GCE

Geology

H014/01: Geology

Advanced Subsidiary GCE

Mark Scheme for June 2019

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

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

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

Annotations

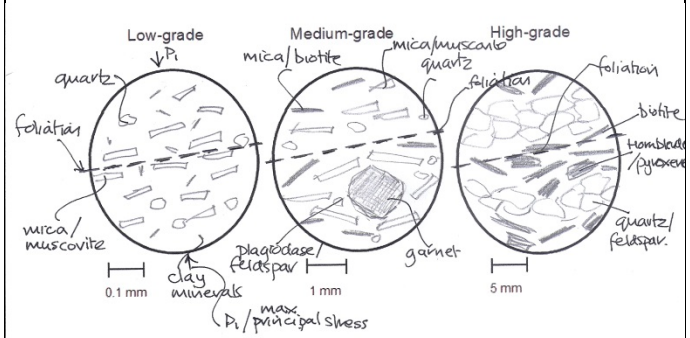
Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording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

Marking Annotations

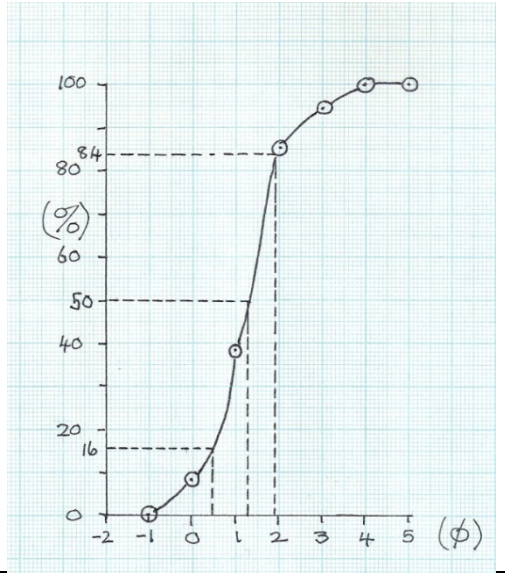
Annotation	Use
BOD	Benefit of Doubt
CON	Contradiction
	Cross
ECF	Error Carried Forward
GM	Given Mark
	Extendable horizontal wavy line (to indicate errors / incorrect science terminology)
I	Ignore
	Large dot (various uses as defined in mark scheme)
	Highlight (various uses as defined in mark scheme)
NBOD	Benefit of the doubt not given
	Tick
^	Omission Mark
BP	Blank Page
L1	Level 1 answer in Level of Response question
L2	Level 2 answer in Level of Response question
L3	Level 3 answer in Level of Response question

Question			Answer	Mark	Guidance	AO
1			B	1		2.1a
2			B	1		1.1c
3			A	1		1.1a
4			A	1		2.1a
5			D	1		1.1a
6			B	1		1.1c
7			A	1		1.1a
8			B	1		1.1a
9			D	1		1.1a
10			A	1		2.1a
11			C	1		2.1a
12			B	1		2.1a
13			D	1		1.1c
14			C	1		2.1a
15			A	1		1.1c
16			B	1		2.1a
17			D	1		2.1b
18			D	1		2.1a
19			A	1		1.1c
20			C	1		2.1a

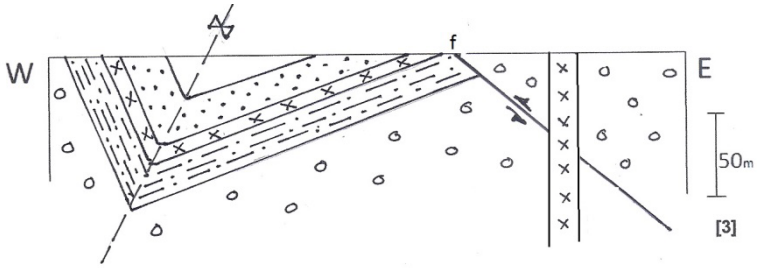
Question			Answer	Mark	Guidance	AO
21	(a)	(i)	= 0.41 to 0.51mm ✓✓	2	**ALLOW** one mark for correct answer to incorrect sig. figs. **ALLOW** one mark for correct working of an average value	2.1b
21	(a)	(ii)	granoblastic / sugary / saccharoidal / all crystals are roughly the same size ✓	1	**DO NOT ALLOW** equicrystalline **ALLOW** inter-locking crystals	1.1a
21	(a)	(iii)	calcite / calcium carbonate / $CaCO_3$ ✓	1		1.1c
21	(a)	(iv)	crystals would be coarser / larger / bigger ✓ greater recrystallization as higher temperatures allow crystals to grow for longer time **OR** greater recrystallization as higher temperatures allow atoms to move more readily **OR** greater recrystallization as higher temperatures mean faster reaction rates **OR** greater recrystallization as fluids from granite may help crystal growth ✓	2	**ALLOW AW**	1.1c 2.1a
21	(b)		quartz / SiO_2 / silicon dioxide / metaquartzite ✓ due to contact / thermal metamorphism **OR** it is an isochemical process **OR** due to recrystallization (of quartz grains) ✓	2		1.1a 2.1a
21	(c)	(i)	Low–grade: platy minerals drawn with long axes parallel **AND** <0.25mm long ✓	6		2.1a

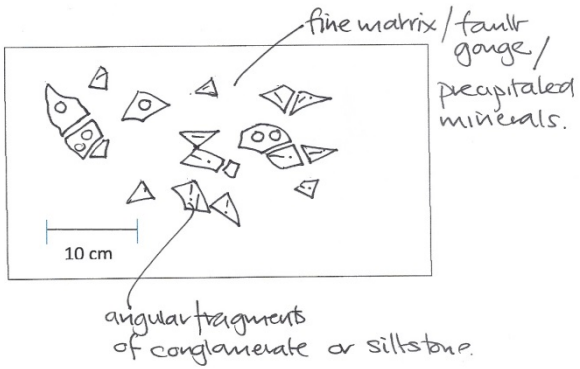
			named minerals labelled as mica / muscovite / chlorite ✓ Medium grade: platy minerals drawn with long-axes sub-parallel to foliation **AND** >1mm in length ✓ platy minerals labelled as mica / muscovite / biotite **OR** garnet drawn and labelled✓ High-grade: dark and light minerals drawn in bands **AND** mineral grain size >2mm diameter ✓ dark minerals labelled biotite / hornblende / augite / mafic / garnet **AND** light minerals as quartz / plagioclase / orthoclase / feldspar / felsic ✓		**ALLOW** kyanite **ALLOW** amphibole / pyroxene / kyanite / sillimanite / K feldspar / potash feldspar 	2.1b 3.1d
		(ii)	opposing arrows drawn perpendicular to foliation **AND** labelled (maximum principal) stress / P_{max} / P_1 ✓	1		2.1a
			Total	**15**		

Question			Answer	Mark	Guidance	AO
22	(a)		assemble a <u>stack</u> of sieves ✓ ensure sieves are clean / uncontaminated✓ each with mesh half the size of the sieve above ✓ coarsest at top and finest at bottom / in correct phi order ✓ weigh a representative sample ✓ cone and quarter method to obtain representative sample ✓ place in top / coarsest sieve **AND** fit lid ✓ shake / rotate stack for significant time ✓ carefully separate sieves (to prevent sand loss) ✓ weigh the contents of each sieve **AND** record results ✓	Max 5	**DO NOT ALLOW** descriptions of methods other than sieving **DO NOT ALLOW** time of less than one minute **ALLOW** any description of using paper to prevent losses	1.1b 2.1b
22	(b)	(i)	Moderately (well) sorted ✓	1	**DO NOT ALLOW** other general descriptive terms such as ‘poor’ or ‘good’	2.1a

22	**(b)**	**(ii)**	points correctly plotted ✓ ✓ at 0, 8, 38, 85, 94, 100, 100 % smooth curve drawn through points plotted ✓	3	6 to 7 correct points for 2 marks 4 to 5 correct points for 1 mark **ALLOW** ecf Less than 4, no marks  **ALLOW** ecf from above **MAX 1** if points are plotted mid-class	2.1b
22	**(c)**		Mean = 1.2 +/- 0.1 Φ ✓ ✓	2	**ALLOW** ecf from b (ii) **ALLOW** one mark for incorrect sig figs.	2.1a
22	**(d)**		Description; any appropriate use of data **OR** there is a larger proportion of coarse grains in the sample **OR** shows a negative / coarse skew ✓ ✓ Explanation; coarser grains are deposited due to high energy conditions ✓ no finer grains as they are kept in suspension / carried out to sea / winnowed by wind ✓	4		1.1a 1.1c 3.1b 3.1d

22	**(e)**		rock would have to be crushed before sieving / whole rock can't be sieved ✓ this does not necessarily produce individual grains / difficult to create individual grains ✓ clumps of grains will appear to increase the coarse percentage ✓ crushed grains / fragments of cement will increase fine percentage ✓ strength of cementation will affect results ✓	Max 2		1.1d 3.1f
			Total	**17**		

Question			Answer	Mark	Guidance	AO
23	(a)	(i)	**D** = ammonite **AND** **E** = trilobite ✓	1	**ALLOW** ammonoid **DO NOT ALLOW** cephalopod **ALLOW** *Paradoxides* for trilobite genus	1.1a
23	(a)	(ii)	**E** extinct before **D** evolved / **E** is older than **D** ✓ siltstone must be older as trilobites restricted to Palaeozoic **OR** mudstone must be younger as ammonites restricted to the Mesozoic ✓	2		2.1a
23	(a)	(iii)	<u>asymmetrical</u> syncline ✓	1	**DO NOT ALLOW** synform	1.1c
23	(b)	(i)	beds marked in correct outcrop sequence and decorated as key ✓ fold drawn in correctly with shallower dips on eastern side ✓ dyke drawn as a vertical intrusion cutting across the fault **AND** not offset by fault ✓ fault drawn in at appropriate angle (40 +/-5^{o}) ✓  [3]	Max 4	**ALLOW** ecf from (a) (i) Shows understanding of equal horizontal and vertical scales	1.1b 1.1d 2.1b 3.1a
23	(b)	(ii)	(half)-arrows drawn in correctly to show correct relative movement ✓	1		2.1a
23	(b)	(iii)	reverse ✓	1	**DO NOT ALLOW** dip-slip / thrust	

23	**(b)**	**(iv)**	recognisable drawing of angular fragments more than 2mm in size ✓ **ANY** two labels from: precipitated minerals fine matrix fault gouge angular fragments fragments of siltstone / conglomerate ✓	2		1.1a 1.1c
23	**(c)**		trend = 014° ✓ Evidence**;** lava flow / extrusive rock is concordant / follows strata **OR** lava flow / extrusive rock bakes rock beneath / does not bake rock above ✓	2	**ALLOW ORA** e.g. dykes are discordant / cut across strata dyke will cause 2 baked margins	3.1e
23	**(d)**		**Level 3 5 – 6 marks** Has a logical order of depositional and structural events with relevant detail on environments and tectonism. *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 order of events is presented correctly with little additional explanatory detail. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 1 – 2 marks** The order of events is not always logical and lacks	6	may include from oldest to youngest conglomerate deposited in high energy conditions; siltstone with trilobites deposited in shallow / low energy / oxygenated marine conditions; uplift / sea level fall / regression volcanism produces lava flow; sandstone deposited in high energy conditions / shallow waters mudstone with ammonites deposited in deep / low energy marine conditions compression on an ESE-WNW axis produces folding further compression on same trend produces reverse fault extension on an NE-SW trend allows dyke intrusion	3.1a 3.1b 3.1e

			evidence showing understanding of conditions. *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**.		erosion to present-day surface A logical order of deposition would **ALLOW** for the ecf resulting from anticlinal structure rather than synclinal in which case the mudstone is the oldest and the conglomerate youngest.	
			Total	**20**		

Question			Answer	Mark	Guidance	AO
24	(a)		width of ocean = 1500km ✓✓ **ANY** two from: formation of accretionary prism / wedge fold mountains form / orogenesis subducting oceanic lithosphere breaks free / complete subduction obduction of ophiolites regional metamorphism intrusion of batholiths (intermediate / silicic) volcanic activity reverse / thrust faulting / nappe formation ✓	3	2 cm a^{-1} x 75,000,000 a = 150,000,000cm = 1,500km **ALLOW** 1 mark for evidence of formula	2.1a
24	(b)	(i)	(fold) mountains match up when continents are joined / oceans closed ✓ fold mountain trends / NE-SW trend / mountains make a linear feature / rock ages / rock types match up ✓ fold mountains were all formed at the same time / by the same collision of continents / orogeny **OR** Caledonian orogeny took place between Ordovician and (Early) Devonian / approx 490 to 390 Ma **OR** this is evidence that the continents have separated / moved relative to each other ✓	3	**ALLOW** dates within 20 Ma	1.1a 2.1a
24	(b)	(ii)	glacial deposits match up when continents are joined / oceans closed ✓ when re-fitted they create a continent with an ice-cap ✓ when re-fitted to create a continent the striations are radial ✓ glacial erratics from Africa are found on S America	Max 3		2.1a 3.1a

			therefore must previously have been joined ✓ glacial deposits were formed in the Carboniferous / approx 300 Ma ✓ Gondwana / southern Africa was centred on the South Pole ✓ this is evidence that the continents have moved relative to each other ✓		**ALLOW** dates within 20 Ma	
24	**(c)**		**Level 3 5 – 6 marks** The answer includes an explanation of Contraction theory, some evidence for it and the logic of the errors involved. A short account of how it came to be discredited. Relevant detail is used in most of these sections. *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** What the Contraction theory is and why it fell out of favour. Some detail provided. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.* **Level 1 1 – 2 marks** Explanation of Contraction theory with no supporting detail. *There is an attempt at a logical structure with a line of reasoning. The information is, in the most part, relevant.* *No response or no response worthy of credit* **0 marks**.	6	Indicative scientific points include: As the Earth cools it shrinks, this causes compression at the surface, the compression results in the formation of fold mountain belts, This occurs on the edges of the fixed continents. This idea is part of the geosyncline model, used to explain the Appalachian and Caledonian mountains. This theory dominant until 1960s, when ocean data was available to support continental drift; Evidence for: the Earth *is* cooling so must contract (but not as fast as Kelvin calculated) Early estimates were 200 – 600 km decrease in circumference Lithosphere would respond by folding / thrust faulting Evidence against: Discovery of radioactivity Means Earth not contracting rapidly Only a few tens of km Not enough for the thousands of km found in mountain belts Contraction would lead to planet-wide contraction,	3.1a 3.1b 3.1c

					whereas there are many examples of tensional regimes e.g. rift valleys, normal faults, ocean ridges etc. new evidence shows mountain ranges are formed due to other processes only fully explained by present day plate tectonic understanding	
24	**(d)**	**(i)**	volcanic islands form above present-day position of plume **OR** plume position is fixed as plate moves over it **OR** older extinct islands / seamounts form a chain as plate moves over plume ✓ ages of islands / seamounts and distance from present-day position give rate of plate movement ✓	2	**ALLOW AW**	1.1c
24	**(d)**	**(ii)**	Global Positioning Systems / GPS ✓	1	**ALLOW** VLBI	1.1a
			Total	**18**		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th><th>AO</th></tr>
<tr><td>25</td><td>(a)</td><td>(i)</td><td>microscope can more easily identify minerals in fine grained rocks ✓
microscope can identify minerals based on cleavage / relief / habit / twinning / pleochroism / extinction ✓</td><td>Max 1</td><td>ORA for hand lens

ALLOW mineral characteristics can be more easily seen</td><td>1.1a</td></tr>
<tr><td></td><td>(a)</td><td>(ii)</td><td>magnetite ✓

magnetite is totally surrounded by olivine
plagioclase and pyroxene crystals have crystallized around olivine / magnetite crystals, so they must have formed later ORA ✓</td><td>2</td><td>ALLOW plagioclase

If mineral = plagioclase ALLOW they are the only euhedral crystals and so formed first</td><td>1.1a

2.1a</td></tr>
<tr><td></td><td>(a)</td><td>(iii)</td><td>equicrystalline / ophitic ✓</td><td>1</td><td>ALLOW poikilitic</td><td>1.1a</td></tr>
<tr><td>25</td><td>(b)</td><td>(i)</td><td><table><tr><th>Mineral</th><th>Total</th><th>%</th></tr><tr><td>magnetite</td><td>1</td><td></td></tr><tr><td>olivine</td><td>2 - 3</td><td></td></tr><tr><td>plagioclase</td><td>30 - 31</td><td></td></tr><tr><td>pyroxene</td><td>19 - 21</td><td></td></tr></table>✓✓</td><td>2</td><td>ALLOW range shown in tally column but MAX 1 if total NOT 54</td><td>2.1b</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><table><tr><th>Mineral</th><th>Total</th><th>%</th></tr><tr><td>magnetite</td><td>1</td><td>1.9</td></tr><tr><td>olivine</td><td>2 / 3</td><td>3.7 / 5.6</td></tr><tr><td>plagioclase</td><td>30 / 31</td><td>56 / 57</td></tr><tr><td>pyroxene</td><td>19 / 20 / 21</td><td>35 / 37 / 39</td></tr></table>✓✓</td><td>1</td><td>ALLOW ecf from b (i)

Max 1 mark for incorrect sig. figs.

ALLOW percentages shown but % values must match tally total given</td><td>3.1a</td></tr>
<tr><td>25</td><td>(b)</td><td>(iii)</td><td>mafic ✓</td><td>1</td><td>ALLOW basic</td><td>2.1a</td></tr>
<tr><td>25</td><td>(b)</td><td>(iv)</td><td>gabbro ✓</td><td>1</td><td></td><td>2.1a</td></tr>
<tr><td>25</td><td>(c)</td><td>(i)</td><td>misidentification of minerals ✓
grid intersection could fall on a boundary between</td><td>Max 2</td><td></td><td>3.1a</td></tr>
</table>

			minerals / grid lines too thick so cover two crystals ✓ (minor / accessory) minerals with a small area may be missed ✓ area (2D) rather than volume (3D) sampled ✓ not enough of the rock is sampled ✓			
25	**(c)**	**(ii)**	increase the magnification of the view ✓ change grid position to get different coverage ✓ take average of several grids / different thin sections / repeat the procedure ✓ sample rock in different orientations ✓ automated / computerised point counting ✓	Max 2		3.1f
			Total	**13**		

Question			Answer	Mark	Guidance	AO
26	(a)	(i)	a trace fossil shows evidence that organisms existed / evidence of activity / trace fossils include tracks, trails, coprolites **AND** body fossils are the preserved hard parts of the organism ✓	1		1.1a
26	(a)	(ii)	**A** trilobite resting trace (*Rusophycos*) ✓ **B** trilobite walking / furrowing / emerging (*Cruziana*) ✓	2	**ALLOW** stationary / at rest / not moving **ALLOW** moving through sediment **ALLOW** moving faster / moving on the sediment	1.1a 2.1a
26	(b)	(i)	Rock **Y**: desert / sand dune ✓ Rock **Z**: glacial **OR** wadi **OR** turbidity flow ✓	2	**ACCEPT** aeolian **ACCEPT** submarine fan	2.1a 2.1b
		(ii)	Rock **Y** there are very few organisms to fossilise **OR** continental environment so poor preservation **OR** high energy / erosion so organisms destroyed before preservation ✓ Rock **Z** glaciers / wadis support very few organisms to fossilise **OR** wadis / turbidity flows have high energy levels so organisms destroyed before preservation **OR** glaciers / wadis / turbidity flows cause erosion so organisms destroyed before preservation **OR** continental environment so poor preservation ✓	2	Both rocks must be discussed for 2 marks	3.1b

26	**(c)**	**(i)**	**P** lagoon **OR** reef **Q** lagoon **R** reef **OR** fore-reef ✓	1	<table><tr><th>sample</th><th>land</th><th>lagoon</th><th>reef</th><th>fore-reef</th></tr><tr><td>P</td><td></td><td>✓</td><td>✓</td><td></td></tr><tr><td>Q</td><td></td><td>✓</td><td></td><td></td></tr><tr><td>R</td><td></td><td></td><td>✓</td><td>✓</td></tr></table>	1.1c
26	**(c)**	**(ii)**	oolitic limestone / oolite ✓ calcite precipitated around a nucleus / shell fragment / sand grain **OR** grains roll / agitated by wave action / move around as they grow ✓	2	**ALLOW** oosparite **ALLOW** oomicrite	1.1a 1.1c
	(c)	**(iii)**	packstone	1		1.1a
	(d)	**(i)**	(plankton / coccoliths) carbonate skeletons dissolve at the CCD / carbonate compensation depth ✓ CO_2 dissolved in sea water increases with depth increased acidity causes dissolution of carbonates ✓ depth varies due to temperature / CO_2 added from atmosphere ✓	Max 2	**ALLOW** calcite compensation depth	1.1c 2.1a
	(d)	**(ii)**	**ANY** two from: fine-grained / mud / <4microns hard calcite-rich crystalline skeletons of calcareous algae / coccoliths / coccolithophores / forams / foraminiferans ✓	1		1.1a
	(d)	**(iii)**	chert / flint ✓ fine / cryptocrystalline form of quartz **OR** occurs as nodules in chalk and limestone **OR** ph / chemical changes during diagenesis causes precipitation **OR** dissolved silica may come from sponge spicules **OR** silicification of fossils ✓	2		
			Total	**16**		

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