

GCE

Geology

Unit **F794**: Environmental Geology

Advanced GCE

Mark Scheme for June 2017

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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.

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These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
	Unclear
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Ignore
	Benefit of doubt not given
	Poor Diagram
	Reject
	Point has been noted, but no credit has been given
	Correct response
	Omission mark
	Maximum (marks available for) Response

Here are the subject specific instructions for this question paper

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/Indicative content	Mark	Guidance
1	(a)	(i)	QWC mark for correct use and spelling of reservoir (rock) as the technical term ;	1	
		(ii)	<p>ANY 2 from:</p> <p>has (high) porosity OR is porous OR has (large volume of) pore space AND <u>explanation</u> – can hold / store gas ;</p> <p>has well sorted grains OR has well rounded grains AND <u>explanation</u> – so has (high) porosity OR is porous OR has large pore spaces ;</p> <p>has (high) permeability OR is permeable AND <u>explanation</u> – allowing gas to flow through OR so it can yield gas ;</p> <p>has good interconnections between the pores OR is jointed AND <u>explanation</u> – so has (high) permeability OR is permeable OR allowing gas to flow through OR so it can yield gas ;</p> <p>has little or no matrix OR little or no cement OR is poorly consolidated OR is unlithified AND <u>explanation</u> – so is porous / permeable ;</p>	2	<p>ALLOW AW</p> <p>MAX 1 if statement porous AND permeable with no explanation and no other marking points awarded</p> <p>ALLOW porous AND permeable to store AND yield gas if explanations are in same order as descriptions for 2 MARKS</p> <p>MUST relate to the properties of a reservoir rock</p> <p>ALLOW hydrocarbons / petroleum / oil as alternatives to gas</p>

Question	Answer/Indicative content	Mark	Guidance
	<p>(iii) fault structure = <u>horst</u> ;</p> <p><u>explanation</u> ANY 2 from: the faults provide a route of <u>migration</u> OR the gas has moved up the faults OR faults are zones of permeability (allowing movement of gas) ;</p> <p>the gas is prevented from migrating further (upwards) by the evaporites / cap rock OR faults above the gas are sealed ;</p> <p>the gas has risen to the top of the upthrow block OR the gas has risen to top of the reservoir rock / sandstone OR the area forms a structural high OR the gas has risen to the crest of the (gentle) <u>anticline / antiformal</u> ;</p> <p>the gas has risen upwards due to <u>low density</u> OR the gas has risen upwards as it <u>less dense than water</u> (in the pore space) OR the gas has migrated down the hydraulic gradient OR the gas has moved from high pressure to low pressure ;</p> <p>the source rock was Carboniferous coal / shale ;</p>	<p>1</p> <p>2</p>	<p>ALLOW horst AND graben</p> <p>DO NOT ALLOW explanations relating to gas stored in reservoir rock / Permian sandstone as the gas is not found throughout the sandstone</p> <p>DO NOT ALLOW gas is less dense than rock</p>

Question		Answer/Indicative content	Mark	Guidance
	(b) (i)	<p>ANY 2 from: directional / deviation / slant / extended reach / horizontal drilling techniques are used to withdraw gas from a large area ;</p> <p>(in primary recovery) the gas comes to the surface under pressure OR release of pressure causes gas to rise OR expansion of the gas causes it to rise ;</p> <p>gas is pumped out (as the pressure reduces) ;</p> <p>(in secondary / enhanced gas recovery) a second borehole is drilled ;</p> <p>(high pressure) air / nitrogen / carbon dioxide / any correct named gas is injected into the reservoir rock to maintain the pressure ;</p> <p>carbon dioxide is denser / heavier than natural gas so is injected below the gas to push it up ;</p> <p>more gas can be pumped into the gas field during the summer when the pressure is high to ensure pressure is maintained during the winter ;</p>	2	<p>DO NOT ALLOW description of how the production well is established</p> <p>DO NOT ALLOW recovery methods only applicable to oil, e.g. nodding donkeys</p> <p>ALLOW AW</p> <p>DO NOT ALLOW gas / natural gas</p>
	(ii)	780,000 million / (4090 x 12) million = <u>15.9</u> years ;	1	MUST be to 1 decimal place

Question	Answer/Indicative content	Mark	Guidance
(d)	<p><u>depleted oil / gas / hydrocarbon</u> reservoir ;</p> <p>ANY 2 for one mark from: reservoirs / traps from which all the recoverable oil / gas has been extracted OR production has finished ; rocks are porous / permeable / capable of storing gas ; there will be impermeable rock / a cap rock above ; geology is well known / equipment left over from when reservoir was in production can be used / they are easy to convert to gas storage ; 50% of the reservoir must be kept filled with gas to maintain pressure ; as previously filled with hydrocarbons they do not require injection of what will then become unrecoverable gas ;</p> <p>OR <u>salt caverns / salt mines</u> ;</p> <p>ANY 2 for one mark from: salt / evaporites are impermeable ; <u>old / existing</u> salt caverns can be used ; new cavities can be created by excavation / solution mining / dissolving the salt ; gas can be replaced / extracted quickly from this type of facility ; requires a 33% cushion of gas ;</p> <p>OR <u>aquifers</u> ;</p> <p>ANY 2 for one mark from: rocks are porous / permeable / capable of storing gas ; there needs to be impermeable rock / an aquiclude above OR it must be a confined aquifer ; an artificial gas field is produced by injecting gas into the pore space ; the gas will need to be dried prior to use ;</p>	2	<p>1 MARK for correct named facility</p> <p>1 MARK for ANY 2 correct descriptions – MUST match named facility</p> <p>DO NOT ALLOW salt <u>dome</u> as named facility</p>
	Total	13	

Question			Answer/Indicative content	Mark	Guidance
2	(a)	(i)	<p>ANY 2 from:</p> <p>rocks / minerals / elements (at the surface) are broken down OR dissolved OR leached OR undergo hydrolysis ;</p> <p>(soluble) minerals / elements / ions / solutes / products are dissolved / removed in solution / transported downwards / transported in groundwater ;</p> <p>aluminium (oxides and hydroxides) / bauxite / laterite is insoluble / the residue OR aluminium (oxides and hydroxides) / bauxite / laterite is left at / close to surface ;</p>	2	<p>ALLOW any correct named rock / mineral</p> <p>ALLOW any correct named soluble mineral / element / ion / solute</p> <p>ALLOW any correct named ore mineral of aluminium</p>

Question		Answer/Indicative content	Mark	Guidance
	(a) (ii)	<p>ANY 2 from:</p> <p><u>factor</u> – tropical / hot climate OR high temperature <u>explanation</u> – to increase the rate of chemical weathering OR to increase rate of chemical reactions OR normally insoluble minerals / clay minerals breakdown ;</p> <p><u>factor</u> – tropical / wet climate OR high rainfall <u>explanation</u> – allows hydrolysis OR water takes part in chemical reactions OR water acts as a catalyst ;</p> <p><u>factor</u> – rock type OR composition / mineralogy of rock <u>explanation</u> – must be rich in aluminium OR poor in iron OR if impure limestone – must be clay-rich as this is source of aluminium ;</p> <p><u>factor</u> – presence of joints / fractures / bedding planes <u>explanation</u> – are zones of permeability OR allow water into rock for chemical weathering OR increase surface area available for chemical weathering ;</p> <p><u>factor</u> – groundwater with a pH near 4 OR groundwater with a pH near 10 OR acid groundwater OR alkaline groundwater <u>explanation</u> – (normally insoluble) silica / quartz / silicate minerals are dissolved / break down ;</p>	2	<p>1 MARK for each correct named factor AND matching explanation</p> <p>ALLOW correct named rock that residual deposits form on, e.g. granite / impure limestone / volcanic ash / tuff</p> <p>ALLOW pH of 4 to 10</p> <p>ALLOW gangue minerals</p>

Question		Answer/Indicative content	Mark	Guidance
(b)	(i)	<p><u>physical property</u> ANY one from: diamond has a hardness of 10 OR is (very) hard OR is physically resistant AND is resistant to erosion / abrasion / attrition / won't wear away during transport OR is resistant to <u>mechanical / physical</u> weathering</p> <p>OR</p> <p>diamond has a density of 3.5 g/cm³ OR is dense OR has a higher than average density AND will be deposited first OR will be deposited where the current velocity slackens OR will be deposited where energy is low ;</p> <p><u>chemical property</u> diamond is unreactive / insoluble / inert / chemically resistant AND is not dissolved / taken into solution during transport OR is resistant to <u>chemical</u> weathering ;</p>	1	<p>MAX 1 if one correct physical property AND one correct chemical property described with no explanations</p> <p>DO NOT ALLOW explanation of weathering during transport</p>
	(ii)	<p>correct cross-section diagram with placer deposit labelled (on beach) ;</p> <p>ANY two points for 1 mark from: two arrows up and down the beach OR swash OR backwash ; sediment is transported up beach ; wave action sorts the minerals OR less dense minerals transported away ; deposition as placer minerals have high density ; deposition as energy of waves reduces OR velocity reduces leaving placer minerals on beach ;</p>	1 1	<p>MAX 1 for plan view</p> <p>DO NOT ALLOW explanation of weathering during transport</p>

Question		Answer/Indicative content	Mark	Guidance
	(b) (iii)	<p>ANY one from: dredging AND loose material is scraped / sucked up ;</p> <p>OR opencast / open pit mining AND loose material is excavated using diggers / bulldozers / dragline excavator / bucket (wheel) excavator ;</p> <p>OR hydraulic mining AND high pressure jets / water jets are used to dislodge material ;</p>	1	<p>ALLOW panning with description</p> <p>MUST include a description of how the material is dug up for open cast</p>
	(iv)	<p><u>advantage</u> ANY one from: ore minerals are already separated from gangue minerals OR ore deposit is likely to be high(er) grade OR there is less waste rock produced / smaller (unsightly) spoil heaps OR subsidence is unlikely to occur OR requires a smaller workforce OR has fewer health and safety requirements so is cheaper OR underground mining can disrupt / pollute groundwater supplies OR underground mining has greater energy requirements / requires more high tech / specialised equipment / ventilation is required ;</p> <p><u>disadvantage</u> ANY one from: (usually smaller ore deposits so) are quickly exhausted OR complex form / sand bars make mining difficult OR a named environmental impact specific to surface placer mining operation, e.g. noise AND dust / scars on landscape / landscape degradation / visual pollution / silt in water affects aquatic ecosystems OR pollution from increased traffic / equipment, e.g. carbon dioxide emissions, oil spills ;</p>	<p>1</p> <p>1</p>	<p>MUST qualify ease OR cost OR safety with a suitable explanation</p> <p>ORA</p> <p>ALLOW <u>long-term</u> environmental damage is lower as deposits are smaller</p> <p>MUST give specific description of damage to habitats / ecosystem</p>

Question	Answer/Indicative content	Mark	Guidance
(c)	<p>ANY 2 from:</p> <p>when mining ceases mine fills up with water OR acid mine drainage water requires on going / expensive treatment ;</p> <p>metal <u>sulfide</u> minerals / galena / sphalerite / chalcopyrite / pyrite react with (atmospheric) oxygen to form sulfur dioxide ;</p> <p>sulfur dioxide dissolves in water to form sulfuric acid OR reduces the pH ;</p> <p>toxic / harmful / poisonous / heavy AND metals / lead / arsenic / cadmium AND are leached from rock / dissolved in the water / contaminate water ;</p> <p>iron produces an orange precipitate / plume / ochre ;</p>	2	<p>ALLOW spelling sulphide / sulphuric</p> <p>ALLOW any correct named metal sulfide mineral</p> <p>ALLOW any other correct named toxic metal</p>

Question	Answer/Indicative content	Mark	Guidance
(d)	<p>ANY 2 <u>named mineral processing operations</u> for one mark from: heap leaching / in situ leaching OR crushing ore / tailings OR smelting ore OR any other correct named mineral processing operation ;</p> <p><u>descriptions of environmental consequences</u> <u>heap leaching</u> OR <u>in situ leaching</u> ANY one from: leaching solution is acidic OR leachate contains (dissolved) toxic / poisonous / heavy metals OR leaching solution can contain cyanide which is poisonous OR leakage may cause pollution of rivers / groundwater / aquifers OR wildlife / birds are at risk of poisoning OR habitats could be harmed OR leakage could cause soil contamination ;</p> <p><u>crushing ore / tailings</u> ANY one from: crushing produces fine grained tailings which are difficult to dispose of OR tailings may contain toxic metals / harmful chemicals used in processing OR uranium tailings are radioactive OR bauxite tailings are alkaline OR tailings dams can fail allowing leakage into surrounding areas OR leakage may cause pollution of rivers / groundwater / aquifers OR crushing produces dust ;</p> <p><u>smelting ore</u> ANY one from: causes atmospheric pollution / acid rain / releases sulfur dioxide / releases carbon dioxide / releases greenhouse gases OR emissions kill vegetation in surrounding area OR a 'dead zone' forms around the smelter OR emissions cause soil contamination in surrounding area ;</p>	<p>1</p> <p>2</p>	<p>a different environmental consequence to match each named mineral processing operation for 1 MARK</p> <p>DO NOT ALLOW repeat of the same environmental consequence for different mineral processing operations</p>
	Total	16	

Question		Answer/Indicative content	Mark	Guidance	
	(b)	(i)	minerals / elements / isotopes / metals / uranium / thorium / potassium (in granite) are radioactive / decay OR radon is a daughter isotope OR radioactive decay produces radon ;	1	ALLOW AW
		(ii)	radon is a gas and can be breathed in OR radon is a dense gas and accumulates at ground level OR radon gas can build up in houses ; radon is radioactive OR radon produces alpha particles OR radon is (strongly) ionising AND increases the risk of cancer OR causes cell mutation OR damages DNA OR bombards / damages lung cells ;	1 1	ALLOW AW
		(iii)	<u>assessment</u> the risk would be higher with sand and gravel OR the risk would be lower with clay ; <u>explanation</u> sand and gravel have a high permeability / are loose / are unconsolidated OR clay is impermeable / has a low permeability / acts as a seal ;	1 1	explanation MUST match assessment DO NOT ALLOW explanation related to porosity
			Total	10	

Question			Answer/Indicative content	Mark	Guidance
4	(a)	(i)	above the water table chalk is unsaturated OR pore spaces contain air (and water) OR is aerated AND below the water table chalk is saturated OR pore spaces contain 100% / only water ;	1	MUST describe situation above AND below the water table
		(ii)	water was under (high) <u>hydrostatic pressure</u> OR the aquifer / fountains are artesian OR the aquifer is confined OR there is impermeable rock / an aquiclude / clay <u>above</u> the chalk OR the water table / potentiometric surface was above the ground surface at this point ;	1	
	(b)	(i)	points plotted correctly and joined with a line ;	2	All points plotted correctly = 1 MARK all plotted points joined with a line = 1 MARK
		(ii)	1940(s), 1950(s), 1960(s) and 1970(s) OR 1940s to 1970s ;	1	ALLOW ECF from 4 (b) (i) ALLOW 1940 to 1980 DO NOT ALLOW 1940 to 1970
		(iii)	<u>description</u> subsidence OR depressions at the surface OR sink holes appear at the surface ; <u>explanation</u> water is removed from the pore space OR water is removed from between the grains OR the pore fluid pressure is reduced AND grains are no longer supported OR rocks collapse downwards OR weight of overlying rocks causes collapse OR load pressure causes collapse OR compaction occurs ;	1 1	

Question		Answer/Indicative content	Mark	Guidance
	(b) (iv)	(permanently) decreases / reduces water storage capacity ; <u>explanation</u> aquifer is compacted OR grains have moved closer together OR pore space is reduced OR porosity is reduced ;	1 1	
	(c) (i)	clay has a (<u>high</u>) porosity / is <u>porous</u> / has <u>pore space</u> so stores / absorbs water / becomes waterlogged OR some <u>clay minerals</u> can swell when wet ;	1	ALLOW clay particles are charged / polar so water sticks to them ALLOW correct named clay mineral
	(ii)	flooding of underground / tube / road tunnels / rail tunnels / basements of buildings / underground car parks OR foundations of buildings become unstable / weaker OR movement / settling / misalignment of building foundations / tunnels may occur OR increased pressure on foundations / tunnels may lead to failure OR damage / flooding of communication cables OR damage to sewers OR groundwater contamination from leaking sewers ;	1	MUST describe flooding below the surface

Question	(d)	Answer/Indicative content	Mark	Guidance
		<p><u>advantage</u> ANY one from: readily accessible / easy to extract / cheaper to extract as lower pumping costs / doesn't always need to be pumped OR doesn't take long to refill / recharge OR treated water can be put back OR dam and reservoir can be used for other purposes, e.g. recreation, hydroelectric power generation ;</p> <p><u>disadvantage</u> ANY one from: water will be polluted / contaminated OR will require treatment OR is not naturally filtered OR requires sufficient rainfall in catchment OR loss of water through evaporation OR water supply may be seasonal OR no backup in drought conditions OR dams and reservoirs are expensive to construct OR large areas of land may be flooded for reservoir / loss of agricultural land OR reservoir will silt up OR construction of dams and reservoirs may trigger earthquakes ;</p>	<p>1</p> <p>1</p>	<p>MUST qualify economics with discussion</p> <p>ALLOW description of any other correct environmental problem associated with dams and reservoirs</p>
		Total	13	

Question	Answer/Indicative content	Mark	Guidance
5	<p><u>building stone</u> <u>named geological material</u> – ANY one or more from: limestone / sandstone / any igneous rock / any metamorphic rock ;</p> <p><u>characteristics</u> – ANY 2 descriptions linked to explanations from:</p> <ul style="list-style-type: none"> • strong / competent with reason OR has high load bearing strength ; • well jointed so easy to extract OR if limestone – soft so can be sawn into blocks / easy to work ; • attractive so has decorative appearance ; • for any rock other than limestone / sandstone – impermeable so waterproof / resistant to weathering ; • if igneous / metamorphic – made of interlocking crystals so impermeable / waterproof OR if limestone / sandstone – well cemented so impermeable / waterproof ; • for any rock other than limestone / marble – chemically unreactive so resistant to chemical weathering ; • uniform so no variation in quality / appearance ; <p><u>bricks</u> <u>named geological material</u> – ANY one or more from: clay / mudstone / shale / correct named unit, e.g. Oxford Clay ;</p> <p><u>characteristics</u> – ANY 2 descriptions linked to explanations from:</p> <ul style="list-style-type: none"> • (plastic / ductile) so can be moulded into shape ; • has high carbon / organic content so acts as an internal fuel during firing OR makes firing more uniform OR reduces energy costs ; • different compositions produce different coloured bricks ; • thick beds so easy to extract ; • constant composition so gives a consistent product ; • contains clay minerals so recrystallises on heating OR so undergoes artificial metamorphism ; • silica / sand / quartz added to produce calcium silicate OR make 		<p>MAX 3 for building stone 1 MARK for correct named geological material(s) MUST give specific rock name</p> <p>1 MARK for each correct description and explanation to match named geological material(s) up to MAX 2 MARK labelled diagrams as text</p> <p>DO NOT ALLOW contradiction between named rock and its characteristic(s)</p> <p>ALLOW slate used for roofing – impermeable so waterproof / resistant to weathering OR has cleavage / foliation so easy to split</p> <p>MAX 3 for bricks 1 MARK for correct named geological material(s)</p> <p>1 MARK for each correct description and explanation to match named geological material(s) up to MAX 2 MARK labelled diagrams as text</p>

Question	Answer/Indicative content	Mark	Guidance
	<p>the brick stronger</p> <p><u>cement and concrete</u> <u>named geological materials</u> – ANY 1 from: limestone / chalk / marble AND ANY 1 from: clay / shale / mudstone / gypsum AND ANY 1 from: sand / gravel / aggregate / crushed rock ;</p> <p><u>cement – characteristic</u> – ANY 1 description linked to an explanation from:</p> <ul style="list-style-type: none"> • limestone / chalk / marble – composed of calcite so provides calcium (carbonate) OR has low magnesium content ; • limestone / chalk / marble – has high purity so makes a consistent product ; • limestone / chalk / marble – soft so can be crushed OR can be crushed without producing too much dust ; • clay / mudstone / shale – added to provide silica / alumina OR is an alumino-silicate ; • gypsum – added to stop cement setting too quickly ; <p><u>concrete – characteristic</u> – ANY 1 description linked to an explanation from:</p> <ul style="list-style-type: none"> • sand / gravel – must be clean so does not have impurities / clay / fines ; • sand / gravel – must be sand size or higher so does not contain clay / fines ; • sand / gravel – must be poorly sorted so grains slot together OR so no holes are left ; • gravel – can be rounded so concrete can be poured ; • sand / gravel – local sources are used so properties can vary ; • concrete / sand / gravel / aggregate / crushed rock is strong / competent / has high crushing strength / has high load bearing strength ; 		<p>MAX 3 for cement and concrete 1 MARK for correct named geological material(s)</p> <p>1 MARK for a correct description and explanation to match named geological material for cement MARK labelled diagrams as text</p> <p>1 MARK for a correct description and explanation to match named geological material for concrete MARK labelled diagrams as text</p>
	Total	8	

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