OCR
Oxford Cambridge and RSA

GCE

Geology

Unit **F794:** Environmental Geology

Advanced GCE

Mark Scheme for June 2018

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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
	Unclear
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
I	Ignore
NBOD	Benefit of doubt not given
PD	Poor Diagram
R	Reject
SEEN	Point has been noted, but no credit has been given
	Correct response
^	Omission mark
MR	Maximum (marks available for) Response

Subject Specific Marking Instructions

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

Question			Answer	Mark	Guidance
1	(a)	(i)	**ANY TWO** from: **faulting:** underlying faults displace the coal seams causing disruption to production **OR** weight of machinery / vibrations could cause underlying faults to reactivate / seismic activity **OR** underlying faults could reactivate causing movement / seismic activity **OR** reactivation / movement along the underlying faults could lead to collapse of quarry sides; **poorly cemented sandstones:** are porous / permeable allowing flooding of the quarry **OR** poorly cemented sandstones are weak leading to collapse of quarry sides **OR** poorly cemented sandstones are unable to take the weight of heavy machinery ; **dipping OR tilted beds / seams / strata:** coal mining machinery is designed to work horizontally and cannot cope with dipping beds / seams / strata **OR** will affect stability of quarry sides ;	2	**DO NOT ALLOW** descriptions of geological problems not shown on cross-section **MAX 1** for two correct geological problems without descriptions **DO NOT ALLOW** descriptions of environmental problems **MUST** be geological **MUST** describe specific mining problem for fault reactivation or movement – **MUST** either describe the cause **OR** the consequence
		(ii)	**ANY FOUR** correct statements for **2 MARKS** from: • the shaft is used for access **OR** coal is hoisted up the shaft ; • (horizontal) roadways / tunnels are driven out (from the shaft) ; • a ventilation shaft is constructed **OR** ventilation is used to avoid gas / methane build up ; • the roof is supported by hydraulic supports / steel supports / chocks / props **OR** the roof supports are mobile / can be moved (after the coal is cut) ; • a coal face / longwall is established between the roadways ; • the coal is cut with a (mechanical) cutter / shearer ; • the coal falls onto / is transported by a conveyor belt ; • the mined-out area / goaf is allowed to collapse ; • mining takes places backwards / retreating (towards the shaft) ; • this allows geological conditions / presence of faults to be assessed in advance ;	2	**ANY TWO** correct statements for **EACH MARK** **MUST** describe **ALLOW** any correct alternative word for movement

Question			Answer	Mark	Guidance
1	(a)	(iii)	**ANY TWO** explanations from: • opencast mining is cheaper as it requires a smaller workforce **OR** wages are lower ; • opencast mining has less health and safety requirements **OR** flooding is less of a problem **OR** (roof) collapse is less likely in opencast mining **OR** roof supports are not needed in opencast mining **OR** subsidence is unlikely to happen in opencast mining **OR** specific safety detail given ; • opencast mining requires less high tech equipment **OR** opencast machines are larger so can remove coal more quickly **OR** open cast mining has higher rates of coal production ; • opencast mining has lower set up costs **AND** specific detail given, e.g. no shafts required ; • opencast mining has no requirement for ventilation **OR** opencast mining is less affected by methane ; • opencast methods can extract thinner seams than underground methods **OR** more of the coal can be extracted using opencast methods **OR** lower rank coal can be mined at a profit from opencast mines ; • opencast mining is less affected by seam splitting **OR** opencast mining is less affected by steeply dipping (coal) seams **OR** opencast mining is less affected by washouts ;	2	**MUST** explain **MUST** qualify ease **OR** cost **OR** safety **OR** rate of production statements with explanations **ALLOW ORA** **ALLOW** less specialised equipment as alternative to less high tech equipment
	(b)	(i)	(rain) water percolating through the waste dissolves soluble chemicals / toxins / elements / metals **OR** (rain) water percolating through the waste collects microbial contaminants **OR** (rain) water percolating through the waste produces <u>leachate</u> **OR** <u>leachate</u> may be toxic **OR** <u>leachate</u> may contaminate / pollute groundwater ;	1	**DO NOT ALLOW** discussion of acid mine drainage water
			rocks / sandstones underlying the landfill site are permeable / jointed / faulted and will allow downwards migration of the leachate / contaminates / pollutants in groundwater **OR** the dip of the underlying rocks will allow lateral migration of leachate / contaminants / pollution in groundwater **OR** a plume of pollution will spread out laterally in response to groundwater flow ;	1	**DO NOT ALLOW** discussion of porosity rather than permeability if movement of fluids is not described

Question			Answer	Mark	Guidance
1	(b)	(ii)	**ANY ONE** description for **1 MARK AND** matching explanation for **1 MARK** from: **description 1:** methane (gas) ; **explanation 1:** methane is highly flammable / explosive **OR** is a greenhouse gas / causes global warming **OR** is produced by bacteria / microorganisms **OR** is produced as waste decays / decomposes ; **description 2:** soil contamination / soil pollution **OR** toxic / poisonous / hazardous soil ; **explanation 2:** due to leachate / chemicals / elements / metals from the waste ; **description 3:** subsidence / settlement ; **explanation 3:** makes site unstable **OR** causes fissures to open allowing (rain) water in **OR** allows harmful substances to escape **OR** occurs as waste decays / decomposes / settles ;	**2**	explanation **MUST** match description
	(c)		the limestone quarry is evaluated **AND** **ANY TWO** reasons from: • not suitable as limestone is permeable allowing escape of fluids / leachate **OR** fluids / leachate will migrate along joints / bedding planes ; • not suitable as the limestone is dipping so fluids / leachate will migrate down dip / to the north ; • not suitable as limestone is chemically reactive **OR** limestone will be dissolved by acid fluids / acid leachate ; • suitable if the limestone quarry is lined with impermeable clay / plastic / geomembrane **OR** grouted before use **OR** other correct named ground improvement strategy used ; • suitable as there are no underlying faults ; • suitable as limestone is strong / competent / has a high load	**2**	**MAX 1** if no statement of suitability **DO NOT ALLOW** discussion of porosity rather than permeability if movement of fluids is not described

Question			Answer	Mark	Guidance
			bearing capacity **OR** the beds are dipping away from the quarry on the north side so stable ;		
1	(d)		**ANY TWO** from: • opencast pit is backfilled with <u>overburden</u> **OR** material from <u>spoil heaps</u> ; • area is covered with top soil and seeded with grass **OR** any contaminated soil is removed **OR** trees are replanted **OR** features such as hedges / fences / ditches are replaced **OR** wildlife is introduced to increase biodiversity ; • acid mine drainage water is treated **OR** reed beds are planted to remove pollutants from water **OR** active chemical treatment is used **OR** drainage systems are put into place ; • slopes are re-contoured to a lower / stable angle ; • land can be returned to agricultural use / grazing **OR** land can be used for industrial development **OR** land can be used for recreation / leisure facilities / country park / nature reserve / golf course / sports field / artificial lake ;	**2**	**MUST** describe human intervention
			Total	**14**	

Question			Answer	Mark	Guidance
2	(a)	(i)	crushed rock aggregate bars drawn: South West England 21.4 (x 10^6 tonnes) South East England 2.4 (x 10^6 tonnes) Midlands 27.6 (x 10^6 tonnes) Northern England 19.1 (x 10^6 tonnes) Wales 12.0 (x 10^6 tonnes)	2	3 **OR** 4 bars plotted correctly = **1 mark** all 5 bars plotted correctly = **2 marks** **DO NOT ALLOW** if first three bars are drawn on grid lines **ALLOW** bars of any width **ALLOW** bars plotted above / on top of the sand and gravel bars
		(ii)	**description:** **ANY ONE** from: • all the regions except South East England produce more crushed rock aggregate than sand and gravel ; • South East England is the only region that produces more sand and gravel than crushed rock aggregate ; • Midlands produced the most crushed rock aggregate ; • South East England produced the most sand and gravel ; **explanation:** **ANY TWO** from: • South West England / Midlands / Northern England / Wales **OR** North and West Britain **OR** everywhere except South East England are underlain mainly by igneous rocks / metamorphic rocks / crystalline rocks / hard rocks ; • less igneous rocks / metamorphic rocks / crystalline rocks / hard rocks are found in South East England ; • Quaternary / Recent / young / river (sands and gravels) / glacial meltwater (sands and gravels) / outwash (sands and gravels) are found mainly in South East England (and the Midlands) **OR** South East England (and the Midlands) has a high proportion of unconsolidated sedimentary rocks ; • less Quaternary / Recent / young / river (sands and gravels) / glacial meltwater (sands and gravels) / outwash (sands and gravels) / unconsolidated sedimentary rocks are found in South West England / Midlands / Northern England / Wales **OR** North and West Britain **OR** anywhere except South East England ;	1 2	description **MUST** contain a comparison of regions **ALLOW** any correct comparison of regions **ALLOW** limestone as a source used for crushed rock aggregate from any of the regions **DO NOT ALLOW** an explanation that the South East has more sand and gravel without information about the source of the sand and gravel

Question			Answer	Mark	Guidance
2	(a)	(iii)	14.0 / 54.5 x 100 = <u>25.69</u> **OR** <u>25.7</u> **OR** <u>26</u> %	1	**DO NOT ALLOW** rounding errors
		(iv)	**QWC mark** for correct use and spelling of **<u>dredging / dredged / dredger</u>** as the technical term ;	1	
		(v)	**ANY TWO** from: stirred up silt **OR** suspended sediment **OR** increased turbidity of water **OR** release of contaminants **OR** fuel / oil spills **AND** damages / disturbs / disrupts marine ecosystems **OR** decreases water quality **OR** settles out and smothers benthonic / epifaunal life on sea bed / any correct named species **OR** prevents <u>photosynthesis</u> ; scraping / damaging / destruction of sea bed **AND** harms / disturbs benthonic / epifaunal / infaunal marine life / any correct named benthonic species **OR** causes loss of habitat / biodiversity of benthonic / epifaunal / infaunal marine species ; alters shape of sea bed **AND** changes patterns of water currents **OR** changes wave patterns **OR** changes direction of sediment transport / movement ; changes patterns of water currents **OR** changes wave patterns **OR** changes direction of sediment transport / movement **OR** removes sediment **AND** can increase (coastal) erosion **OR** can affect coastal habitats / any correct named coastal habitat, e.g. estuary / beach ;	2	each marking point **MUST** contain a description **AND** a matching explanation **MUST** be specific to extraction of marine aggregates – **NOT** general discussion of environmental consequences of mining **ALLOW** noise pollution affecting correct specified marine organism **MUST** refer to marine organisms

Question			Answer	Mark	Guidance
2	(b)	(i)	**ANY ONE** form: rock / material needed for construction can be transported by boat / ship **OR** is easily accessible by boat / ship **OR** rocks used for construction are expensive to transport by road / rail **OR** super-quarries are often located in remote / mountainous areas so transport by boat / ship is the only feasible method ;	1	
		(ii)	**ANY ONE** from: • often situated in areas of outstanding natural scenery / covers large area **AND** causes landscape degradation / destruction of habitats / loss of biodiversity / site is too large to be restored after quarrying ceases ; • noise / dust **AND** produced by heavy / large machinery / large equipment **OR** dump trucks **OR** drilling **OR** blasting ; • surface water pollution **AND** caused by chemical spills / oil spills / dust / crushed rock particles ;	1	**ALLOW AW** to large / extensive but must include idea of large scale
			Total	11	

Question			Answer	Mark	Guidance
3	(a)	(i)	90 m = 9000 cm / 120 years = 75 cm / year **ALLOW** between 70 and 80 cm / year ;	1	
		(ii)	247 m = 24700 cm / 75 **OR** 247 m / 0.75 329.3 years **ALLOW** between 315 and 350 years	1	**ALLOW ECF** from **3 (a) (i)** **ALLOW** some tolerance on distance measurement if **ECF**
	(b)	(i)	the gneiss is evaluated **AND** **ANY TWO** reasons from: • suitable as gneiss is crystalline **OR** made of interlocking crystals **OR** gneiss is strong / competent ; • suitable as gneiss is made of hard minerals **OR** hard quartz **OR** hard feldspar **OR** gneiss is resistant to abrasion / attrition **OR** gneiss is physically resistant ; • suitable as gneiss does not have cleavage **OR** bedding ; • not suitable as gneissose banding / foliation are planes of weakness **OR** reduce strength ; • not suitable as gneiss contains feldspar which undergoes hydrolysis ;	2	**MAX 1** if no statement of suitability **ALLOW ANY** other correct named hard mineral found in gneiss **IGNORE** mica / biotite
		(ii)	**ANY ONE** from: rip rap would absorb / dissipate / reduce wave energy **OR** rip rap acts as a barrier to the waves **OR** waves would break on the rip rap rather than the beach **OR** rip rap would trap sediment to build up the beach ;	1	
		(iii)	**ANY ONE** from: unattractive appearance **OR** imported rip rap not in keeping with area **OR** may make access to the beach difficult **OR** are dangerous to walk on **OR** may get increased erosion at either end of the revetment **OR** may get increased erosion further along the coast **OR** disturbs / damages / destroys habitats on beach ;	1	**MUST** describe environmental problem specific to rip rap revetments **ALLOW** CO_2 emissions **OR** other correct environmental consequence of placing rip rap on site **DO NOT ALLOW** discussion of excavation or transport of rip rap

Question			Answer	Mark	Guidance
3	(b)	(iv)	**ANY TWO** descriptions **AND** matching explanations from: **description 1:** groynes – made of wood / blocks of rock **OR** groynes extend out at 90° / perpendicular to coast / at high angle to coast **AND** **explanation 1:** prevent loss of sediment by longshore drift **OR** allow sediment build up on up drift side **OR** trap sediment to build up beach ; **description 2:** beach nourishment / replenishment **OR** imported sand **OR** moving sand onto beach **AND** **explanation 2:** builds up the level of the beach **OR** replaces material transported away **OR** reduces removal of sediment by wave action ; **description 3:** sea wall / retaining wall – made of concrete / stone **OR** has vertical / sloping / curved walls **OR** bank – made of clay / gravel **AND** **explanation 3:** (hard surface) reflects wave energy **OR** absorbs / dissipates wave energy **OR** protects the beach from wave action ; **description 4:** gabions / artificial reefs / off shore breakwaters – cages of rock **OR** can be offshore **OR** are parallel to coast **AND** **explanation 4:** reduce erosion from wave action **OR** are effective at absorbing wave energy **OR** protect the beach from wave action ;	**2**	each marking point **MUST** contain a description **AND** a matching explanation **MAX 1** for correct descriptions of two methods with no explanations **MAX 1** for correct explanations of two methods with no descriptions **DO NOT ALLOW** protect beach from erosion with no qualification as erosion is given in question
			Total	**8**	

Question			Answer	Mark	Guidance
4	(a)		a useful / valuable material ;	1	**ALLOW AW** for material
	(b)	(i)	**supply:** **ANY ONE** from: determined by available reserves of the metallic mineral **OR** extraction leads to depletion / less available **OR** the cut-off grade determines how much is economic to mine **OR** exploration can increase reserves / supply **OR** may be limited by the mining / mineral processing techniques that can be used to extract the metallic mineral **OR** improved mining / mineral processing techniques increase reserves / supply **OR** may be limited by political interference in countries where the metallic minerals are found, e.g. environmental law, mineral rights / land ownership / access regulations, stockpiling of strategic metallic minerals ; **demand:** **ANY ONE** from: determined by how useful / valuable the metallic mineral is **OR** determined by how much people need to maintain their standard of living **OR** determined by population growth / new technologies increasing demand ; **OR** new materials can replace the need for metals reducing demand ;	1 1	**ALLOW AW** **ALLOW** implicit discussion of supply and demand **MAX 1** if factors are the wrong way round

Question			Answer	Mark	Guidance
4	(b)	(ii)	**ANY TWO** from: metals are non-renewable resources **OR** they are finite **OR** geological processes that form metal deposits are very slow / take millions of years **OR** metals are not replaced within human timescale ; the rate of extraction exceeds the rate of renewal **OR** the rate of extraction cannot continue into the future **OR** there will be nothing left for future generations **OR** demand for (rare / precious) metals (for new technologies) is outstripping their reserves / supply ; not all the metal present can be extracted at a profit **OR** not all the metal present can be extracted using existing technology ; high grade deposits are being worked out **OR** only low grade deposits remain **OR** costs remain the same regardless of the grade of the ore being extracted ; environmental damage / pollution is too great / irreversible ; it is not always feasible to recycle metals ;	2	**ALLOW AW** for metal e.g. ore, mineral **ALLOW** thousands of years

Question			Answer	Mark	Guidance
4	(c)		**ore:** a rock containing valuable metal(s) / ore mineral(s) **OR** (a rock that is) a mixture of ore minerals and gangue minerals ; **ore mineral:** a mineral containing valuable metal(s) **OR** a naturally occurring compound or element containing valuable metal(s) **OR** a mineral that contains enough metal(s) to make it economically feasible to extract **OR** a mineral that contains metal(s) that can be extracted at a profit **AND** a correct named example of an ore mineral, e.g. magnetite / cassiterite / galena / sphalerite / chalcopyrite / gold ; **gangue mineral:** a waste **OR** worthless **OR** low value mineral / material **AND** a correct named example of a gangue mineral, e.g. quartz / calcite / pyrite ;	**1** **1** **1**	**ALLOW 1 MARK for** correct definitions of ore mineral **AND** gangue mineral if no correct named minerals are given **ALLOW 1 MARK** for one correct named ore mineral **AND** one correct named gangue mineral if definitions of ore mineral and gangue mineral are incorrect **ALLOW ANY** correct named ore mineral **OR** diamonds **DO NOT ALLOW** rock names **DO NOT ALLOW** metal names unless the metal can be found in its native state **ALLOW ANY** correct named gangue mineral **DO NOT ALLOW** rock names
	(d)	(i)	**QWC mark** for correct use and spelling of **hydrothermal** as the technical term ; **ANY TWO** from: minerals crystallise / precipitate in order of temperature **OR** minerals crystallise / precipitate in order of solubility ; at point **D** high temperature minerals form **OR** least soluble minerals form **OR** minerals at **D** crystallise / precipitate first **OR** cassiterite forms first **OR** cassiterite forms closest to intrusion ; at point **E** low temperature minerals form **OR** most soluble minerals form **OR** minerals at **E** crystallise / precipitate last **OR** galena / sphalerite form last **OR** galena / sphalerite form furthest from intrusion ;	**1** **2**	**DO NOT ALLOW** are deposited **DO NOT ALLOW** discussion of melting point or density

Question			Answer	Mark	Guidance
4	(d)	(ii)	anticline / antiform **AND** symmetrical **OR** is plunging **OR** fold axial plane trace trends NE-SW ;	1	
		(iii)	**description:** veins are parallel to fold axial plane (trace) **OR** veins are on the crest / on the hinge / in the core of the anticline / antiform / fold **OR** the veins have formed along <u>tension</u> joints ; **explanation:** the joints resulted from stretching / tension on the top surface of the anticline / antiform **OR** the joints resulted from stretching / tension during folding **OR** the joints are zones of permeability **OR** the hydrothermal fluid has moved along joints **OR** as hydrothermal fluid moved along joints it cooled / expanded / reacted with the country rock causing the minerals to crystallise / precipitate out ;	1 1	
	(e)	(i)	geological situation / structure that concentrates oil / gas / petroleum in one place ;	1	**ALLOW AW** **MUST** include idea of concentration in one place **DO NOT ALLOW** definitions of reservoir rock or cap rock
		(ii)	labelled diagram showing: **FOUR** correct labels for **2 MARKS**: • salt dome in correct position ; • impermeable rock / cap rock **/** suitable named rock in correct position ; • dipping permeable rock / reservoir rock **/** suitable named rock in correction position adjacent to salt dome ; • oil with gas above drawn <u>horizontally</u> at top of reservoir rock beneath cap rock adjacent to salt dome **;**	2	**ANY TWO** correct for **EACH MARK** **ALLOW** correct rock symbols in place of rock names can be drawn on one side **OR** both sides of salt dome

Question	Answer	Mark	Guidance

Question			Answer	Mark	Guidance
4	(e)	(iii)	**ANY TWO** from: a layer / bed of evaporites / halite / gypsum is buried by later sediments / rocks **OR** a layer / bed of evaporites / halite / gypsum is formed by evaporation of water and crystallisation / precipitation of salts ; evaporites / halite / gypsum have a lower density (than surrounding rocks) **OR** evaporites / halite / gypsum have a density of 2.2 / 2.3 g/cm^3 **AND** rise upwards **OR** form diapirs **OR** behave in a similar way to magma ; the overlying beds / sediments / rocks are pierced / uplifted / folded / form an anticline **OR** causes the sediments / rocks on either side of the salt dome to dip **OR** oil / gas from a source rock rises up and is trapped in dipping reservoir rocks **OR** oil / gas from a source rock rises up adjacent to the salt dome and is trapped beneath a cap rock ;	**2**	
			Total	**19**	

Question			Answer	Mark	Guidance
5			**geophysical exploration** **seismic survey:** **MAX ANY 3** from: • (artificial) seismic waves / shock waves / vibrations are generated by explosions / a thumper truck / vibro truck / vibroseis / air gun **OR** seismic waves are shot ; • reflection / refraction seismic surveys can be carried out **OR** seismic waves are reflected at layer boundaries / bedding planes **OR** angle of incidence = angle of reflection of seismic wave(s) ; • returning seismic waves are detected by geophones / hydrophones ; • the (two way) travel times / time taken for the waves to return to surface is used to calculate depth (to reflective layers) **OR** a seismic profile / seismic section is plotted to show the subsurface geology / underlying rocks / trap structures **OR** computer processing allows 3D modelling of subsurface geology / underlying rocks ; • seismic velocities through rocks give information about composition / density / porosity / presence of oil / potential reservoir rocks can be identified / potential cap rocks can be identified ; **gravity survey:** **MAX ANY 3** from: • a gravimeter is used **OR** variations in the Earth's gravitational field strength are measured ; • gravity data are corrected for latitude **OR** altitude **OR** topography to give density of underlying rocks ; • lines joining points of equal gravitational field strength are plotted on a map **OR** gravity anomaly map is drawn **OR** Bouger anomaly map is drawn ; • evaporites / salt domes produce a <u>negative</u> (gravity) <u>anomaly</u> **OR**	**8**	**MARK** labelled diagrams as text **DO NOT CREDIT** repetition of text on diagrams **MAX 3** for seismic survey **ALLOW** speeds **MAX 3** for gravity survey

Question			Answer	Mark	Guidance
			evaporites have a deficit of mass ; • density of evaporites / halite / gypsum is lower / 2.2 – 2.3 g/cm^3 **AND** surrounding rocks have higher density / density 2.5 – 3.0 g/cm^3 ; **exploration drilling:** **MAX ANY 3** from: • a cylindrical rotating drill is used **OR** drill bit is studded with diamonds to cut through rock ; • drill bit is cooled / lubricated by drilling mud **OR** density of drilling mud is controlled by adding barite **OR** barite is added so drilling mud reaches the bottom of the hole ; • recovered rock chips / drill core is examined by geologists / mud loggers to identify rock types ; • microfossils are used to find the age of rocks / correlate the geology between boreholes ; • down-hole logging / wire-line logging can be carried out **OR** geophysical instruments are mounted on a sonde and lowered into the borehole ; • down hole measurements of porosity / gamma ray spectroscopy / resistivity can be made ;		density description **MUST** include at least one correct numerical value to attain mark **MAX 3** for exploration drilling **ALLOW ANY** correct named microfossil used for dating / correlation
			Total	**8**	

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