different filters had been trialled to see if the amber filter was best • Time intervals between each measurement were too long <u>AO3.1f Develop and refine practical design and procedures</u> • Use mass rather than volume of samples **C**, **S** and **M** • Grade / sieve samples to ensure uniform grain size within each sample • Try different colorimeter filters to establish most suitable • Recalibrate the colorimeter between each experiment run • Specify volume of water to add to each boiling tube / use measuring cylinder • Shake each boiling tube for the same amount of time / same way • Sample with pipette at a specific marked position on each boiling tube • Specify volume to sample with pipette

Question			Answer	Mark	AO Element	Guidance
						• Repeat experiment several times and find mean / average results • Control transfer time from cuvette to colorimeter • Use different cuvettes or wash cuvette between experiments • Use shorter time intervals between each measurement
5	**(b)**		**MAX any three** descriptions of method: Use (glass or transparent sided) flume tank / circular flume / bowl / tray **AND** line bottom with sand ✓ Coloured sand **OR** dark and light grains will make formation process easier to see ✓ Place tape measure / ruler along / around / up tank ✓ Use protractor / clinometer (to measure dip angles) ✓ Add flow of water **OR** stir the water in one direction (to generate current) ✓ Vary speed of flow / current (for different experimental runs) ✓ An electric motor and paddles would give better control ✓ Use stopwatch to time (migration / formation) ✓ Use photograph(s) / video recording (to show change over time / for measuring purposes) ✓	**Max 4**	1.1b 2.1b 3.1f M2.5 HSW4	Mark labels on any diagrams as text **MAX 3** for description of experiment **ALLOW** description of an experiment using dry sand and a fan / hair dryer to create current

Question			Answer	Mark	AO Element	Guidance
			MAX any three for data: Measure rate of deposition on lee slope **OR** rate of erosion of stoss slope **OR** rate of dune migration ✓ Measure dune height / wavelength ✓ Measure lee slope / foreset dip / angles ✓ Use systematic sampling **OR** measure at set time intervals ✓ Repeat experiment and find mean / average / standard deviation ✓ Analyse any valid correlation, e.g. dune height to current speed **OR** use Spearman's rank correlation ✓			**MAX 3** for data collection, sampling and processing

Question			Answer	Mark	AO Element	Guidance
6	(a)	(i)	Continents appeared to be fixed in position ✓ Evidence showed the Earth was cooling (from a molten state) ✓ Only movement was thought to be due to cooling of the Earth (which caused contraction) ✓ No horizontal crustal movement was thought to occur **OR** only vertical crustal movement was thought to occur ✓ Experiments showed linear ridges form on cooling spheres similar to linear mountain chains ✓ Mountain ranges formed as wrinkles as the Earth cooled / contracted ✓ Trends of mountain chains correspond with the lines of greatest sediment accumulation (in geosynclines) ✓ Rocks in mountain belts contain marine fossils (showing they originated in geosynclines **/** the rocks had moved upwards) ✓ Shrinkage of a few 10s of km could explain mountain building / orogeny ✓	**Max 2**	3.1a	

Question			Answer	Mark	AO Element	Guidance
6	(a)	(ii)	The text shows that over the past 100 years new theories have built on old theories (geosyncline model / continental drift / seafloor spreading / subduction) ✓ Early ideas / Wegener / Du Toit had no mechanism ✓ The mechanism / understanding of processes was provided by later work / Holmes / Hess / Benioff / Tuzo Wilson / Sykes ✓ Basic model of plate tectonics has been solved ✓ Ridge push / slab pull are relatively recent refinements (to the plate tectonics model) and show ideas are still changing ✓ New evidence is being provided by technological advancements such as seismic tomography / deep sea drilling / supercomputer modelling / basalt geochemistry / isotope geochemistry / radiometric dating ✓ Recent discovery of plates being torn apart away from plate boundaries **OR** 2021 work **OR** work by Toronto researchers needs to be explained, so the paradigm isn't completely solved ✓	**Max 4**	3.1a 3.1b 3.1c	

Question			Answer	Mark	AO Element	Guidance
6	(a)	(iii)	Presence of mid / intraplate volcanoes / volcanic islands / atolls / seamounts ✓ Presence of linear chains of volcanic islands (each one younger than the one before) ✓ High heat flow in areas otherwise aseismic / away from plate boundaries ✓ Discovery of core / mantle boundary plumes using seismic tomography / basalt geochemistry ✓	**Max 1**	1.1c	**DO NOT ALLOW** description of island arcs **ALLOW** correct named chain of islands **ALLOW** any correct geotechnical imaging method
6	(b)		Built on the early ideas of catastrophism / gradualism ✓ Neptunist theory / some geologists suggested all rocks were sedimentary in origin / all formed in the oceans **OR** plutonism theory / some geologists suggested all rocks were igneous in origin / all formed from magma ✓ Recognition that processes operating today are the same as those in the past (identified early) **OR** observation of present-day processes allowed development of the theory of uniformitarianism ✓ Processes were linked together to become the rock cycle model **OR** processes that formed sedimentary, igneous and metamorphic rocks were linked together ✓ Much of the modern rock cycle theory was developed by Hutton (and Lyell) ✓	**Max 2**	3.1b	

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