GCE

Geology

H414/01: Fundamentals of 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
~~	Wavy underlined words must be present or similar-meaning 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

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
1	B - gabbro	1	
2	B - 3	1	
3	B - 3780 Ma	1	
4	A – ^{14}C	1	
5	D – imbricate structure	1	
6	D - confined	1	
7	A - aquiclude	1	
8	D - Zinc	1	
9	C - Water	1	
10	D - sands	1	
11	C - Hematite	1	
12	C – Kimmeridge clay	1	
13	C – Lower Palaeozoic	1	
14	B - Devonian	1	
15	C – Shoulder girdle	1	
16	C – 100 mm	1	
17	A – Expels water when heated	1	
18	B – 5%	1	
19	C - **…….**	1	
20	B – There are two intrusions present	1	
21	D – Dip-slip thrust	1	
22	A – Oil shale drilling	1	
23	B – 11.9 years	1	
24	A – Poorly sorted and angular grains	1	
25	A – Connate water	1	

Question			Answer	Mark	Guidance
26	(a)	(i)	labelled diagram to have silicon to oxygen ratio of 1:4 ✓ shows single tetrahedra bonded to cations ✓	1 max	**ALLOW** labelled drawing of single silica tetrahedron
		(ii)	A – pyroxenes **AND** B – amphiboles ✓	1	**ALLOW** correctly named pyroxenes and amphiboles **ALLOW** augite and hornblende
		(iii)	cleavage occurs due to the weaker bonds between chains ✓ A and B / single and double chains have a different shape / unit cell proportions thus cleavages will be present at different angles ✓ pyroxenes – weaker bonds between the chains that result in two cleavage directions, roughly 90^0 ✓ pyroxenes are single narrow chains hence 90^0 , amphiboles – cleavage develops where bonding is weaker between the chains/ two cleavages almost at $60^0/120^0$ ✓ amphiboles are double chains hence $60^0/120^0$ ✓	1 max	

	(b)	**(i)**	*Answers indicated in columns* ***Classification*** Siderophile ✓ Atmophile ✓ ***Description*** combine readily with oxygen / commonly form oxides **OR** form low density compounds which remain near Earth's surface / lithosphere / crust ✓ elements which combine more readily with sulfur / form higher density sulphides **OR** form high density compounds which occur deeper than lithophiles / not as deep as siderophiles **OR** form high density compounds which occur in the mantle ✓	4	**DO NOT ALLOW** "rock loving"
	(b)	**(ii)**	early Earth was differentiated / proto-Earth as loose collection of all possible elements ✓ some of which reacted with each other to form compounds such as oxides and sulphides ✓ differentiation by gravity occurred ✓ denser compounds moved inwards towards the centre of mass / core ✓ lighter compounds displace outwards to form the surrounding mantle / crust ✓	2 max	**ALLOW** 1 mark; if discussion of at least **TWO** of the named zones of the Earth where they occur; atomophile = atmosphere / oceans lithophile =crust chalcophile =mantle siderophile = core
			Total	**9**	

Question			Answer	Mark	Guidance
27	(a)	(i)	X – Sedimentary (rock) **AND** Y – Igneous (rock) ✓ **AND** Z – Metamorphic (rock)	1	**ALLOW** magma **OR** intrusive igneous rocks
		(ii)	burial recrystallisation crystallisation diagenesis ✓✓	2 max	1-3 correct for 1 mark 4 correct for 2 marks
	(b)		rate of change = 5.0 ✓ ^{0}C km^{-1} ✓	2	**Correct answer = 2 marks** even if no working shown **ALLOW** ^{0}C/km **ALLOW** +/- 0.5 ^{0}C km^{-1} **If answer is incorrect,** then **award 1 mark** for: depth difference / temperature difference (even if incorrectly read off graph) depth 30km – 10 km = 20 km temperature 700 – 600 = 100^{0}C 100/20 = 5.0
	(c)	(i)	*Description* the continuous reaction series explains the crystallisation of plagioclase feldspars ✓ anorthite / An / Ca Plagioclase forms at high temperature **AND** albite/ Ab / Na Plagioclase forms at low temperatures ✓ *Explanation* calcium-rich plagioclase is stable at high temperatures, but as cooling continues it reacts with the melt✓ early formed plagioclase reacts with the melt to form more sodium-rich crystals as temperature decreases ✓	max 3	**ALLOW** two descriptions and one explanation for maximum marks **ALLOW** annotations / explanations on the diagram – mark as text

			ALTERNATIVE ANSWER 1) magma cools 2) reaches liquidus 3) first crystals form (An/Ca rich) 4) magma becomes albite / Ab / Na rich 5) magma cools along liquidus 6) crystals react / change to be more Albite / Ab / less Anorthite / An rich 7) last crystals have same composition as starting melt **OR** overall solid has same composition as starting melt		2 correct = 1 mark 3 or 4 correct = 2 marks 5 or more correct = 3 marks
		(ii)	80% An 20% Ab ✓	1	**ALLOW** 75 – 85% An **OR** 25 – 15% Ab
		(iii)	zoned crystal drawn and labelled with at least two different correct compositions ✓ Ca rich forms first / at centre at high temperatures ✓ Na rich forms last/ at edge/ rim at lower temperatures ✓ fast / quick cooling prevents equilibration / reactions ✓	3	Max 2 if no diagram Max 1 if centre is Ca-rich **AND** rim is Na-rich is written but no diagram
			Total	**12**	

Question			Answer	Mark	Guidance
28	(a)	(i)	orthoquartzite ✓ >90% quartz / quartz rich / mature ✓ well sorted **AND** well rounded ✓ average grains 0.0625 – 2 mm ✓	2 max	**DO NOT ALLOW** desert sandstone **OR** quartzite **ACCEPT** monomineralic Max 1 if rock incorrect **ACCEPT** any grain size within 0.0625 – 2mm range **ACCEPT** arenaceous
		(ii)	16% / 0.16 ✓	1	**ALLOW** 15.6% / 0.156
		(iii)	greywacke ✓ **description;** fine to coarse grain sizes poorly sorted angular / sub angular / sub rounded grains / fragments poly-mineralic **OR** quartz, mica and rock fragments more than 15% clay matrix / clay rich matrix / matrix supported / (compositionally / texturally) immature ✓ **environment of deposition;** continental slope / at the base of continental slope / alluvial fan / wadi **OR** as a turbidite deposit / by a turbidity current / submarine fan ✓	3	Max 2 if environment of deposition not given
		(iv)	recognisable desert sandstone drawn with correct scale ✓ Iron oxide / hematite coating the quartz grains / cement quartz grains (compositionally / texturally) mature (very) well sorted (very) well rounded fine sand sized / <1 mm grains high sphericity **OR** millet seed frosted grains ✓✓	3	Mark annotations as text
			Total	**9**	

Question			Answer	Mark	Guidance
29	(a)	(i)	triple point labelled where three fields intersect on chart ✓	1	
		(ii)	kyanite **AND** andalusite **AND** sillimanite labelled in correct fields ✓	1	
		(iii)	kyanite ✓	1	**ALLOW** ecf from (a) (ii)
		(iv)	contact metamorphism - **C** **AND** regional metamorphism – **B** ✓	1	
		(v)	**Mineralogy** low grade / greenschist / low P/T / slate / phyllites forms chlorite / muscovite/ biotite / mica ✓ medium grade/ greenschist / amphibolite / blue schist / medium P/T schist forms muscovite / biotite / garnet/ kyanite ✓ high grade / amphibolite / high P/T / gneiss forms sillimanite / quartz / feldspar ✓ **texture** low grade / greenschist / low P/T / slate/phyllites forms slaty cleavage / crenulation cleavage ✓ medium grade/ greenschist / amphibolite / blue schist / medium P/T schist forms schistosity / porphyroblastic texture✓ high grade / amphibolite / high P/T / gneiss forms gneissosity / gneissose banding ✓ general trend from microscopic crystal size in slates through to coarse crystals in gneiss ✓ general trend from planar foliation (slate) to wavy banding in gneiss ✓	4 max	**ALLOW** ecf from (a) (ii) Max 3 if only mineralogy or texture are described

		(vi)	**Prograde** metamorphism / recrystallisation of a rock due to increase in the intensity / increasing grade / of metamorphism/ increase in temperature and or pressure ✓ H_2O / CO_2 are driven off ✓ **Retrograde** metamorphism / recrystallisation due to decrease in the intensity / decreasing grade / of metamorphism / decrease in temperature and or pressure ✓ the hydration / carbonation and oxidation as the rocks are returned to the surface ✓ chemical reactions take place more slowly as temperature is decreased ✓	2 max	**ALLOW** metamorphosing a higher grade rock to allow minerals to form that are stable in a low grade rock
			Total	**10**	

Question			Answer	Mark	Guidance
30	(a)	(i)	**Level 3 5 – 6 marks** Deals with preservation potential using a logical sequence of headings / paragraphs. Each factor must explain the mechanisms by which preservation potential is affected. Most factors are explained. *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** Preservation is addressed under a series of 'headings' but not all 'headings' are covered. Some explanations are 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** Some of the factors affecting preservation are presented but without showing clear understanding of the mechanisms involved *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	May include: a short reference to exceptional preservation; compaction causes fossils to be flattened; diagenesis may dissolve the fossil or replace it with another mineral; size of sediment will determine preservation with fine sediment being better as oxygen is excluded and detail preserved; the presence of oxygen accelerates bacterial decay and encourages scavengers low pH / acidic / high pH / alkaline / hypersaline restricts bacterial decay and discourages scavengers fast burial increases chance of whole body fossils being preserved; distance transported / amount of erosion as fossils are fragmented during transportation / erosion; high energy produces lots of fragments due to collisions low energy produces more complete fossils due to lack of water movement; hard parts made of silica may be preserved unaltered aragonite can be easily altered from the original composition, calcite is readily soluble in ground water; metamorphism / recrystalisation / melting can destroy the fossil;
		(ii)	accurately labelled diagram of mould and cast ✓	3	**ALLOW** description of casts and moulds forming trace

			(external) mould is where fossils are dissolved out of the rock they are in leaving a void / impression in sediment ✓ (internal) mould can occur if the shell buried whole and soft tissues decay leaving an internal void / or sediment infilling giving impressions of internal features ✓ void infilled with another mineral to form cast (e.g. calcite or quartz) ✓		fossils such as footprints **DO NOT ALLOW** replacement
			Total	**9**	

Question			Answer	Mark	Guidance
31	(a)	(i)	Mesozoic **AND** Quaternary ✓	1	**BOTH** correct for one mark
		(ii)	benthonic large living on or just above the sediment **AND** nektonic small in size as find it easier to swim in the water column ✓ benthonic not very streamlined **AND** nektonic streamlined as streamlining needed for strong swimming ✓ benthonic have eyes on top of cephalon to see above, in front and around / 360° AND Nektonic have eyes on stalks / complex eyes to see in front and below✓ benthonic many pleura / many legs for walking **AND** nektonic may have fewer legs as they swim in the water column ✓ benthonic did not have separated pleura **AND** nektonic had separated pleura to aid buoyancy / surface area discussed ✓ benthonic lacked an inflated glabella **AND** nektonic may have had these for buoyancy ✓	3 max	Both benthonic and nektonic points discussed for one mark, comparing each morphological feature **ORA**
	(b)		geographically widespread so it can be found in a variety of locations / geographically widespread as nektonic✓ abundant so good chance of being found ✓ fossils made of hard parts so will fossilise ✓ distinctive morphology so easy to identify ✓ rapid evolution so defines narrow time zones / short stratigraphic range ✓	2 max	**ALLOW** one mark for two descriptions but no explanations

	(c)		macrofossils easier to observe in hand specimens / microfossils harder to see and identify ✓ macrofossils relatively rare / microfossils more common✓ macrofossils may not be whole / microfossils preserved whole in rock cuttings / more abundant in rock chippings ✓ microfossils good for the oil industry / drilling ✓	2 max	
			Total	**8**	

Question			Answer	Mark	Guidance
32	(a)	(i)	marks a zone where seismic waves slow down ✓ rocks lose rigidity because of an increase in temperature ✓ the zone is rheid / plastic / flows / ductile ✓ made of peridotite / ultramafic ✓ (5%) partially molten ✓	1 max	**DO NOT ALLOW** semi molten
		(ii)	iron-nickel composition / siderophiles ✓ outer core is liquid (with reduced rigidity) ✓ S waves do not travel through outer core ✓ outer core has zero rigidity ✓ P waves slow down / refract ✓ has convection currents ✓ (geo) magnetic field is generated there ✓ between 2900km and 5100km ✓	2 max	
		(iii)	**Level 3 5 – 6 marks** The development of the present Solar System is described in order with explanations of the mechanisms responsible *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 development is described in order but there may be some omissions / errors. Some mechanisms are provided. *There is a line of reasoning with some structure. The information presented is relevant and supported by some evidence.*	6	May include: approx 4.57 billion years ago solar system formed giant cloud (nebula) of molecular hydrogen and dust collapses nebula possibly hit by shockwave of supernova event nebula of molecular hydrogen and dust collapses and becomes denser cloud decreases in size, rate of rotation increases flattens out into a protoplanetary disc (denser) material drawn towards the centre due to gravity nuclear fusion is triggered in the sun accretion of dust / rock planetesimals form planetesimals form protoplanets protoplanets nearest centre collide / accrete and form terrestrial planets gas / volatiles / lighter elements form gas giants further form the sun asteroid belt forms due to failed planet / exploded

			Level 1 1 – 2 marks The development is described in a few stages but little evidence of understanding is provided. *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**.		planet
			Total	**9**	

Question			Answer	Mark	Guidance
33	(a)	(i)	3.94 +/- 0.20 cm/a **OR** 39.4 +/- 2.0 km Ma^{-1} ✓✓	2	**Correct answer = 2 marks** even if no working shown **ALLOW** 0.039 m/a **ALLOW** correct calculations where these have been indicated on the map. **ALLOW** km/Ma **ALLOW** calculation in cm/a or km/year if unit correct ALLOW 0.000039 +/- 0.000002 **OR** 3.8 x 10^{-5} km/year **If answer is incorrect,** then **award 1 mark** for: (measured distance/length of scale) x 100km = actual distance (24mm/21mm) x 100 Actual distance / difference in age 114.286 / (14.5 - 11.6)
		(ii)	*Description* mantle plume stationary column of high heat flow / hotspot is a surface expression of a mantle plume ✓ *Explain* plate movement over stationary plume / hotspot ✓ volcanic activity produces islands above hotspot ✓ oldest islands furthest from the plume / youngest over hotspot / plume ✓	2	max one mark if no explanation
		(iii)	crystals formed in lava align in the direction of lava flow ✓	1	
		(iv)	major intrusions cool slowly leading to a range of ages ✓ margins cool before interior of major intrusions ✓ decay products (gas) may leave the rock leading to a younger age ✓ weathering / erosion breaks the closed system ✓ metamorphism resets the age✓	1	
			Total	**6**	

Question			Answer	Mark	Guidance
34	(a)	(i)	graph B ✓	1	
		(ii)	compression gives rise to folding / reverse faults / thrusts ✓ shear gives rise to strike-slip faulting / transform faulting ✓ tension gives rise to normal faulting ✓ joints arise from shear / tensional forces ✓	2 max	**ALLOW** any named fold or fault structure **ALLOW** any appropriate normal fault structure
		(iii)	change in length/original length 0.10 to 0.20 **OR** change in width/original width 0.44 to 0.54 ✓✓ (width before – width after) / width before = strain	2	**ALLOW** percentage 10-20% **OR** 44-54% **If answer is incorrect,** then **award 1 mark** for: change in length/original length **OR** change in width/original width change in length calculation original 4.6cm new is 5.2cm, 5.2 – 4.6 = 0.6/4.6 = 0.13 change in width calculation original 4.8cm new 2.5cm, 4.8 – 2.5 = 2.3/4.8 = 0.48
			Total	**5**	

Question			Answer	Mark	Guidance
35	(a)	(i)	whether the area is tectonically stable / no active faulting ✓ area free from natural hazards ✓ there is a low water table / water table is below the mine ✓ impermeable rock / salt means no groundwater ✓ salt is a good conductor of heat **OR** salt is dry✓ rock above is strong enough to prevent collapse ✓	2 max	
		(ii)	acid mine drainage ✓ mining operations break up rocks ✓ mining operations disturb ground water ✓ create voids for ground water to fill and introduce oxygen ✓ water reacts with sulphides to produce acid / metals in solution ✓ toxic metals / lead / mercury / arsenic / iron / heavy metals leached ✓ contamination from mining equipment ✓	2 max	
		(iii)	dewatering / draining / pumping the mine ✓ abandoned mine could be flooded and sealed ✓ neutralise the acidity / run over crushed limestone / adding bases to neutralise Acid Mine Drainage and precipitate metal salts ✓ precipitate the metals as non-toxic salts which can be disposed of correctly ✓ natural / constructed / human made wetland ecosystems ✓ use of tailings ponds to contain contaminants ✓	2 max	
		(iv)	1.6×10^7 **OR** 16000000 ✓✓	2	**ALLOW** 16425000 **OR** 1.6425×10^7 **ALLOW** one mark for evidence of correct method or ecf
			Total	**8**	

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