GCE

Geology

H414/01: Fundamentals of geology

A Level

Mark Scheme for June 2025

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

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

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

MARKING INSTRUCTIONS

PREPARATION FOR MARKING
RM ASSESSOR

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

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor

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

MARKING

1. Mark strictly to the mark scheme.

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

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 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, email or via the RM Assessor messaging system.

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 the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

7. There is a NR (**No Response**) option. Award NR (No Response):

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g., 'can't do', 'don't know')

- OR if there is a mark (e.g., a dash, a question mark) which is not an attempt at the question.

Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The RM Assessor **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

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: Not applicable in F501
To determine the level – start at the highest level and work down until you reach the level that matches the answer
To determine the mark within the level, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

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 **28(a)** and **31(c)**.

12. **Annotations**

Annotation	Meaning
	Correct
	Incorrect
	Omission/missing information
	Benefit of doubt given
	Contradiction
	Rounding Error
	Error in number of significant figures
	Error carried forward
	Level 1 (in levels of response question)
	Level 2 (in levels of response question)
	Level 3 (in levels of response question)
	Benefit of doubt not given
	Seen (to show content on a page has been noted, but not credited)
	Ignore
	Blank page

13. **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

13. **Subject-specific Marking Instructions**

INTRODUCTION

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

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

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

Question			Answer	Marks	AO Element	Guidance
1			C	1	1.1a	**C** – FeS_2
2			C	1	2.1b	**C** – > fingernail and < copper coin
3			D	1	2.1a	**D** – Rhyolite
4			C	1	2.1a	**C** – Packstone
5			B	1	2.1a	**B** – Inverted cross-bedding
6			C	1	1.1d	**C** – Median = 15.5 mm
7			C	1	1.1d	**C** – Tsunami deposit
8			A	1	1.1a	**A** – (Boundary between inner and outer core)
9			D	1	1.1c	**D** – Rigid crust and rigid upper mantle
10			B	1	1.1a	**B** – 11.5 g cm^{-3}
11			B	1	1.1c	**B** – Lead = chalcophile and oxygen = lithophile
12			A	1	1.1c	**A** – Maximum and minimum principal stresses are both horizontal
13			B	1	2.1b	**B** – Resistivity survey
14			C	1	1.1d	**C** – Passive treatment
15			B	1	1.1c	**B** – High pore fluid pressure and reduced friction
16			B	1	2.1a	**B** – Competent rock above and incompetent rock below
17			C	1	2.1b	**C** – Vegetation
18			B	1	1.1d	**B** – 11 mm
19			D	1	2.1a	**D** – Silurian
20			C	1	2.1a	**C** – Nektonic
21			C	1	2.1a	**C** – (Shortest stratigraphic range)
22			B	1	1.1a	**B** – Only 1 and 2
23			D	1	1.1c	**D** – An increase in the proportion of ^{18}O
24			C	1	2.1b	**C** – 1485°C
25			D	1	2.1b	**D** – 100% anorthite / 0% diopside

Question			Answer	Marks	AO Element	Guidance
26	(a)		**A** = Lava flow ✓ **B** = Sill ✓	2	AO2.1a	**ACCEPT** lava
26	(b)		• Has reddened / oxidised / weathered / uneven top surface ✓ • Eroded clasts are found in the sandstone above ✓ • Contains vesicles (at the top) ✓ • Only has one baked margin (below) **OR** there is no baked margin above ✓ • Only contains xenoliths at the bottom **OR** from the rock below ✓	Max 3	AO2.1a	**IGNORE** crystal size as not shown on the diagram **ALLOW** included fragments below **ACCEPT** concordant with the bedding
26	(c)		• Has two baked margins (above and below) ✓ • Has xenoliths at the top **OR** from the rock above (as well as below) ✓	2	AO2.1a	**IGNORE** crystal size as not shown on the diagram **ALLOW** included fragments above and below **ALLOW** No vesicles present **ACCEPT** concordant with the bedding

Question			Answer	Marks	AO Element	Guidance
27	(a)		Lath shaped / zoned crystal drawn with: Centre labelled calcium-rich / Ca-rich / anorthite-rich ✓ Rim labelled sodium-rich / Na-rich / albite-rich ✓	 1 1	AO2.1a	 **ALLOW** Ca / anorthite in centre **ALLOW** Na / albite in rim
27	(b)		• (Calcium and sodium) ions / atoms are similar in ionic radius / size ✓ • (Calcium and sodium) ions / atoms have a similar charge **OR** both have a positive charge **OR** Ca ion has 2^+ charge **AND** Na ion has 1^+ ✓ • Calcium and sodium / ions / atoms completely substitute / swap for each other in the same site in the mineral lattice **OR** fit in the same site in the mineral lattice ✓ • Can have any composition from 0 to 100% of each element / atom / ion ✓	**Max 2**	AO1.1a AO1.1c	**AW** **ACCEPT** Si and Al substitution
27	(c)	(i)	• Olivine crystals are mafic / ferromagnesium minerals / rich in iron / magnesium **OR** contain less silica than the other minerals in the magma ✓ • Olivine crystals form early / at high temperature (while the remaining magma is still liquid) **AND** due to high density settle through the magma ✓ • The process of magmatic differentiation / fractional crystallisation / fractionation occurs ✓ • (Removal of the olivine / mafic / ferromagnesium minerals) increases the relative amount of silica / SiO_2 in the remaining magma **OR** magma becomes more intermediate / silicic in composition ✓	**Max 3**	1.1c	

Question			Answer	Marks	AO Element	Guidance
27	(c)	(ii)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.000065 OR 6.5 x 10^{-5} (m s^{-1}) award 3 marks** Correct substitution of data into the formula: $v = \frac{9.8 \times (2 \times 10^{-3})^2 \times (3800 - 2900)}{18 \times 30}$ ✓ = 0.0000653 ✓ = <u>0.000065 **OR** 6.5 x 10^{-5}</u> (m s^{-1}) to 2 sig fig ✓	**3**	AO2.1b	**MAX 2** for correct answer not to 2 sig fig.
27	(d)		Mixture of crystals in liquid / magma **OR** magma is a liquid – crystal mush **OR** magma is between liquidus and solidus ✓ Weight / pressure of overlying crystals squeezes the liquid out leaving the crystals behind ✓	**1** **1**	AO1.1a AO1.1c	
27	(e)	(i)	Texture: coarse crystals **OR** average crystal size > 5mm **OR** stated average crystal size > 5mm ✓ Composition: silicic / felsic **OR** contains K feldspar / orthoclase / quartz ✓	**1** **1**	AO3.1b	
27	(e)	(ii)	• <u>Coarse</u> crystal size **OR** average crystal size > 5mm **AND** indicates magma / rock cooled slowly **OR** at depth ✓ • Porphyritic texture **OR** presence of phenocrysts **AND** indicates two stages / two depths of cooling ✓ • K feldspar (phenocrysts) crystallised first **AND** slowly ✓ • Magma rose to a higher / shallower level and cooled more rapidly to form the finer groundmass / other minerals **OR** groundmass / other minerals crystallised later **AND** faster ✓	**Max 3**	AO3.1e	**MAX 2** if states groundmass is fine **OR** magma was extruded

Question			Answer	Marks	AO Element	Guidance
			• Euhedral shape of K feldspar phenocrysts indicates they grew freely in liquid magma **OR** anhedral shape of crystals in groundmass / other minerals indicates they filled in the space between the K feldspar crystals ✓			
27	**(f)**		(Phenocrysts of K feldspar suggest) K feldspar crystallised first **/** at higher temperature **OR** the groundmass / finer crystals suggest the other minerals crystallised later / at lower temperature ✓ Bowen's Reaction Series shows biotite / plagioclase crystallise before **OR** at higher temperatures than K feldspar / quartz ✓ Explicit evaluation – the granite specimen does not (fully) support the order of crystallisation shown in Bowen's Reaction Series ✓	**1** **1** **1**	AO3.1c	**AW Eg** partly supports

Question			Answer	Marks	AO Element	Guidance
28	(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)** Describes and explains in detail how diagenetic **AND** metamorphic processes result in textural and mineralogical changes as mud is converted into mudstone, shale and slate. *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 and explains how some diagenetic **AND** / **OR** metamorphic processes result in textural and / or mineralogical changes as mud is converted into mudstone, shale and slate. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** May list or give a basic outline of how one or more diagenetic **OR** metamorphic process results in changes to the sediment or rock. *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**	2 x AO1.1a 2 x AO1.1c 2 x AO2.1a	**Indicative points may include:** **Diagenetic processes** • Burial occurs as sediment is covered by younger layers of sediment • Diagenesis takes place at low temperatures and pressures close to the Earth's surface • Occurs at temperatures below 200°C or pressures below 200 MPa / 2 kbars • Lithification changes loose unconsolidated sediment into rock • Main process affecting mud / mudstone is compaction • Compaction results from weight of overburden / load pressure • Water is squeezed out / porosity is reduced / grains move closer together • Bed thickness reduces • Clay minerals align as mud / mudstone is converted to shale • Shale becomes fissile • Pressure (dis)solution may occur • Although less common in fine grained sediments, cementation may occur **Metamorphic processes** • Occurs at temperatures above 200°C or pressures above 200 Mpa / 2 kbars

Question			Answer	Marks	AO Element	Guidance
						• As temperature increases minerals become unstable / breakdown and undergo recrystallisation • Recrystallisation is the solid-state process that changes minerals into new crystalline metamorphic minerals • Mudstone minerals are aluminosilicates / rich in aluminium so the resultant metamorphic minerals are aluminosilicates / rich in aluminium • Mudstone minerals recrystallise to form chlorite / mica / biotite / muscovite in slate • Directed pressure / compressive stress results in development of a foliation / slaty cleavage in slate • Flat platy minerals / mudstone minerals / micas align perpendicular to the maximum pressure • Relict structures / bedding or deformed fossils may be present in slate • Pyrite porphyroblasts may form

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO Element</th><th>Guidance</th></tr>
<tr><td>28</td><td>(b)</td><td>(i)</td><td>• Have the same chemical composition OR (chemical composition is) Al_2SiO_5 ✓
• form polymorphs OR have different crystal structures ✓
• They form at different temperatures and pressures ✓</td><td>Max 2</td><td>AO1.1c</td><td>1 mark for composition

1 mark for crystal form</td></tr>
<tr><td>28</td><td>(b)</td><td>(ii)</td><td><table><tr><th>Metamorphic pathway</th><th>Maximum temperature (°C)</th><th>Maximum pressure (MPa)</th></tr><tr><td>Regional</td><td>605</td><td>570 +/- 10</td></tr><tr><td>Contact</td><td>595 +/- 10</td><td>110</td></tr></table>✓</td><td>1</td><td>AO2.1b</td><td>Both correct for 1 mark</td></tr>
<tr><td>28</td><td>(b)</td><td>(iii)</td><td>Contact metamorphic rocks will not have a foliation OR have a granoblastic texture AND were not subjected to directed stress / directed pressure OR pressure was low OR only an increase in temperature ✓

Regional metamorphic rocks will have a foliation AND were subjected to directed stress / directed pressure OR due to pressure at 90° ✓</td><td>1

1</td><td>AO1.1a
AO1.1c</td><td>ALLOW sugary / saccharoidal

ALLOW slaty cleavage / crenulation cleavage / schistosity / gneissose banding as AW for foliation

Max 1 for both contact and regional textures correct but no correct explanations</td></tr>
<tr><td>28</td><td>(c)</td><td></td><td>Description: Uplift (closer to the Earth’s surface) OR erosion resulting in the removal of overlying rocks ✓

Explanation: High temperature / pressure minerals are no longer stable at lower temperatures / pressures OR high temperature / pressure minerals are replaced by minerals stable at lower temperatures / pressures OR minerals undergo hydration ✓</td><td>1

1</td><td>AO1.1a

AO1.1c</td><td>ACCEPT thrusting / folding</td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>AO Element</th><th>Guidance</th></tr>
<tr><td>29</td><td>(a)</td><td>(i)</td><td>E-W trending line drawn through mudstone to the west of fault F1 stopping at the unconformity (Y1=Y2) ✓

E-W trending line drawn through mudstone to the east of fault F1 ✓

Max 1 if two correct axial plane traces drawn but cross over a fault / unconformity or not complete</td><td>1

1</td><td>AO2.1b</td><td>ALLOW axial plane trace drawn through the centre of the mudstone OR offset towards the limb dipping at 73°

IGNORE any axial plane drawn to the east of X2.

Lines must not cross the faults or unconformity</td></tr>
<tr><td>29</td><td>(a)</td><td>(ii)</td><td>Antiform / anticline ✓

Asymmetrical OR (fold axis is) inclined OR fold is open OR interlimb angle is 86° OR trends E – W ✓</td><td>1

1</td><td>AO2.1a</td><td>AW

ACCEPT non / not plunging</td></tr>
<tr><td>29</td><td>(b)</td><td></td><td><table><tr><td>Type of movement</td><td>Strike slip OR dextral ✓</td></tr><tr><td>Amount of displacement</td><td>85 +/- 5 (metres) ✓</td></tr><tr><td>Type of tectonic stress</td><td>Shear ✓</td></tr></table></td><td>3</td><td>2 x AO2.1a
1 x AO2.1b</td><td>ACCEPT horizontal
DO NOT ACCEPT transform</td></tr>
<tr><td>29</td><td>(c)</td><td></td><td>Features are discordant / cross cutting ✓</td><td>1</td><td>AO2.1a</td><td>AW</td></tr>
<tr><td>29</td><td>(d)</td><td></td><td>Faulted by two (N – S trending / normal) faults ✓

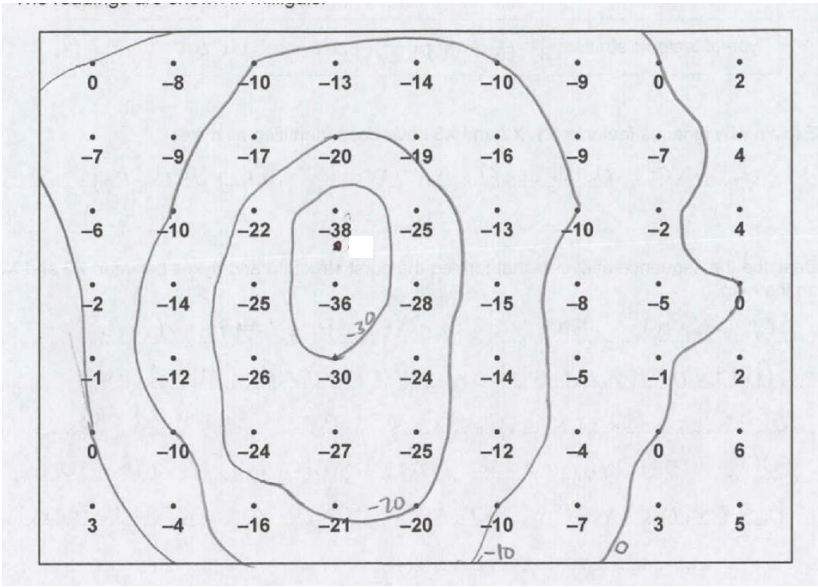
There is an upthrown block between the faults
OR Fault at X2 is downthrown to west / upthrown to the east
AND fault at X3 is downthrown to east / upthrown to the west ✓

Magma / dykes intruded along the faults ✓</td><td>1

1

1</td><td>AO3.1b</td><td></td></tr>
</table>

Question			Answer	Marks	AO Element	Guidance
29	(e)	(i)	Unconformity ✓	1	AO2.1a	
29	(e)	(ii)	Deposition of older beds / mudstone, sandstone, siltstone **OR** older beds folded / tilted / uplifted ✓ Period of erosion (to produce plane of unconformity) ✓ Deposition of younger beds / conglomerate / sediment ✓	Max 2	AO1.1a AO1.1c	
29	(f)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 14.3 (metres) award 2 marks** Correct statement of formula **OR** correct working: $t = w \sin\theta$ **OR** 40 x sin 21 **OR** sin 21 = 0.358 ✓ = <u>14.3</u> m ✓	2	AO2.1b	**ALLOW ANY** correctly rounded number **ALLOW ANY** number of decimal places

Question			Answer	Mark	AO Element	Guidance
30	(a)	(i)	0, -10, -20 AND -30 milligal isolines drawn correctly on map ✓  	**3**	AO2.1b	**1 OR 2** lines draw correctly for **1 mark** **3** lines drawn correctly for **2 marks** All **4** lines drawn correctly for **3 marks**
30	(a)	(ii)	Trap type: Salt dome / salt diapir **OR** anticline formed above salt dome / salt diapir ✓ Explanation: Produces negative (gravity) anomaly **OR** there is a deficit of mass ✓ Salt / halite / evaporites have a lower density than the surrounding rocks **OR** density of salt / halite / evaporites is 2.3 / 2.2 g cm^{-3} **AND** surrounding rocks have a higher density / density in range 2.5 – 3.0 g cm^{-3} ✓	**1** **1** **1**	AO3.1b	**ALLOW** anticline trap for **MAX 2**: Anticline trap; Anticline has resulted in lower density material surrounded by higher density material;

Question			Answer	Mark	AO Element	Guidance
30	(a)	(iii)	**D** labelled close to the 0 milligal isoline (from any + value to the -10 milligal isoline) ✓	1	AO3.1d	**ALLOW** inside the central -30 milligal isoline if anticline formed above salt dome / salt diapir given for **(i)** **ALLOW** inside the central -30 milligal isoline if anticline trap given in **(i)**
30	(b)		• Microfossils are abundant / small / have hard parts so are found in large numbers / intact in drill core / drill chips ✓ • Foraminifera / coccolith(ophores) / radiolaria / palynomorphs / dinoflagellates / pollen grains / spores can be used ✓ • Microfossils can be used for biostratigraphy **OR** can be used as zone fossils **OR** the same microfossils are found in the same aged rocks **OR** allow rocks to be dated / correlated ✓ • First appearance **OR** last appearance **OR** stratigraphic range of a microfossil species / genus can be used to identify specific time zones / date rocks ✓ • Many microfossils were planktonic so are geographically widespread / found in most rock types ✓ • Microfossils show rapid evolution **OR** each genus has a short stratigraphic range ✓ • They can indicate the environment of deposition ✓	**Max 3**	1 x AO1.1a 2 x AO1.1c	
30	(c)		• Directional drilling is used **OR** boreholes are drilled and turned horizontally **OR** boreholes are lined for strength / to prevent leakage ✓ • Large volumes of water at <u>high pressure</u> are pumped into the borehole to fracture rocks **OR** open bedding planes / joints (to release the natural gas) ✓	**Max 3**	1 x AO1.1a 2 x AO1.1c	**IGNORE** any discussion of oil **AW** eg forceful / under pressure

Question			Answer	Mark	AO Element	Guidance
			• Sand **OR** grains of aluminium oxide / ceramic are injected with the water to keep the fractures open ✓ • Chemicals are added to prevent corrosion of pipes **OR** increase the viscosity of the water **OR** keep the sand in suspension **OR** eliminate bacteria ✓ • Gas is extracted from production wells / from a borehole **OR** gas flows to the surface under hydrostatic pressure **OR** gas rises up through boreholes ✓			

Question			Answer	Marks	AO Element	Guidance
31	(a)		**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 2840 (metres) award 2 marks** Correct working: 86 - 15 = 71°C 71 / 25 = 2.84 (km) ✓ x1000 = <u>2840</u> (metres) ✓	**2**	AO2.1b	**MAX 1** for 2.84 (failed to convert km to m) **MAX 1** for 3520 metres (failed to subtract surface temperature) **OR** 4120 metres (added surface temperature)
31	(b)		Rainwater / precipitation ✓ Entered aquifer / rocks at recharge zone **OR** entered where aquifer / rocks are open to atmosphere **OR** entered where aquifer / rocks are unconfined **OR** onto the exposed limestone / sandstone ✓	**1** **1**	AO1.1a AO1.1c	 **ACCEPT** Mendip Hills

31	(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 evidence and information from the cross-section diagram to describe and explain how the rock types **AND** geological structures have resulted in the formation of springs at Bath. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*	**6**	2 x AO1.1a 2 x AO1.1c 2 x AO2.1a	**Indicative points may include:** **Rock types** • Limestone / sandstone form aquifers • Limestone is porous / permeable • Sandstone is porous / permeable • Detail of porosity / permeability, e.g. grains likely to be well rounded / well sorted • Limestone may contain caves / solution cavities which increase porosity • Aquifer rocks will have good interconnections between the pore spaces • Aquifer rocks likely to have little or no cementation

			Level 2 (3–4 marks) Uses some of the evidence and information from the cross-section diagram to describe and explain how the rock types **OR** geological structures have resulted in the formation of springs at Bath. *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)** Lifts some information from the cross-section diagram to attempt to describe or explain why there are springs at Bath. *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.			• Impermeable strata / aquicludes / aquitards above (and below) form a confined aquifer / artesian basin • Groundwater is under hydrostatic pressure • Groundwater rises up to the piezometric surface • Groundwater will flow out at the surface to form springs **Geological structures** • Limestone / sandstone are likely to have joints / bedding planes which are zones of permeability allowing groundwater flow • Syncline / synform / basin structure forms aquifer or produces hydrostatic head of water • Permeable rocks extend to depth allowing groundwater to be heated due to the geothermal gradient • Faults are natural zones of weakness / form fluid pathways / channel groundwater to the surface (at Bath)
31	**(d)**	**(i)**	Dissolved / taken into solution from rocks / minerals **OR** due to chemical weathering / carbonation / hydrolysis of rocks ✓	**1**	AO1.1c	
31	**(d)**	**(ii)**	Residence time ✓	**1**	AO1.1a	
31	**(d)**	**(iii)**	Cation content: Water mainly contains / is rich in Ca^{2+} / calcium (ions) ✓	**1**	AO3.1a	**ACCEPT** low in Mg^{2+}, Na^{+}, K^{+} **ACCEPT** low in SO_4^{2-}, Cl^{-}

			Anion content: Water mainly contains / is rich in $HCO3^-$ / hydrogen carbonate / bicarbonate (ions) ✓	**1**		
31	**(d)**	**(iv)**	• Water will be hard ✓ • Will form limescale / white deposits (in pipes / kettles / toilets / washing machines / dishwashers) ✓ • Makes soap / detergents difficult to lather ✓ • Harmless to health ✓	**Max 2**	AO1.1a AO1.1c	**ALLOW** calcium content is good for teeth / bones **OR** some people prefer the taste

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