GCE

Geology

H414/01: Fundamentals of geology

A Level

Mark Scheme for June 2022

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

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

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

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.
2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are available in RM Assessor.
3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

MARKING

1. Mark strictly to the mark scheme.
2. Marks awarded must relate directly to the marking criteria.
3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.
4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the RM Assessor messaging system.

5. Work crossed out:

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

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

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

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

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

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

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

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

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

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

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

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

   If you have any questions or comments for your Team Leader, use the phone, the RM Assessor messaging system, or email.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

Read through the whole answer from start to finish, using the Level descriptors to help you decide whether it is a strong or weak answer. The indicative scientific content in the Guidance column indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the skills and science content evidenced within the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.

Once the level is located, award the higher or lower mark:

The higher mark should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.

The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.

In summary:

The skills and science content determines the level.

The communication statement determines the mark within a level.

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

11. **Annotations**

Annotations available in RM Assessor

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

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

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. Subject Specific Marking Instructions

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

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

You should ensure that you have copies of these materials.

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

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

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

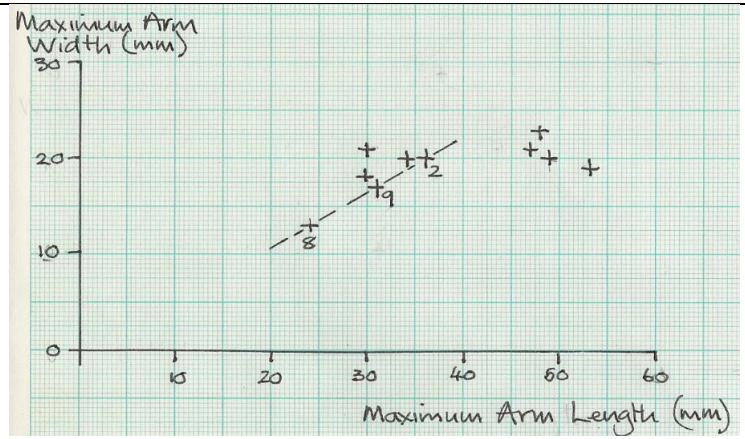
Question			Answer	Mark	Guidance	AO
26	(a)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 3300 (kg m^{-3}) award 2 marks** 14.92 / 4.52 = 3.3008 x 1000 = 3300.88 ✓ 3300 (kg m^{-3}) ✓	2	**ALLOW** 1 mark for answer not given to 2 sig figs e.g. 3300.9 kg m^{-3}	2.1b
	(a)	(ii)	Geological factor: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

26	**(a)**	**(v)**	pyroxene 26% +/- 15% opaque mineral 0.5 to 2% mineral with fractures 73% +/- 15% ✓	1	**MUST** have all 3 correct for mark **DO NOT ALLOW** if total does not add up to 100%	2.1b
26	**(a)**	**(vi)**	peridotite ✓ crystal size is > 5mm / coarse (therefore a plutonic igneous rock) ✓ mafic minerals / olivine and pyroxene / mainly olivine **OR** it is an ultramafic rock ✓	3	**ALLOW** harzburgite, dunite, lherzolite	1.1a 3.1b
26	**(b)***		Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 5 – 6 marks** The factors resulting in magmatic differentiation due to fractional crystallisation are described and explained along with the resulting change in the chemistry of the magma. Correct named ore mineral example(s) are given and the process is described in logical / time order of events. Technical terminology is used correctly. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated* **Level 2 3 – 4 marks** The processes are described in a logical order with an attempt at explanations and some use of technical terminology. Correct named ore mineral example(s) may be given.	6	Indicative scientific content may include: • only applies to large-scale plutonic magma bodies with slow cooling / cooling over Ma • mafic and ultramafic intrusions • different minerals crystallise at different temperatures • at the highest temperatures metal oxides / ore minerals will form • named ore mineral example: chromite / magnetite / any other correct named ore mineral • platinum group elements (PGE) / platinum /palladium • these crystals / minerals are much denser than the magma and will tend to sink / settle down • these crystals / minerals sink due to gravity settling • these crystals / minerals are removed / separated from the magma • the melt becomes more silicic / less mafic / the chemistry changes • magma saturated in sulfide • sulfur exsolves forming an immiscible liquid • droplets of immiscible sulfide liquid are denser than magma so sinks	1.1a 1.1c 2.1a 3.1b

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

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

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

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

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

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

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

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

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

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

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

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

Question			Answer	Mark	Guidance	AO
30	(a)		**ANY** three from: • volume of the Earth is measurable / known ✓ • mass of the Earth can be found using the acceleration due to gravity measured at the surface ✓ • the density of the whole Earth is 5500 kg m^{-3} ✓ • density of rocks at the surface are 2700-2900 kg m^{-3} ✓ • density of the whole Earth is higher than the density of rocks at the surface **ORA** ✓ • the core and mantle must be higher density than the crust ✓ • density of upper mantle can be measured as occasionally it is thrust up or found as xenoliths at the surface ✓	3	**ALLOW** correct density in g cm^{-3} **ALLOW** any value within this range **Max 1** mark for idea of Earth density – crust density = mantle / core density	1.1c 2.1a
30	(b)*		**Level 3 5 – 6 marks** There is an explanation of how the properties of the outer core result in refraction due to velocity changes and cause the P and S wave shadow zones. The inner and outer cores are correctly described in terms of states and depths. Technical terminology is used correctly. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated* **Level 2 3 – 4 marks** The P and S wave shadow zones are described correctly. Refraction / velocity changes may be referred to. Some correct description of the states and depths of	6	May include: • P wave velocity is controlled by incompressibility, rigidity and density • S wave velocity is controlled by rigidity and density • liquids have no shear strength / zero rigidity • changing wave velocity at a boundary results in refraction • slowing causes waves to be refracted towards the normal /steepened **ORA** • seismic shadow zones are areas on the Earth's surface where seismic waves are not recorded • S waves stop at the outer core boundary / Gutenberg discontinuity • seismic shadow zones are caused by outer core being liquid	1.1a 1.1c 2.1a 3.1b

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

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