GCE

Geology

H414/02: Scientific literacy in geology

A Level

Mark Scheme for June 2022

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

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 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
	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. 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

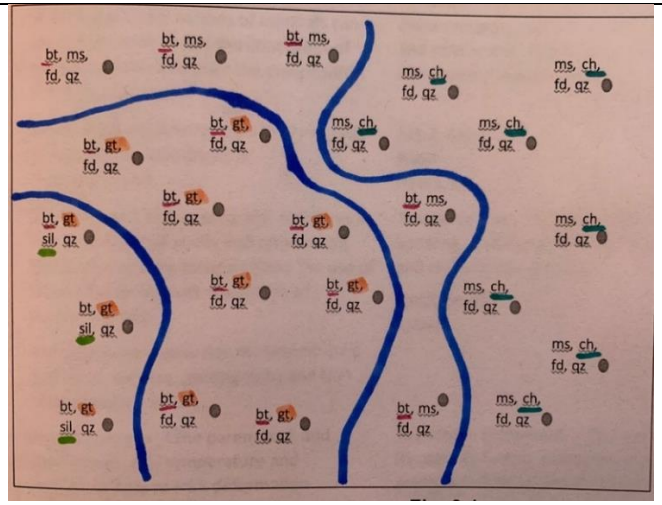
Question			Answer	Marks	AO element	Guidance
			There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant. **0 marks** *No response or no response worthy of credit.*			
1	**(c)**	**(ii)**	Cement / Matrix ✓ Grain size ✓ Textural maturity ✓ Sorting ✓ 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>

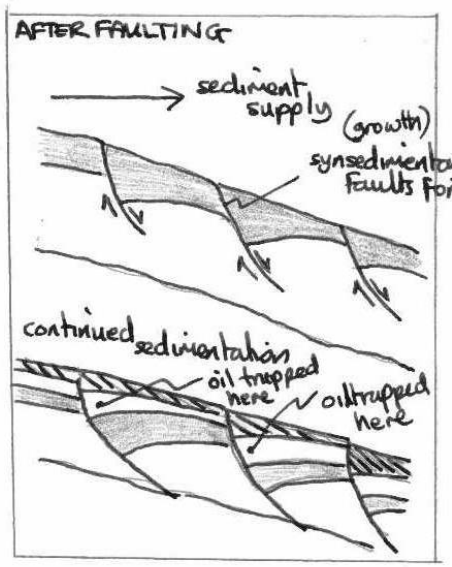
Question			Answer	Marks	AO element	Guidance
3	(e)		Refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Gives detailed description and explanation of prograde regional metamorphism, using correct textural terms linked to correct 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

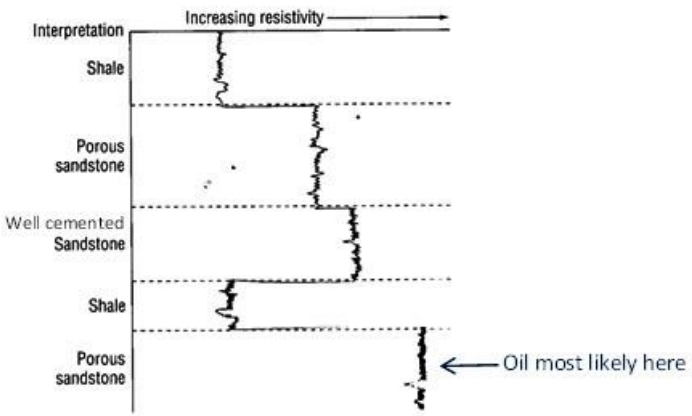
Question			Answer	Marks	AO element	Guidance
			during regional metamorphism *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*			• Schistosity and gneissose banding occur due to 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

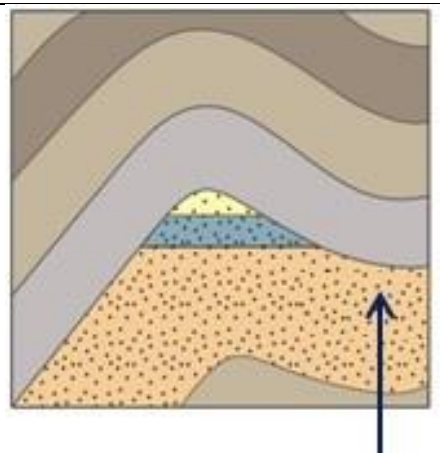
Question			Answer	Marks	AO element	Guidance
4	(a)	(i)	**Any two from:** • Pannotia was a supercontinent (which formed during the Precambrian) ✓ • Break up of supercontinent / Pannotia formed smaller / microcontinents **OR** led to the formation of Gondwana ✓ • Gondwana remained around the South Pole ✓ • 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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