GCE

Geology

H414/02: Scientific literacy in geology

Advanced 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

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td></td><td>
<table>
<tr><td>Name of diagenetic process</td><td>Explanation of process</td><td></td></tr>
<tr><td>Cementation</td><td>• minerals added from circulating water / pore fluid OR minerals crystallise / precipitate in pore spaces OR infill of pore space by mineral cement</td><td>✓</td></tr>
<tr><td>• Compaction</td><td>sediment squeezed by weight of overlying sediment; porosity and permeability reduced.</td><td>✓</td></tr>
<tr><td>• Recrystallisation</td><td>crystals change in size and shape</td><td>✓</td></tr>
<tr><td>• Pressure solution OR <u>dis</u>solution</td><td>minerals dissolve where grains press into each other.</td><td>✓</td></tr>
</table>
</td><td>4</td><td>MUST state either source of cement OR use technical terms e.g. crystallise / precipitate / infill / pores

DO NOT ALLOW description of infilling by fine grains or matrix</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td><u>24</u> (°C km^{-1}) ✓✓

(220 – 50) / 7</td><td>2</td><td>ALLOW 23 to 25

MAX 1 for correct answer to incorrect sig figs</td></tr>
<tr><td></td><td>(b)</td><td>(ii)</td><td>ANY range between 4 to 6.5 (km) ✓</td><td>1</td><td>MUST state both lower and upper limit of range within tolerance

ALLOW subtraction of bottom of range from top of range if correct working shown, e.g. 6.5 - 4 = 2.5</td></tr>
</table>

1	**(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)** Describes in detail how a range of the key diagnostic properties of colour, composition, grain size, grain shape and sorting are used to classify siliciclastic rocks **AND** gives a comprehensive range of named examples linked to their properties. *There is a well-developed explanation / description which is clear and logically structured. The information presented is relevant and substantiated with examples.* **Level 2 (3–4 marks)** **EITHER** Describes in outline most of the key diagnostic properties **OR** Describes in detail some of the key diagnostic properties **AND** gives a suitable range of named examples. *The explanation / description of properties shows some structure. The information presented is relevant and gives some examples.* **Level 1 (1–2 marks)** States some appropriate diagnostic properties **AND** limited named examples may be given. *There is an attempt at a logical structure. The information is in the most part relevant but lacking in range and detail.* **0 marks** *No response or no response worthy of credit.*	6	**Key scientific indicative points include:** **AO 2.1a Applies knowledge and understanding of diagnostic properties needed to classify siliciclastic rocks and AO 3.1b Interprets geological information, ideas and evidence to classify / give examples of the different siliciclastic rocks** **grain size** • coarse **OR** > 2mm = rudaceous / conglomerate / breccia • medium **OR** 2 – $^{1}/_{16}$ / 0.0625 mm = arenaceous / sandstone / named sandstone • fine **OR** < $^{1}/_{16}$ / 0.0625 mm = argillaceous / shale / mudstone / clay / siltstone **grain shape / roundness / sphericity** • angular clasts = breccia / greywacke / arkose • rounded clasts = conglomerate / orthoquartzite / desert sandstone • high sphericity = desert sandstone **sorting** • poorly sorted = breccia / greywacke • moderately sorted = arkose • well sorted = orthoquartzite / desert sandstone **composition / mineralogy** • mainly quartz **OR** > 90% quartz = orthoquartzite • mainly quartz **OR** > 90% quartz **AND** iron oxide / haematite cement = desert sandstone • quartz and feldspar **OR** > 25% feldspar = arkose • lithic / rock fragments = greywacke / conglomerate / breccia • > 15% clay / matrix = greywacke • monomictic / polymictic = conglomerates **colour** • red = haematite cement • pink = arkose

					• grey = greywacke **others** • e.g. layered / fissile / laminated / fossil content / plasticity A <u>labelled</u> flow diagram would be appropriate, although not a requirement, to help the interpretation
			Total	**13**	

Question			Answer	Mark	Guidance
2	(a)	i	**Earth structure ANY 1** from: • Earth contains a very dense core / core has density greater than 5.5 g cm^{-3} ✓ • must be high density material at depth to get a mean of 5.5 cm^{-3} ✓ • (low density surface rocks must be balanced by) high density material at depth ✓ **processes of formation ANY 1** from: • differentiation occurred ✓ • more dense elements settled to form core ✓ • elements partitioned on the basis of Goldschmidt classification ✓ • separation into layers based on density / gravity settling ✓	1 1	**ORA** for less dense elements
	(a)	ii	**Earth structure ANY 1** from: • Earth's surface consists of (lithospheric) plates ✓ • (zones of) earthquakes / seismic activity / epicentres mark plate boundaries ✓ • middle of plates are aseismic ✓ • lithosphere is rigid / brittle ✓ **internal processes ANY 1** from: • ridge push **OR** slab pull processes (drive lithospheric plate movements) ✓ • magma rises / rifting occurs / new (oceanic) crust / lithosphere forms at mid ocean ridges / divergent plate boundaries ✓ • crust / lithosphere is destroyed / subducted at subduction zones / convergent plate margins ✓ • brittle failure in rigid lithospheric plates create earthquakes ✓ • lithosphere is moving on deformable plastic / rheid asthenosphere ✓ • lithospheric plates move as they are the cold thermal upper boundary of mantle convection cells ✓ • (internal) heat drives the movement ✓	1 1	**ALLOW AW** **ALLOW AW** **ALLOW** convection (currents / cells in mantle) move (lithospheric) plates

2	**(b)**		Location	Type of plate boundary	Type of volcanic activity	Composition of magma	Example of rock type	4	**ANY** 1 or 2 marking points for 1 mark **ANY** 3 or 4 marking points for 2 marks **ANY** 5 or 6 marking points for 3 marks **ANY** 7 or 8 marking points for 4 marks **ALLOW** both types of plate margin given as convergent with no qualification for 1 marking point **ALLOW** destructive as an alternative to convergent **ALLOW** any correct named example of pyroclastic rock for either location, e.g., tuff / agglomerate / ignimbrite **DO NOT ALLOW** rhyolitic / andesitic / basaltic as rock names
			The Andes in South America	<u>oceanic-continental</u> **AND** convergent / subduction zone	(more) explosive **OR** stratovolcanoes / composite cones / calderas **OR** infrequent	silicic / rhyolitic **OR** intermediate / andesitic	rhyolite / andesite		
			Indonesia	<u>oceanic-oceanic</u> **AND** convergent / subduction zone / island arc	(less) explosive **OR** stratovolcanoes / composite cones / calderas **OR** infrequent	intermediate / andesitic **OR** (intermediate / andesitic to) mafic / basaltic	andesite / basalt		

2	**(c)**	**(i)**	**ANY 3** from: • rock / lava containing magnetic minerals / iron minerals / magnetite **OR** mafic rock **OR** basalt ✓ • unpaired electrons in the outer shell of Fe atoms (forming Fe minerals) in magma spin parallel to the Earth's magnetic field ✓ • minerals align with the Earth's magnetic field at the time **OR** minerals align in direction of the Earth's magnetic field **OR** minerals show alignment with respect to the poles at the time ✓ • magnetic inclination is the dip of the Earth's magnetic field ✓ • magnetic inclination varies with latitude **OR** magnetic inclination gives palaeolatitude ✓ • magnetism is preserved as remanent magnetism ✓	3	**ALLOW** when minerals cool below Curie point the magnetism is fixed permanently
	(c)	**(ii)**	**ANY 3** from: • show the two continents were moving North **OR** show the changes in latitude ✓ • before 200Ma / beginning of Cretaceous the curves are parallel to each other / match each other so the two continents were joined together / moving together ✓ • at 200Ma / during Cretaceous the curves diverge / differ so the continents split apart / moved separately / moved independently ✓ • at 50 Ma the two continents collided / joined as the curves match ✓	3	**ALLOW AW** **ALLOW** general statement that matching curves show the continents were joined **OR** diverging curves show the continents were moving independently for 1 mark
			Total	**14**	

Question			Answer	Mark	Guidance
3	(a)		**ANY TWO** descriptions **AND** matching explanations from: description 1: cut-off curtain **OR** construct barrier beneath dam **AND** explanation 1: impermeable **OR** to prevent leakage under the dam ✓ description 2: clay or plastic / geomembrane lining **AND** explanation 2: impermeable barrier to prevent leakage **OR** because the rocks are permeable ✓ description 3: grouting **OR** drilling holes and pumping in liquid cement **AND** explanation 3: to reduce permeability **OR** to make the limestone / sandstone impermeable **OR** to seal the faults / prevent leakage through the faults **OR** to seal joints in the limestone / prevent leakage through joints in the limestone **OR** to strengthen the underlying rocks ✓	2	each marking point **MUST** contain a description **AND** a matching explanation **ALLOW MAX 1** for two correct descriptions with no or incorrect explanations **DO NOT ALLOW** stops leakage with no qualification for explanation
	(b)	(i)	**ANY 2** from: granite and basalt are competent rocks (so strong) ✓ crystalline / made of interlocking crystals ✓ no <u>pore</u> space ✓ no bedding planes which form planes of weakness ✓	2	**DO NOT ALLOW** discussion of hardness **MUST** refer to rock, not minerals in the rock **ALLOW** lack of foliation / any correct named type of foliation as an alternative to bedding
	(b)	(ii)	compressive strength is resistance to stresses / forces acting towards each other / pushing ***/*** squeezing / crushing **AND** tensile strength is resistance to stresses / forces pulling apart / stretching / extension ✓	1	**ALLOW AW**

3	**(b)**	**(iii)**	**ANY 2** from: • rock (beneath dam) may not be able to support weight of dam / added load pressure **OR** rock beneath dam may fail / collapse due to added weight of dam ✓ • (mass of) <u>water / reservoir / increased hydrostatic pressure</u> adds weight / compresses underlying rock ✓ • added mass / weight / compression could reactivate faults **OR** cause seismic activity ✓ • added mass / weight could cause subsidence as sink holes are present suggesting underground caves ✓ • differential subsidence may occur **OR** if rock / strength varies subsidence could occur ✓	2	**ALLOW AW**
	(b)	**(iv)**	<u>47.4</u>% **OR** <u>32.1</u>% ✓✓ correct use of means of ranges: limestone (250+30)/2 = 140 **AND** sandstone (170+20)/2 = 95 (140-95)/95 x 100 = 47.4% **OR** (140-95)/140 x 100 = 32.1% <u>31.8</u>% **OR** <u>46.7</u>% ✓✓ correct use of mid-point of ranges: limestone (250-30)/2 = 110 **AND** sandstone (170-20)/2 = 75 (110-75)/110 x 100 = 31.8% **OR** (110-75)/75x100 = 46.7% <u>48.5</u>% ✓✓ lower end of range 30/20 = limestone is 50% stronger than sandstone ✓ upper end of range 250/170 = limestone is 47% stronger than sandstone ✓ (50+47)/2 = 48.5%	2	**MAX 1** for correct answer given to more than one decimal place **MAX 1** for correct working shown with incorrect answer **2 MARKS** for correct answer of percentage strength difference based on a valid comparison of the ranges of strength of the two rocks

3	**(c)***		Refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Uses a good balance of information / evidence given in the text, maps and table 3.1 to evaluate and make detailed judgements of the pros and cons of building a dam on the proposed site. Gives a clear decision as to whether the site is appropriate or not. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Uses some of the information / evidence given in the text, maps and table 3.1 to evaluate and make judgements of some of the pros and cons of building a dam on the proposed site. The decision as to whether the site is appropriate may not be explicit. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Some information / evidence is lifted from the text, maps and table 3.1 to identify some of the pros and / or cons of building a dam on the proposed site. A judgement may be attempted. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*	6	**Indicative points include:** **AO 3.1c Evaluates information from (cross sections and) maps for evidence to help in decision and AO 3.1d Makes judgements in terms of the pros and cons** **faults** • present • zones of permeability / allow leakage of water • may be reactivated / move • could cause engineering problems • could weaken dam foundations • juxtapose different rock types **strength of rocks** • compressive strength of underlying rocks is high **OR** underlying rocks are competent so can support mass of dam / reservoir / water • (compressive) strength of underlying rocks is variable • lowest / bottom of range of (compressive) strength values should be considered as are minimum strengths • differential subsidence could occur • reservoir is on two different rock types of differing strengths / could affect stability • **IGNORE** discussion of tensile and shear strength **limestone** • limestone may be permeable so could get leakage • limestone may be uncemented so could get leakage / weakens rock • limestone underlying dam / reservoir may jointed so could get leakage / weakens rock • limestone contains sink holes / caves / cavities which weakens rock / may cause collapse /

					subsidence • limestone is chemically reactive **sandstone** • sandstone may be permeable so could get leakage • sandstone may be uncemented so could get leakage • sandstone underlying dam / reservoir may be jointed so could get leakage / weakens rock **sink holes** • could allow leakage / collapse **construction considerations** • material for facing and core locally available / transport costs will be low • filling of reservoir could encroach on / cut off road • local workforce readily available / local employment opportunities / reduces costs • water is needed for expanding local industry **catchment considerations** • narrow valley allows relatively small dam • several rivers flowing into proposed site / good catchment area / high rainfall
			Total	**15**	

Question			Answer	Mark	Guidance
4	(a)	(i)	**ANY 2** from: • high temperature minerals are mafic / ferromagnesium-rich **OR** low temperature minerals are felsic / silica-rich ✓ • early formed / high temperature mafic / ferromagnesium minerals are low in silica **OR** only incorporate a small amount of silica (in their structure) ✓ • magmatic differentiation / fractional crystallisation / fractionation occurs ✓ • mafic / ferromagnesium minerals are dense and undergo gravity settling ✓ • removal of mafic / ferromagnesium minerals from the magma increases the relative amount of silica / SiO_2 ✓	2	**ALLOW** correct named mafic mineral, e.g., olivine, pyroxene / augite
	(a)	(ii)	magma with high silica content has a high viscosity **OR** magma with low silica content has a low viscosity ✓ magma at divergent plate boundaries is mafic / has low silica content / is fluid so volcanic landforms are fissure volcanoes / shield volcanoes / volcanoes have shallow(er) angled sides ✓ magma at convergent plate boundaries is silicic / intermediate / has high silica content / is viscous so volcanic landforms are stratovolcanoes / volcanoes have steep(er) angled sides ✓	1 1 1	**ALLOW** correct numerical values for silica content **ALLOW** correct description of silica content and viscosity within discussion of plate boundaries for first marking point **ALLOW** calderas for convergent plate margins
	(b)	(i)	the students should not have excluded any of the values **OR** the mean value of 60 seconds they calculated is incorrect ✓ the mean is calculated by adding together the results and dividing by the number of values **OR** correct working of mean shown **OR** they should have calculated the mean value as 63 seconds ✓	1 1	**ALLOW** students (incorrectly) excluded 71 seconds / repeat test 3

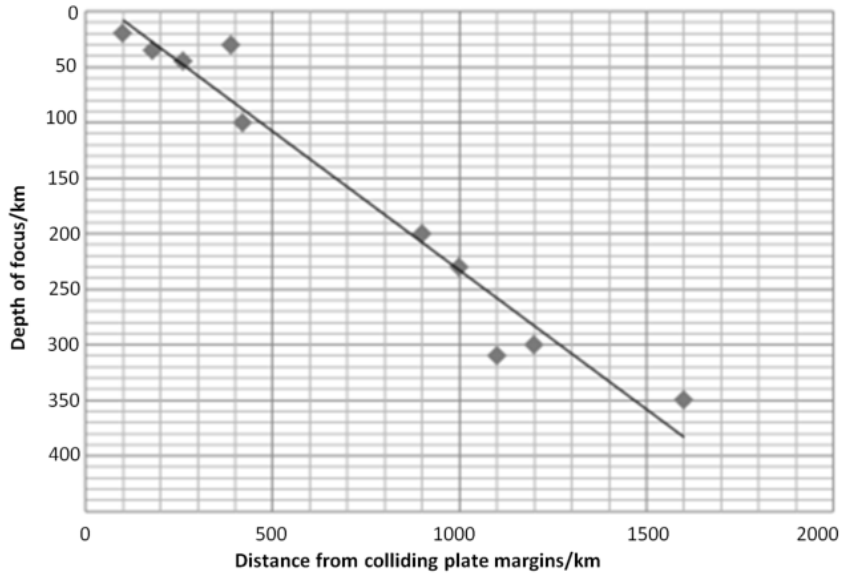
<table>
<tr><td>4</td><td>(b)</td><td>(ii)</td><td>90 +/- 1 OR 86 +/- 1 (Pa.s) ✓✓✓

conversion of time to velocity:
EITHER 0.25 ÷ 63 OR 0.25 ÷ 60
= 4.00 x 10^{-3} OR 0.004 OR 3.97 x 10^{-3} OR 0.00397 OR 4.17 x 10^{-3} OR 0.00417 ms^{-1} ✓

substitution in equation: = $\frac{2 \times 9.8 \times (6.6 \times 10^{3}) \times (2.5 \times 10^{-5})}{9 \times \text{calculated velocity}}$ ✓</td><td>3</td><td>MAX 2 for correct answer not given to 2 or 3 sig figs

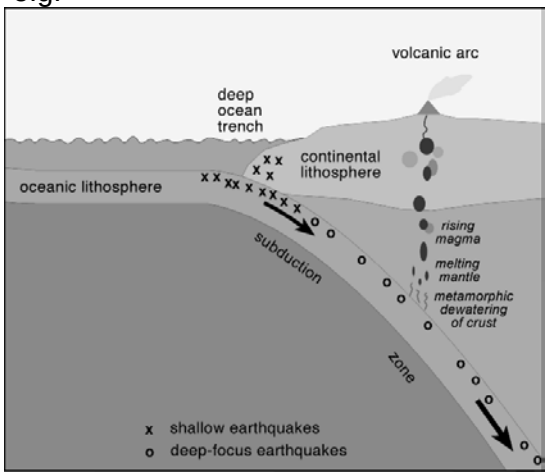
ALLOW ECF of velocity for remaining calculation</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td>suitable labelling of both axes with distance as x axis and depth as y axis AND use of graph area (at least 2/3) ✓

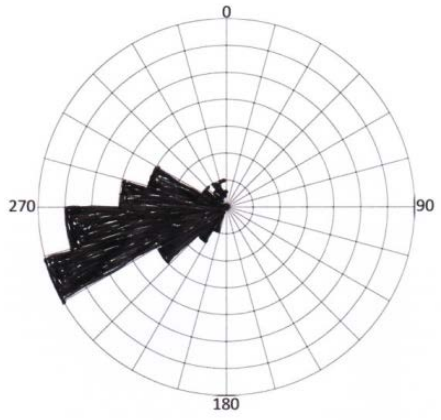
correct plotting of points ✓

sensible choice of line of best fit ✓
 
</td><td>3</td><td>ALLOW if drawn upside down – i.e. depth zero and distance zero bottom left

ALLOW one incorrect point

<table>
<tr><th>Distance (km)</th><th>Depth of focus (km)</th></tr>
<tr><td>100</td><td>20</td></tr>
<tr><td>180</td><td>35</td></tr>
<tr><td>260</td><td>45</td></tr>
<tr><td>390</td><td>30</td></tr>
<tr><td>420</td><td>100</td></tr>
<tr><td>900</td><td>200</td></tr>
<tr><td>1000</td><td>230</td></tr>
<tr><td>1100</td><td>310</td></tr>
<tr><td>1200</td><td>230</td></tr>
<tr><td>1600</td><td>350</td></tr>
</table></td></tr>
<tr><td>4</td><td>(c)</td><td>(ii)</td><td>point inside the Earth at which the earthquake originates OR point</td><td>1</td><td></td></tr>
</table>

			inside the Earth where the fault ruptures **OR** point below the surface where the earthquake occurs **OR** point along the fault where it slips / ruptures ✓		
	(c)	**(iii)**	**description:** earthquakes are generated along Benioff Zone **OR** the further from the trench the deeper the subducted plate **OR** as distance from the plate boundary increases, the depth of earthquake foci increase ✓ **explanation:** the inclined zone of seismicity / Benioff Zone marks the top of the subducted plate / is the result of subduction **OR** plates are prevented from moving by friction **OR** stored stress is released as seismic waves when the plates move ✓ **correct labelled diagram:** ✓ e.g.  	1 1 1	**MUST** describe the positive correlation **MARK** labels as text
			Total	**17**	

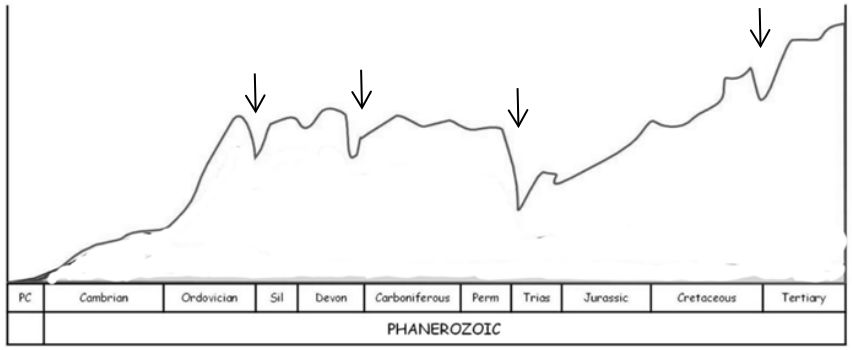
Question			Answer	Mark	Guidance
5	(a)	(i)	**ANY 4** from: • rapid flow / avalanche of sediment down (continental) slope ✓ • turbidity current / powerful current scours / erodes base / produces flute casts ✓ • heavier coarse material deposited first as energy starts to drop ✓ • graded bedding / parallel laminations / fining upwards sequence suggests decreasing current velocity / energy reduction / laminar flow ✓ • greywacke / sandstone is the result of deposition from the turbidity current ✓ • ripples and cross bedding suggest lower velocity / reduction in current **OR** unidirectional current **OR** form on a flatter seafloor ✓ • silts and muds suggest no / little current **OR** are deposited in low energy conditions **OR** result from suspension settling **OR** are interturbidites **OR** are deposited in normal / deep marine conditions ✓ • low energy conditions allow the fossils (at the top of the sequence) to be preserved ✓ • the sequence repeats as the next turbidity current occurs **OR** turbidite and interturbidite deposits are repeated ✓	4	**MAX 2** if interpreted as a fluvial / river sequence **MAX 3** if explained in reverse age order **ALLOW 1 MARK** for description of fining upwards sequence from oldest to youngest if no other marks awarded
	(a)	**(ii)**	 • at least 4 correct compass labels / bearings labelled ✓ • correct plotting of data ✓ • direction of flow is in one direction – shown on diagram **OR** described in text ✓ • direction of flow is towards west south west / WSW ✓	4	**ALLOW** west **OR** towards 241 to 270° **ALLOW ECF** for current direction if rose diagram is incorrect

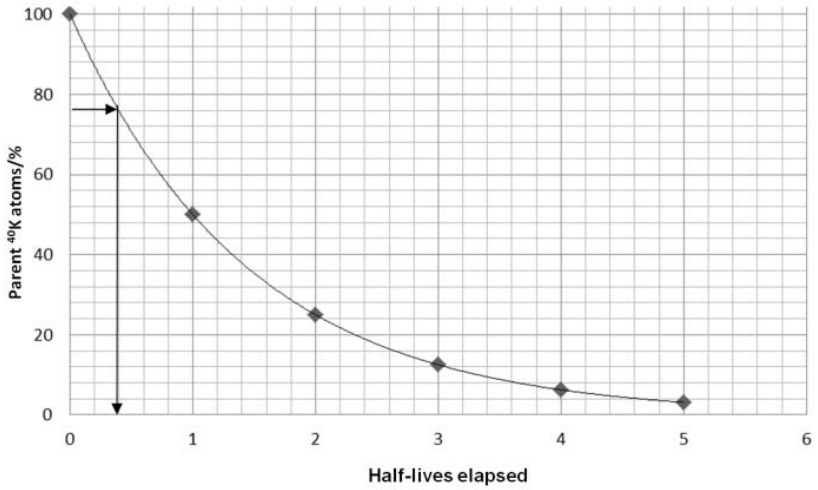
5	**(b)**		**ANY 4** from: • description of difference(s) between graphic logs – west graphic log has less greywacke units / thicker shales beds ✓ • rose diagram – flute casts / turbidity flows / sediments moved / transported from the east **OR** to the west ✓ • graphic logs – greater thickness of shales suggest deeper / lower energy conditions to the west ✓ • more greywacke units / thinner shales suggest higher energy conditions / currents flowing more rapidly to the east ✓ • overall suggests land / shallow water / proximal to east **OR** deeper marine / deeper water / distal to west ✓ • thicker greywacke units in east suggest continental shelf / land (mass) / source of sediment is from the east ✓ • more turbidity currents reached the east **OR** not all the turbidity currents reached the west (as there are less greywacke units) ✓ • repeated units show cycles of deposition **OR** repeated turbidity currents **OR** conditions alternated from turbidite to interturbidite / higher energy to lower energy ✓	4	**ORA**

5	**(c)**		**ANY 5** from: • biostratigraphic correlation is main method used ✓ • requires use of (zone) fossils ✓ • correlation is done using first appearance **OR** stratigraphic ranges **OR** extinction **OR** fossil assemblages **OR** matching fossils mean beds are the same age ✓ • zone fossils must show rapid evolution / rapid morphological changes **OR** have short stratigraphic ranges ✓ • uses pelagic / planktonic / nektonic fossils **OR** fossils must have a wide distribution ✓ • correlation could use graptolites **OR** graptolites are zone fossils for the Lower Palaeozoic ✓ • graptolites could be preserved in shale ✓ • correlation could also use trilobites / corals **OR** trilobites / corals are also used as zone fossils for the Welsh Basin ✓ • lithostratigraphic correlation would not be possible **OR** there are diachronous beds / lateral variation / different numbers of beds / couldn't match up the greywacke / shale units as there are different numbers to west and east ✓ • chronostratigraphic correlation / radiometric dating would not be possible because there is a lack of suitable elements / minerals for radiometric dating **OR** ash / tuff bands in the Welsh Basin have been used to attempt radiometric dating / chronostratigraphic correlation ✓	5	**ALLOW** conodonts
			Total	**16**	

Question			Answer	Mark	Guidance
6	(a)	(i)	**ANY 2** for 1 mark from: Arthropoda / Brachiopoda / Mollusca / Hemichordata ✓	1	**DO NOT ALLOW** if any soft bodies organisms are included in list
	(a)	(ii)	**ANY 4** from: • deep water / basin **AND** low energy conditions ✓ • low energy / no currents **AND** no fragmentation / abrasion of organisms ✓ • anaerobic / anoxic conditions **AND** little decay (of soft material) / no scavenging **OR** replacement by pyrite / pyritisation occurred ✓ • fine-grained sediment / carbonate muds **AND** detail preserved / no crushing / abrasion by coarse grains / have low permeability ✓ • rapid burial (in mud from carbonate platform) **AND** no time for breakage / decay / scavenging / preserves organisms ✓ • early replacement (of original material) **AND** less alteration **/** fine detail preserved ✓	4	each mark is for a suggested condition **AND** matching explanation **MAX 1** if 3 conditions described with no explanations
	(a)	(iii)	**ANY 3** from: • soft organism / body contains organic carbon ✓ • organism is buried (by fine sediment) ✓ • subjected to load pressure **OR** weight of overburden **OR** compaction ✓ • elevated temperatures and pressures ✓ • volatile components / oxygen / hydrogen / nitrogen / water driven off ✓ • (reduced volume results in) relative increase in % carbon ✓ • leaves carbon residue / imprint / is 2D ✓	3	**ALLOW** suitable named composition **ALLOW** any correct named volatile
	(b)	(i)	X <u>0.7</u> +/- 0.1 ✓✓	2	**ALLOW ECF** for 1 mark for correct calculation based on incorrect measurement

6	**(b)**	**(ii)**	**epifaunal evidence ANY 1** from: • many appendages / legs / limbs / thoracic segments suggest *Olenoides* walked on the seafloor ✓ • eyes high on cephalon gives all round 360° vision / upwards and forwards vision ✓ • genal spines / spines on pleura / thorax / pygidium prevents sinking into soft sediment ✓ **in-situ evidence ANY 1** from: • antennae / appendages / legs / limbs are not disarticulated / broken off ✓ • cephalon, thorax and pygidium are still articulated **OR** thoracic segments are not separated ✓	1 1	**ALLOW** antennae **ALLOW AW**
	(b)	**(iii)**	**ANY 2** from: • moults / undergoes ecdysis ✓ • cephalon breaks along the facial suture **OR** splits along facial suture **OR** had sutures on face it split along **OR** free cheeks break away **OR** fixed cheek remained attached ✓ • (soft) body exits the carapace / exoskeleton ✓ • is vulnerable until new carapace / exoskeleton hardens ✓	2	**ALLOW** shed their exoskeleton
	(c)	**(i)**	<u>sudden / rapid</u> increase in (all types of) organisms (during / towards end of Early Cambrian / by Middle Cambrian) ✓	1	**ALLOW** fossils as alternative to organisms **ALLOW** alternative words for sudden / rapid **DO NOT ALLOW** sudden decrease / stop

6	(c)	(ii)	**ANY 3** for 1 mark from: ✓  	1	**ALLOW** arrows immediately before or over dips **DO NOT ALLOW** any incorrect arrows
	(c)	(iii)	**ANY 3** from: • global cooling / icehouse conditions / glacier formation due to continent / land mass situated over South Pole **OR** continent / land mass situated over South Pole allowed growth of ice cap ✓ • loss of continental shelf / shoreline habitat **OR** increased competition on continental shelf ✓ • organisms unable to evolve / adapt (fast enough) to changing conditions ✓ • changes in ocean chemistry **OR** less nutrients flowing into ocean ✓ • ocean circulation patterns affected ✓ • unstable climate / weather patterns caused by unbalanced Earth / concentration of continent / land mass over South Pole ✓ • global heat transfer affected ✓ • interior of continent will be cold **OR** arid **OR** unsuitable for terrestrial life ✓ • ice cap on land mass had high albedo / reflectivity causing it to become even colder / a positive feedback / a runaway effect ✓	3	**MAX 2** if not related to the formation of a supercontinent / Gondwanaland

6	**(d)**	**(i)**	 <u>500</u> Ma ± 10 ✓✓	2	**ALLOW** 0.4 of half-life labelled on graph or stated in text for 1 mark
	(d)	**(ii)**	<u>643 to 648</u> Ma ✓✓ $N/N_0 = 0.70 = e^{-\lambda t}$ $\ln 0.70 = -\lambda t$ $\lambda = 0.693/1250 = 5.544 \times 10^{-4}$ $t = \ln 0.70 / \lambda = 643$ Ma	2	range allows rounding of λ **ALLOW 1** mark for any correct working shown
	(d)	**(iii)**	loss of argon gas **OR** incorrect ratio **OR** too much parent isotope **OR** not enough daughter isotope **AND** will suggest a <u>younger</u> age **OR** gives <u>underestimation</u> of age ✓	1	
			Total	**25**	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

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