GCE A LEVEL MARKING SCHEME

SUMMER 2023

A LEVEL
GEOLOGY – COMPONENT 3
A480U30-1

INTRODUCTION

This marking scheme was used by WJEC for the 2023 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

GCE A LEVEL GEOLOGY

COMPONENT 3 - GEOLOGICAL APPLICATIONS

SUMMER 2023 MARK SCHEME

Instructions for examiners of A Level Geology when applying the mark scheme

1 Positive marking

It should be remembered that candidates are writing under examination conditions and credit should be given for what the candidate writes, rather than adopting the approach of penalising him/her for any omissions. It should be possible for a very good response to achieve full marks and a very poor one to achieve zero marks. Worthwhile answers that meet the requirements of the question, but do not appear on the mark scheme are to be given credit.

2 Tick marking

Low tariff questions should be marked using a points-based system. Each credit worthy response should be ticked in red pen. The number of ticks must equal the mark awarded for the sub-question. The mark scheme should be applied precisely using the marking details box as a guide to the responses that are acceptable. Do not use crosses to indicate answers that are incorrect.

3 Annotated diagrams

Where a candidate has answered a question wholly or partly by use of an annotated diagram, credit must be awarded to the annotations which form credit-worthy responses as outlined in the marking details box. Candidates must be credited only once for valid responses which appear both as annotations to diagrams and within a section of prose in the answer to the same question.

4. Banded mark schemes

Banded mark schemes are divided so that each band has a relevant descriptor. The descriptor for the band provides a description of the performance level for that band. Each band contains marks. Examiners should first read and annotate a candidate's answer to pick out the evidence that is being assessed in that question. **Do not use ticks** on the candidate's response. Once the annotation is complete, the mark scheme can be applied. This is done as a two-stage process.

Stage 1 – Deciding on the band

When deciding on a band, the answer should be viewed holistically. Beginning at the lowest band, examiners should look at the learner's answer and check whether it matches the descriptor for that band. Examiners should look at the descriptor for that band and see if it matches the qualities shown in the learner's answer. If the descriptor at the lowest band is satisfied, examiners should move up to the next band and repeat this process for each band until the descriptor matches the answer.

If an answer covers different aspects of different bands within the mark scheme, a 'best fit' approach should be adopted to decide on the band and then the learner's response should be used to decide on the mark within the band. For instance if a response is mainly in band 2 but with a limited amount of band 3 content, the answer would be placed in band 2, but the mark awarded would be close to the top of band 2 as a result of the band 3 content.

Examiners should not seek to mark candidates down as a result of small omissions in minor areas of an answer.

Stage 2 – Deciding on the mark

Once the band has been decided, examiners can then assign a mark. During standardising (marking conference), detailed advice from the Principal Examiner on the qualities of each mark band will be given. Examiners will then receive examples of answers in each mark band that have been awarded a mark by the Principal Examiner. Examiners should mark the examples and compare their marks with those of the Principal Examiner.

When marking, examiners can use these examples to decide whether a candidate's response is of a superior, inferior or comparable standard to the example. Examiners are reminded of the need to revisit the answer as they apply the mark scheme in order to confirm that the band and the mark allocated is appropriate to the response provided.

Indicative content is also provided for banded mark schemes. Indicative content is not exhaustive, and any other valid points must be credited. In order to reach the highest bands of the mark scheme a learner need not cover all of the points mentioned in the indicative content but must meet the requirements of the highest mark band. Where a response is not creditworthy, that is contains nothing of any significance to the mark scheme, or where no response has been provided, no marks should be awarded.

Section A

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
1.	(a)		**Any two x (1) from:** • vertical movement • fault (credit reference to plate boundary/subduction) • displaces water column	2			2		
	(b)		(19.30 -13.45) = 5.75 hours (accept 5.25hrs to 6.25 hrs) (1) $\frac{4174}{5.75}$ (1) also ecf = 726 km h^{-1} (accept 668-795) (1) also ecf		3		3	3	3
	(c)	(i)	**Any three x (1) from** • low wave height/size/amplitude • quantified wave height • low frequency • long wavelength • long period • high speed • in deep ocean • similar to normal sea waves		3		3		
		(ii)	1.1m (1)	1			1	1	1

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
		(iii)	**Any two x (1) from:** • increased in height • credit reference to values • increased in frequency /wavelength decreases • decreased in velocity	2			2		
	(d)		**Any four x (1) from:** • risk is low • highest tsunami wave only 1.1 metres high (or reference to the incorrect value quoted in Q1(c)(ii)) • lower than high tide level • tsunami struck at low tide • plenty of time for warning to be given • warning system in the Pacific • may have tsunami defences that would reduce effects • however, wave speed is high • tsunami waves more powerful than normal waves (+1) for development			4	4		4
			Question 1 total	**5**	**6**	**4**	**15**	**4**	**8**

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
2.	(a)		**Any two x (1) from:** • in low pH (strong acid) lead has high concentration • concentration reduces to minimum when solution is pH 8.5 - 9 • concentration increases as solution becomes more alkaline	2			2		2
	(b)	(i)	**Any two x (1) from:** • water slightly acidic when enters mine • pH decreases/becomes more acidic as water passes through mine • credit use of numbers	2			2		
		(ii)	**Any two x (1) from:** • lead is more soluble as acidity increases/changes quantified • lead is dissolved into mine water • lead transported in solution • more lead discharged/enters river at low or high pH values credit reference to lead being more reactive in acid		2		2		
	(c)	(i)	**Any three x (1) from:** • acid reacts with limestone/limestone is a base/alkali • neutralises/increases pH of mine water • lead becomes less concentrated • precipitation of lead and other metals		3		3		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
		(ii)	**Either:** Preventing water from entering the vertical shafts (1) – reducing throughflow of water to be contaminated (1) **Or:** Reed beds/use of plants (1) – contaminated water passes through and vegetation takes up the heavy metals. (1) **Or:** Other reasonable suggestion up to 2 marks	2			2		
	(d)		**Any two x (1) from:** • draining slope • vegetation • reducing angle of slope/terracing • construct fences across the slope/netting/geotextiles • retaining structures e.g. gabions • prevention of erosion of the toe of the slope by the river + (2) for explanation. Max (2) for identifying strategies.	4			4		
			Question 2 total	**10**	**5**	**0**	**15**	**0**	**2**

Section B

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
3.	(a)		**Any two x (1) from:** • cross-cutting/discordant • of Carboniferous (Millstone Grit) by Permian (LML or MPM) • different strike directions • different dip angles • fault cross cuts • the Carboniferous but not Permian		2		2		
	(b)	(i)	Max vertical thickness = 1.2 cm (1) * 2500 or * 25 m or correct other method = 3,000 cm / 30 m (1)		2		2	2	2
		(ii)	**Any three x (1) from:** Shallow angle • wide outcrop • compared with narrow thickness To East • older rocks (LML and MPM) are to the west/younger rocks (UPM and SSG) are to the east • superposition - must dip East to be below UPM/beds dip towards younger rocks/UPM is to the East and MPM is to the west.		3		3		3
		(iii)	Outcrop width 900m (accept 850 - 950) (1) Sin angle dip = 30m/900m (1) allow ecf 0.033 Inverse sin = 1.9 degrees = 2 degrees (1) allow ecf		3		3	3	3
			Question 3 total	**0**	**10**	**0**	**10**	**5**	**8**

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
4.	(a)	(i)	Anticline - Oldest beds crop out in the centre (1)	1			1		
		(ii)	Plunging to NE (1) Plunge to SW (1) Closing/v shape of outcrop in the direction of plunge (1) (credit reference to pericline)		3		3		3
		(iii)	**Any one x (2) from:** Description of: • interlimb angle: open/ tight • axial plane attitude: upright, slightly inclined • axial plane trace trend: NE-SW • asymmetric: limbs of different length • antiform: beds dip away from the APT/stated directions of bed dip • accept other reasonable e.g. correct description of hinge shape, amplitude, pericline, dome, actual measurements, axis curved		2		2		2
	(b)	(i)	~490m (accept 480 – 500) (1)	1			1	1	1
		(ii)	Reverse (1) **Any one x (1) from:** • hanging wall moved up/footwall moved down • compression/crustal shortening	2			2		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		**Any three x (1) from:** • yes/probably • **both** compressional structures/sigma max horizontal/sigma max the same direction • axial plane and fault have parallel/ NE-SW orientation • However, reference to fault cutting/later than the fold			3	3		3
	(d)		**Any four x (1) from:** • more springs close to anticline axis/axial plane trace • tension joints on fold axis pathway to surface • close to Harrogate fault – associated minor faults • fractures/faults give secondary porosity/pathways to surface. • steep dip – aquifer to depth • recharge on anticline axis – highest point/water table • less steep limb = springs further away • faults bring permeable rocks adjacent to impermeable rocks			4	4		
			Question 4 total	**4**	**5**	**7**	**16**	**1**	**9**

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
5.	(a)	(i)	Ca – 30% Mg – 27% Na – 43% (1) The 3 correct calculations expressed to 2 sig figs (1)		2		2	2	2
		(ii)	Spring T correctly plotted (1)	1			1	1	1
		(iii)	Line from 50:50 (Ca:Mg) through 100% Na (1)	1			1	1	1
		(iv)	**Any two x (1) from:** • each spring shows similar 1:1 ratios • where high concentration of Na - springs close to 1:1 • where low Na/higher Ca concentration – more variable • use of numbers	2			2		
	(b)		**Any three x (1) from:** • no groundwater connection between the springs • waters from different depths. • different length of time waters are circulating allows for greater dissolving of elements • variation of chemistry of source rocks • mixing of waters – concentration/dilution of elements +1 for development Credit other sensible answers			3	3		
			Question 5 total	**6**	**2**	**3**	**9**	**4**	**4**

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
6.	(a)	(i)	**Any two x (1) from:** • in all directions/radial • 2 dominant orientations • stated - NNW-SSE (accept NW-SE and W-E) • most common is E-W	2			2		
		(ii)	**Any two x (1) from:** • subsidence orientations similar to orientation of joints • difference noted – joints N-S compared to NNW-SSE • wider variation of orientation of hollows than joints			2	2		
	(b)		**Any three x (1) from:** Western boundary • base MPM (evaporite) Eastern boundary • thicker Sherwood sandstone provides roof support • lack of caverns • gypsum is highly soluble in water • groundwater flow dissolves the gypsum/creates caverns • collapse of surface layers to fill void/reference to collapse of caverns Increase to East • dip to East – gypsum deeper • two gypsum layers (UPM and MPM) • separated by permeable limestone for groundwater flow • increased thickness of gypsum to the East • groundwater flow mainly towards the East • increased size of caverns to the East		3		3		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		**Any three x (1) from:** • same rock types present • over 4 km wide in places • same shallow dip to East • so groundwater flow is to the East • similar risks/high risk • not a risk in the far west of box A where the MPM is not below ground • not a risk in far east of box A where the SSG forms a roof rock credit other evaluative points e.g. cannot know the risk if we don't know whether caverns are present			3	3		3
			Question 6 total	**2**	**3**	**5**	**10**	**0**	**3**

Section C option 1 Quaternary Geology

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
7.	(a)	(i)	**Any two x (1) from:** • coarse grains/pebbles/quantified • angular clasts • very poorly sorted • description of orientation/alignment	2			2		2
		(ii)	**Any three x (1) from:** • Not or unlikely to be glacial/ disagree with statement • unlikely – glacial deposits are usually boulder/clay mixtures • boulders – carried; clay – eroded rock flour • glacial deposits even more poorly sorted than photo • no alignment in glacial deposits • but both glacial and these sediments angular because lack of attrition • both glacial and these sediments poorly sorted because rapid deposition • could be periglacial/scree sediment reworked **max 2 if answer does not include recognition that this is a periglacial deposit**			3	3		
	(b)		Fluvioglacial/ fluvial (1) **Any two x (1) from:** • attrition in the flow rounds the clasts • cross-bedding indicates unidirectional flow • sorting by current selecting particular clast size • fining upwards indicates migration of river channel		3		3		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		**Any three x (1) from:** • seasonal deposition/annual cycles • finer grained when lake is frozen • coarser grained when ice melts • graded bed represents one year's deposition • incremental dating • some varves may have been eroded away so complete duration cannot be determined Credit other reasonable answers			3	3		
			Question 7 total	**2**	**3**	**6**	**11**	**0**	**2**

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
8.	(a)	(i)	**Any two x (1) from:** • latitudes greater than 50° • continents • North America/Scandinavia/Antarctica	2			2		
		(ii)	**Any three x (1) from:** • isostatic readjustment • weight of continental ice depressed crust • ice melting removes load • crust not in isostatic equilibrium • flow of displaced asthenosphere/ mantle	3			3		
	(b)	(i)	$\frac{0-8.8}{2000}$ (accept use of 8.7 – 8.9) (1) -4.4×10^{-3} (accept 4.4×10^{-3} and 0.0044) (1)		2		2	2	2
		(ii)	**Any three x (1) from:** • lack of ice in this area • area was previously uplifted • asthenosphere/ mantle now flowing away from this area • pivot effect of rigid lithosphere/ crust		3		3		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		**Any three x (1) from:** • coastal sediments/raised beaches • dating of organic material • radiocarbon dating • GPS measurements • satellite remote sensing • over time/rate can be calculated + (1) for development	3			3		
			Question 8 total	**8**	**5**	**0**	**13**	**2**	**2**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
9.			**Indicative content:** Ice cores contain isotopes of oxygen that act as a proxy for climate ^{18}O is heavier than ^{16}O, ^{16}O is preferentially taken up by evaporation, ^{18}O requires more energy to evaporate. High ^{18}O: ^{16}O ratio in ice during warm periods; low ^{18}O: ^{16}O ratio in ice during cold periods Ice cores from Antarctica give continuous records over hundreds of thousands of years Ice cores can also trap atmospheric samples CO_2 composition of the atmosphere as a proxy for global temperature Can show cycles of change Correlation with other data from oceans Milankovitch cycles predicted the patterns of climatic change seen in ice core data Discussion of Milankovitch cycles Isochrons from volcanic ash layers in ice can be dated **5-6 marks:** A thorough understanding of how ice cores can provide evidence of climates during the Quaternary. Knowledge of the Milankovitch cycles and the pattern of changing Quaternary climates. Discussion of how these may be correlated so the data support the theory. *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.*	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			3-4 marks: A sound understanding of how ice cores can provide evidence of climates during the Quaternary. Some knowledge of the Milankovitch cycles and the pattern of changing Quaternary climates. Supported by limited discussion of how the ice core data can support the Milankovitch theory. Answer that is only ice core, and no Milankovitch, max = 4 marks *The candidate constructs a coherent account including many of the key elements of the indicative content and little irrelevant material. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.* **1-2 marks:** A partial understanding of how ice cores can provide evidence of climates during the Quaternary. May be some awareness of the pattern of Milankovitch cycles. Supported by generic discussion of the geological evidence. Only Milankovitch in the answer = max 2 marks *Coherence is limited by omission and/or inclusion of irrelevant material. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks:** *The candidate does not make any attempt or give an answer worthy of credit.*						
			Question 9 total	**6**	**0**	**0**	**6**	**0**	**0**

Section C Option 2 Evolution of Britain

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
10.	(a)		Circular/rounded/oval (1) Diameter 27km (accept 25-29km) (1)	2			2		
	(b)		**Any two x (1) from:** • greater gravitational field/pull/effect • higher density of gabbro than the surrounding rocks • use of exemplar values to compare densities of gabbro and surrounding rock i.e. more than one value		2		2		
	(c)	(i)	$\frac{65-42}{5}$ (credit use of 64 to 67 and 41 to 44) (1) 4.6 mGal km^{-1} (accept 4.0 – 5.2) (1)		2		2	2	2
		(ii)	**Any three x (1) from:** • presence of granite • lower density • reduced gravitational field/pull/effect • reduces the density contrast of the gabbro		3		3		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)		**Any three x (1) from:** • incorrect • too far north to be in Variscan orogenic belt • Variscan orogeny occurred before the Palaeogene • Palaeogene Igneous Province • largely mafic composition • related to opening of Atlantic • normal faults, tensional stress + 1 for development			3	3		
			Question 10 total	**2**	**7**	**3**	**12**	**2**	**2**

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
11.	(a)	(i)	Normal (1) Hanging wall downthrown/dips to downthrow side (1)	2			2		2
		(ii)	No marker bed on both sides of fault (1)		1		1		
		(iii)	**Any two x (1) from:** • large amount of throw/over 3000m • fault could not have displaced this amount in one movement • varying thickness of Cenozoic beds • different dips of Cenozoic beds compared to Jurassic and Triassic beds	2			2		
	(b)		**Any two x (1) from:** • shows rocks not exposed at surface • shows subsurface relationships • shows lateral variations • more complete/thicker sequences of rocks • reference to use of microfossils in boreholes	2			2		
	(c)		**Any two x (1) from:** • found in all three boreholes • similar ammonites found in sequence in each borehole • marine environment in Jurassic across much of Britain • ammonites are zone fossils, or a stated generic features of ammonites as zone fossils (to a max of 1 mark) allow + 1 for development	2			2		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(d)		**Any three x (1) from:** • reactivated fault created deepening basin • thicker sequence of sediments • no erosion in Mochras borehole/no gaps/complete sequence • no igneous intrusions that would metamorphose sediments			3	3		
			Question 11 total	**8**	**1**	**3**	**12**	**0**	**2**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
12.			**Indicative content:** **Magnetic data** explained; vertical at poles and horizontal at Equator Curie point - orientation of magnetic field of minerals in rocks aligned parallel to Earth's magnetic field at time of cooling Gives position of pole and angle of inclination to indicate latitude Angle of inclination changes in rocks of different ages Some sediments may show evidence of magnetisation Apparent polar wandering - determination of position of magnetic pole at time of cooling (remanent magnetism) Positions of pole relative to continent gives latitude of continent at a particular time and shows changes over time . **Sedimentary evidence** linked: deposits that are indicative of climatic zone. Desert and hypersaline deposits in Devonian and Permo/Trias. Carboniferous equatorial deposits (coal, limestones) Jurassic tropical shallow marine deposits **5-6 marks:** A thorough understanding of how paleomagnetic evidence is preserved in rocks. Knowledge of the application of magnetic data to determine past positions of latitudes using palaeomagnetic evidence. Exemplification of sedimentary environments linked to latitudinal climatic zones using the British geological record. *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.*	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			3-4 marks: A sound understanding of how palaeomagnetic evidence is preserved in rocks. Knowledge of the application of magnetic data to determine past latitudes using palaeomagnetic evidence. There may be exemplification of a sedimentary environment from the British geological record. *The candidate constructs a coherent account including many of the key elements of the indicative content and little irrelevant material. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.* **1-2 marks:** A partial understanding of how palaeomagnetic evidence is preserved in rocks. There is some awareness of the application of magnetic data to determine past latitudes using palaeomagnetic evidence. The answer may be supported by generic examples of geological evidence. *Coherence is limited by omission and/or inclusion of irrelevant material. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks:** *The candidate does not make any attempt or give an answer worthy of credit.*						
			Question 12 total	**6**	**0**	**0**	**6**	**0**	**0**

Section C Option 3 Geology of the Lithosphere

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
13.	(a)	(i)	~90kms (Accept 85 - 95) (1)	1			1	1	1
		(ii)	Distance/Time in working (1) ~ 4.5 cm yr^{-1} (credit range 4.1- 4.9) (1)		2		2	2	2
	(b)	(i)	**Any three x (1) from:** • ocean magnetometer records field reversals as an anomaly • anomalies mapped as stripes • distance from ridge to anomaly measured • compared to pattern from continental data to obtain the age • distance over time = age	3			3		
		(ii)	Explanation of the <u>radiometric dating</u> of • volcanic island chains (1) • with distance from mantle plume (hotspot) (1) Accept also: • dating of oldest ocean floor sediments/dating using microfossils (1) • and distance from ridge (1) or • radiometric dating of basalt rock samples obtained by dredging/drilling basalt cores (1) • and distance from ridge (1) or • GPS measurements (1) • measured over time (1)	2			2		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		Pacific (1) **Any three x (1) from:** • ocean basin bigger/wider in Pacific • Pacific surrounded by trenches/few in Atlantic • subduction well underway at edges of Pacific/minor in Atlantic • faster rate of seafloor spreading in Pacific - slower in Atlantic • ocean ridge is not central in Pacific/MAR is central in Atlantic/subduction of Pacific ridge		4		4		
			Question 13 total	**6**	**6**	**0**	**12**	**3**	**3**

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
14.	(a)	(i)	**Any two x (1) from:** **650ºC:** • Fracture at lower strain • Brittle • Less strain/ deformation • More stress needed to reach elastic limit • Higher compressive strength • Yield point/yield strength higher **850ºC:** Fracture at higher strain Ductile/plastic More strain/deformation Less stress to reach elastic limit Lower compressive strength Yield point/yield strength lower	2			2		
		(ii)	Line drawn from origin • above 850º C line (1) • extending further to the right than the 850º C line (1)		2		2		
	(b)		**Any three x (1) from:** • not A • although there is a thrust fault • thrust too small to be a major thrust • thrust fault plane on map is dipping in the wrong direction if looking west • the beds dip to the north on the photo and on the map/same dip direction at Location A			3	3		

Question			Marking details	Marks Available					
				AO1	AO2	AO3	Total	Maths	Prac
	(c)		**Any two x (1) from:** • sigma max is horizontal/sigma min is vertical • convergent margins – compression • folds and thrust represent crustal shortening features associated with compression	2			2		
	(d)		**Any two x (1) from:** • lower crust – hotter/more confining pressure • results in ductile deformation - folds • early orogenic deformation prior to faulting **Any two x (1) from** • uplift – cooler/less confining pressure • results in brittle fracture - thrusting (reverse faulting) • later orogenic deformation after folding (cross-cutting the folds) **To a maximum of 3 marks**			3	3		
			Question 14 total	**4**	**2**	**6**	**12**	**0**	**0**

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
15.			**Indicative content:** Seismic wave velocities depend upon density, incompressibility and rigidity. With depth, incompressibility and rigidity increase at a greater rate than the increase in density. Thus P- and S-waves speed up (refraction). Seismic waves slow/refract back towards the normal in low velocity zone (LVZ) – marking asthenosphere. Lithosphere/asthenosphere boundary defined in terms of rock strength at the 1300ºC isotherm. **5-6 marks:** A thorough understanding of the factors affecting seismic wave velocities relating to density and elastic properties, and their changes through the lithosphere and asthenosphere (LVZ) leading to slowing/refracting of waves. An appreciation of the distinction between lithosphere and asthenosphere is shown (e.g. rock strength, temperature, seismic properties). *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.*	6			6		

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
			3-4 marks: A sound understanding of the reduced seismic velocities and wave refraction in the LVZ and how these relate to the elastic properties of the mantle. Some reference to the distinction between lithosphere and asthenosphere is shown (e.g. rock strength, temperature, seismic properties). *The candidate constructs a coherent account including many of the key elements of the indicative content and little irrelevant material. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.* **1-2 marks:** A partial understanding of the reduced velocities of seismic waves in the LVZ with limited links to wave refraction. Simplified understanding of how earthquake velocities relate to mantle properties. Some reference to the difference between the lithosphere and asthenosphere. *Coherence is limited by omission and/or inclusion of irrelevant material. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks:** *The candidate does not make any attempt or give an answer worthy of credit.*						
			Question 15 total	**6**	**0**	**0**	**6**	**0**	**0**