OCR
Oxford Cambridge and RSA

GCE

Geology

Unit **F794:** Environmental Geology

Advanced GCE

Mark Scheme for June 2015

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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.

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

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

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)	surface water water in rivers / in lakes / in reservoirs / behind dams **;** groundwater water held in pore space of rocks below the water table **OR** water stored in porous / permeable rocks **OR** water in an aquifer / artesian basin **;**	**1** **1**	
		(ii)	advantage **ANY** one from: rocks act as a natural filter **OR** rocks act to filter / purify the water **OR** rocks clean the water **OR** water is filtered as it passes through pore space / between grains **;** no loss of water through evaporation **;** no large seasonal change in water level **;** no requirement to build expensive / environmentally damaging dams / reservoirs **;** contains dissolved minerals that could be good for health **;** disadvantage **ANY** one from: requires suitable sedimentary rocks / presence of aquifers **;** water abstraction may cause subsidence at surface **;** saltwater encroachment may occur in coastal areas **;** (difficult to access because) boreholes have to be drilled **OR** wells have to be dug cost of pumping water **OR** cost of raising water vertically **OR** cost of drilling boreholes **OR** cost of digging wells **;** groundwater may not be suitable for drinking due to presence of dissolved salts / toxic elements / (industrial / agricultural / landfill) pollutants / any correct named pollutant **;** pollutants have a long residence time **;** aquifer takes time to recharge **;** (over) abstraction of water may cause lowering of water table / overlapping cones of depression / groundwater mining **;**	**1** **1**	**ALLOW** the advantage and the disadvantage if implicit rather than explicit **ALLOW** description of any correct environmental problem associated with building of dams / reservoirs **DO NOT ALLOW** discussion of cost unless qualified with a reason **MUST** describe problem associated with over abstraction

Question			Answer/Indicative content	Mark	Guidance
		(iii)	<u>renewable</u> **ANY** one from: surface water percolates down through pore space of rocks to replenish groundwater **;** aquifers must have recharge zones at surface **;** aquifers must be live / being recharged **/** recharged by rainfall / recharged by surface water / recharged as part of the water cycle **;** <u>sustainable</u> **ANY** one from: provided rate of use / extraction does not exceed rate of recharge **;** provided water is used in a way that can continue into the future **;** provided natural systems are able to clean the water fast enough**;** water can be pumped back into aquifer to make it (more) sustainable **;** provided water / wells are not over-pumped **;**	**1** **1**	**MAX 1** if two correct definitions but the wrong way round **ALLOW AW** **ORA**
	(b)	**(i)**	(222 – 153 / 222 x 100 = 31.08%) <u>31.08%</u> **OR** <u>31.1%</u> **OR** <u>31%</u> **;**	**1**	**ALLOW** correct answer given as a negative number

Question			Answer/Indicative content	Mark	Guidance
		(ii)	<u>description</u> **ANY** one from: as the water level drops the salinity increases **OR** as the water level rises the salinity decreases **;** there is a negative correlation (between water level and salinity) **;** <u>explanation</u> **ANY** one from: water is being evaporated so salts become more concentrated **;** water is being evaporated due to hot, arid conditions **;** salts transported into the lake by streams become more concentrated / less diluted as the water level drops **;** water is being evaporated faster than it is being replenished **;** the volume of water has decreased but the amount of salt stays the same **;** the volume of water has decreased so the concentration of salt increases **;** salt isn't evaporated so increases relative to water **;**	**1** **1**	**ORA** **ALLOW** surface area rather than water level
		(iii)	desiccation cracks / mud cracks **;**	**1**	**ALLOW** <u>salt</u> pseudomorphs
			Total	**10**	

Question			Answer/Indicative content	Mark	Guidance
2	(a)	(i)	**ANY** one from: the amount of the resource / oil that can be extracted at a profit / economically **;** the amount of the resource / oil that can be extracted using existing technology **;**	1	**MUST** have idea of quantity **ALLOW** how much / quantity / proportion / accumulation / area as alternatives to amount **DO NOT ALLOW** amount of resource left in crust / ground
		(ii)	**ANY** two from: exploration data is incomplete **OR** exploration boreholes are spaced out and information / faults may be missed **OR** exploration methods indicate the presence of oil but not the amount **;** there will be variations in the reservoir rock composition / properties / permeability **OR** the amount of compaction / diagenesis / cementation of the reservoir rock may vary **OR** the degree of sorting of the reservoir rock may vary **;** the viscosity of the oil **OR** the temperature / pressure in the reservoir rock may vary affecting the amount of oil that can be extracted **;** difficult to estimate volume of reservoir rock **OR** difficult to estimate volume of oil in reservoir **OR** computer programs / mathematical models / calculations of oil reserves are very complex **OR** there are many variables / factors to be considered **;** the price of oil may change **OR** market prices fluctuate **OR** oil companies may overestimate the reserves to boost share prices **;** extraction technology may improve increasing reserves **;**	2	

Question			Answer/Indicative content	Mark	Guidance
		(iii)	the production rate declines because **ANY** one from: most of the oil has been pumped out **OR** the reservoirs are depleting**;** the (hydrostatic) pressure reduces as the oil is extracted the rate of flow slows down **;** all the gas has come out of solution **;** the oil has a high surface tension and sticks to grains **;**	**1**	
		(iv)	Purbeck Fault Zone fault is zone of permeability **OR** fault allowed oil migration **OR** oil migrated up the fault **OR** oil migrated along the fault (into Cretaceous chalk) **OR** fault is unsealed and allowed migration of oil **;** oil that was not prevented from migrating up the fault by a cap rock / impermeable rock / correct named impermeable rock from cross section reached the surface to form oil seeps **OR** (Cretaceous) chalk / rock above the fault is permeable allowing surface seeps **;** fault F1 fault F1 formed traps **;** fault F1 has reservoir / permeable rock on one side and cap rock / impermeable rocks on the other (so forms oil traps) **OR** adjacent to fault F1 there are impermeable rocks / cap rocks / Oxford Clay above reservoir / permeable rocks **;** either fault faults allowed migration of oil from the source rock / Lias into the reservoir rock / Sherwood reservoir / Bridport reservoir **;** route of oil migration was up the Purbeck Fault Zone into the permeable	**3**	**MUST** discuss the role of the faults **MAX 2** if only one named fault discussed or if faults discussed generally **DO NOT ALLOW** migration of oil down faults **ALLOW** correct named permeable and impermeable rocks from cross section

Question			Answer/Indicative content	Mark	Guidance
			Sherwood Sandstone and across fault F1 **;**		
	(b)	**(i)**	<u>Sherwood</u> arkose **OR** feldspathic sandstone **;** <u>Bridport</u> sandstone **OR** orthoquartzite **OR** quartzite **;** <u>Frome</u> fossiliferous limestone **OR** bioclastic limestone **OR** shelly limestone **;**	**1** **1** **1**	**ALLOW** 1 mark for Sherwood = sandstone **AND** Frome = limestone **ALLOW** arkosic arenite for Sherwood **ALLOW** quartz arenite or calcareous sandstone for Bridport **DO NOT ALLOW** desert sandstone **OR** metaquartzite for Bridport **ALLOW** muddy / impure limestone for Frome
		(ii)	**QWC mark** for correct use and spelling of **<u>porous / porosity / pore space</u>** as the technical term **AND** <u>explanation</u> – to hold / store the oil **;** **QWC mark** for correct use and spelling of **<u>permeable / permeability</u>** as the technical term **AND** <u>explanation</u> – to allow migration of oil **OR** to allow extraction of oil **OR** to allow flow of oil **;**	**1** **1**	**MARK** first spelling of each term **DO NOT ALLOW** multiple spellings of the same word if any are incorrect each marking point **MUST** contain both the named property spelled correctly **AND** an explanation **ALLOW** 1 mark for both key properties stated and spelled correctly with no explanations
	(c)		**ANY** one from: allowed oil to be extracted from the reservoir rock over a large area **;** lowered the environmental impact of extracting oil in an Area of Outstanding Natural Beauty **;** lowered the risk of offshore oil spills **OR** reduced the risk of offshore blowout **;** avoided expensive / unsightly offshore oil rigs / platforms **OR** (offshore) oil rigs / platforms could be a hazard to shipping **;** cheaper because only needs a single wellhead **;** allowed drilling rigs to be on land which reduced costs **;**	**1**	**ALLOW** any other sensible suggestion **DO NOT ALLOW** statements of cost **OR** ease of extraction without a correct explanation

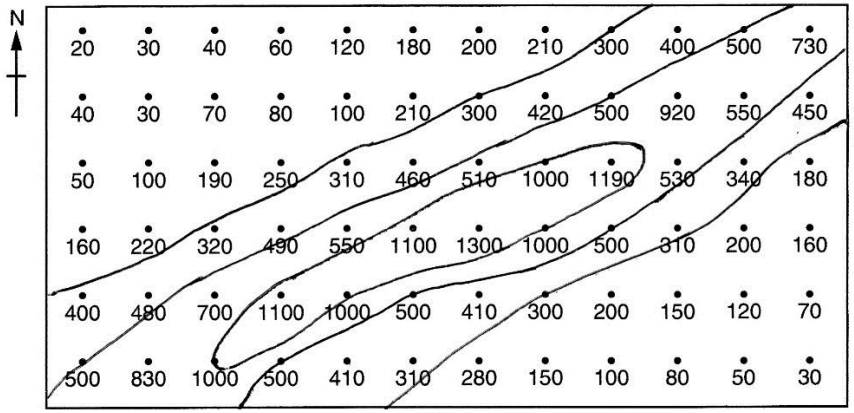
Question			Answer/Indicative content	Mark	Guidance
	(d)	(i)	<u>composition</u> contains (high amount) of kerogen / organic compounds / total organic carbon / (total) organic matter **OR** a source rock that did not undergo enough <u>maturation</u> to produce oil / petroleum / hydrocarbons **;** composed of clay minerals (mica and quartz) **OR** flat platy minerals **;** <u>characteristics</u> **ANY** two for one mark from: fine grained **;** dark coloured / black **;** has laminations / is thinly bedded **;** is fissile / compacted **;** composed of clay minerals (mica and quartz) **OR** flat platy minerals **;**	**1** **1**	**ALLOW** carbon rich **ALLOW** correct grain size in mm **DO NOT ALLOW** repetition of composition
		(ii)	**ANY** two from: could trigger seismic activity / earthquakes **OR** could reactivate existing fractures / joints / faults **OR** could open up existing fractures / joints **;** gas / fracking fluids / water could contaminate / pollute nearby groundwater / aquifers **;** fracking requires large volumes of water that could deplete local water supplies **;** spills of chemicals / fracking fluid could contaminate / pollute soils / surface water supplies **;** <u>release / leakage</u> of greenhouse gases / methane / natural gas / sulphur dioxide / nitrous oxides / volatile organic compounds / silica particulates / sand (into the atmosphere) **;** risk of explosions / fire / asphyxiation **;**	**2**	**MUST** describe

Question			Answer/Indicative content	Mark	Guidance
			noise **AND** dust pollution from drilling **;**		
		(iii)	**ANY** 2 from: reserves of (conventional) oil / gas are decreasing / running out **OR** the demand for oil / gas is high / increasing **;** so despite high production costs **AND** negative environmental impacts production from unconventional sources will increase **;** oil / gas are non-renewable energy resources because they take millions of years to form **OR** oil / gas are non-renewable energy resources because when they are burned the products are lost as gases to the atmosphere **;** there are large areas of oil shale in the British Isles that could produce (unconventional) petroleum / (natural) gas **OR** Britain is currently reliant on imported (natural) gas **OR** it will reduce Britain's reliance on imported (natural) gas **;** there are large reserves of unconventional petroleum in tar sands **OR** there are large reserves of extra heavy crude oil **OR** frozen gas hydrates could be a source of methane in the future **;** the technology for fracking is well known **OR** (natural) gas is already being produced from fracking on a large scale in the USA **OR** technology for processing oil shale has been developed **OR** technology for extracting unconventional petroleum is improving **;** renewable energy resources are unlikely to be able to make up the energy deficit **OR** renewable energy resources are expensive to implement **OR** technology for renewable energy resources is still being developed **;**	**2**	**DO NOT ALLOW** discussion of costs without explanation **MUST** explain the term non-renewable **ALLOW** discussion of any correct named renewable energy resource
			Total	**19**	

Question			Answer/Indicative content	Mark	Guidance
3	(a)	(i)	(ocean – continent) convergent plate margin **OR** subduction zone **;**	1	**ALLOW** (ocean – continent) destructive plate margin **IGNORE** ocean – continent
		(ii)	**ANY** three from: the subducted plate (partially) melts **OR** rising magma (partially) melts continental crust **OR** (partial) melting (at base) of continental crust is source of magma **;** the subducted ocean crust is a source of water **OR** dewatering of the subducted crust reduces the melting point of rocks **OR** dewatering of the subducted crust increases the water content of resultant magma **;** there is magma rising **OR** (partial) melting increases the silica content of magma **OR** the magma is intermediate / silicic **OR** magma mixing occurs **OR** magma cools at depth / below surface **OR** magma forms batholiths / granite **;** magma / (granite) intrusions are rich in water / volatiles **OR** magma / (granite) intrusions are source of hydrothermal fluid **OR** magma / (granite) intrusions are source of heat **OR** water **OR** metals / copper **;** metals / copper that form hydrothermal ore deposits are incompatible with silicate minerals so collect in residual / late-stage / hydrothermal fluids in magma chamber **;**	3	**ALLOW** pluton as alternative to batholith
	(b)	(i)	primary copper ore 0.5 / 0.007 = 71.43 **OR** 71.4 **OR** 71 **AND** zone of secondary enrichment (3.5 / 0.5) = 7 **OR** (3.5 / 0.007) = 500 **;**	1	**DO NOT ALLOW** rounding errors

Question			Answer/Indicative content	Mark	Guidance
		(ii)	copper is leached from rocks **OR** copper is taken into solution **OR** copper is dissolved **OR (**insoluble) copper sulfides are converted to (soluble) copper sulfates / carbonates / oxides **AND** (exposed / primary) copper ore is subjected to chemical weathering **OR** at surface / above water table conditions are oxidising / oxidation occurs **;** copper is transported downwards **OR** copper is leached downwards **AND** as it in solution **OR** as it has dissolved **OR** as rainwater / groundwater percolates into rock **OR** rocks are permeable **;** copper ore is (re)precipitated **OR** (soluble) copper sulfates / carbonates / oxides are converted to (insoluble) copper sulfides **AND** below water table conditions are reducing / anoxic / reduction occurs **OR** the water table is the redox boundary **;**	**1** **1** **1**	each marking point **MUST** contain both description **AND** explanation **ALLOW** correct named copper minerals **ALLOW** spelling sulphide / sulphate **DO NOT ALLOW** use of the term deposition
		(iii)	**ANY** one from: copper ore in zone of enrichment is high(er) grade (than the primary ore / rest of deposit) **;** copper is concentrated into a smaller volume **OR** copper is concentrated in one place **;** mining companies mine the zone of enrichment first to offset cost of exploration / putting mine into production **;** less waste material is produced **;**	**1**	**ORA**

Question			Answer/Indicative content	Mark	Guidance
	(c)		<u>diagram</u> labelled diagram of site of deposition at meander bend **OR** in plunge pool **OR** in pot holes **OR** upstream of projections **OR** downstream of confluences **;** <u>explanations</u> gold is dense / heavy **AND** is (preferentially) deposited **OR** gold is inert / chemically unreactive / chemically resistant **AND** is not dissolved **OR** is not taken into solution **OR** gold has no cleavage **AND** is not broken up **OR** gold is malleable **AND** is not broken up **OR** gold is malleable **AND** rolls into nuggets **;** deposition occurs where there is a reduction in velocity / energy **;**	**1** **1** **1**	diagram – **MUST** include correct site of gold placer deposit with direction of river flow indicated **DO NOT AWARD MARK** if states gold is transported in solution
			Total	**12**	

Question			Answer/Indicative content	Mark	Guidance
4	(a)	(i)	300, 500 and 1000 ppm copper isolines drawn correctly **;**  	**2**	**1 OR 2** isolines drawn correctly = **1 mark** all **3** isolines drawn correctly = **2 marks** **ALLOW** different positions of isolines to those shown in answer column provided they are correct **MAX 1** if concentric shape of all 3 isolines correct with no crossing lines but lines don't go through 300, 500 or 1000 or lines go through points other than 300, 500 or 1000 **IGNORE** margins of the map beyond the plotted points
		(ii)	**ANY** one from: rock / veins containing copper were exposed / outcrop at surface **;** rock / veins containing copper have been <u>weathered / eroded</u> releasing copper into the soil **;**	**1**	**DO NOT ALLOW** discussion of transport beyond the soil
		(iii)	<u>description</u> one area of anomalous / high copper values occur striking NE – SW **OR** the copper anomaly forms a linear shape **OR** forms a concentric pattern with highest concentration in the centre **OR** copper concentrations increase into the centre **;** <u>explanation</u> a joint / fault / bedding plane may have controlled the distribution of the copper in the soil **OR** there is a vein of copper beneath the surface **OR** soil is above the top of an intrusion / batholith **/** dyke **;**	**1** **1**	**ALLOW ECF** from **4 (a) (i)** **ALLOW** along crest / hinge / axis / top of anticline
		(iv)	anywhere within the 1000 ppm isoline shaded / indicated **;** area of highest copper values / highest copper concentration (will be directly above the source of the copper) **;**	**1** **1**	**ALLOW ECF** if 1000 ppm isoline is inaccurate **ORA**

Question			Answer/Indicative content	Mark	Guidance
	(b)		**ANY** two from: can be used to identify areas of soil contamination / soil pollution **OR** can be used to identify areas where soils contain heavy metals / lead / arsenic / cadmium / mercury which are toxic / poisonous / harmful **;** can be used to identify anomalous amounts of metals / elements in soils **OR** can be used to identify concentrations of metals / elements above their normal / background values in soils **OR** normal / background values for metals / elements in soils can be established ; geochemical atlases can be compiled for use by environment agencies / environmental geochemists **;** can be used to identify areas with a higher concentration of radioactive elements / radioactive metals / radioactive minerals **OR** areas at risk from radon gas pollution **;** results can be used to <u>monitor / assess</u> habitats / ecosystems / biogeochemical cycles **OR** results allow assessment (by farmers) of the impact of metals in soils on grazing animals / crops **;** results can be used to assess the impacts of industrial activity / mining / mineral processing / waste disposal on the environment **;**	**2**	**DO NOT ALLOW** discussion of environmental problems that would not be directly identified using a soil survey **DO NOT ALLOW** the word anomaly on its own **DO NOT ALLOW** areas of high radioactivity **ALLOW** correct named radioactive element **ALLOW** alternative words to monitor / assess that have the same meaning

Question			Answer/Indicative content	Mark	Guidance
	(c)		**ANY** two from: many of the old / abandoned mines in Britain were not subject to current environmental regulations / laws **OR** it is not possible to establish who is responsible for paying for restoration / clean-up of old / abandoned mines **;** (old) spoil heaps **/** (old) tailings dams may contain toxic metals **OR** may be unstable **OR** will be subject to weathering / erosion / failure **;** old mine buildings / engine houses / abandoned open cast quarries / abandoned open cast pits cause landscape degradation / visual pollution **OR** it takes a long time for habitats / ecosystems / biodiversity to recover after mining ceases **;** subsidence / unstable ground / holes in the ground caused by the collapse of old / abandoned underground mine workings **OR** the position of old mine workings is unknown and they could collapse **;** (groundwater / surface water pollution by) acid mine drainage water **OR** groundwater / surface water pollution by low pH water containing toxic metals **OR** when mining ceases mine fills up with water containing toxic metals that can pollute groundwater / surface water **;** extra detail of acid mine drainage water – metal sulfide minerals / any correct named sulfide mineral react with oxygen to form sulfur dioxide **OR** sulfur dioxide dissolves in water to form sulfuric acid **OR** acid mine drainage water requires on going / expensive treatment **;**	**2**	**DO NOT ALLOW** answers referring to current mining processes, e.g. noise and dust from machinery / blasting, destroys habitats, deforestation, etc. **DO NOT ALLOW** discussion of smelting or heap leaching **DO NOT ALLOW** discussion of leachate / leaching of metals not linked to acidic water **ALLOW** spelling sulphide / sulphur / sulphuric
			Total	**11**	

Question			Answer/Indicative content	Mark	Guidance
5			description 1 sea walls / retaining wall – made of concrete / stone **OR** have vertical / sloping / curved walls **OR** banks – made of clay / gravel **;** explanation 1 (the hard surfaces) reflect wave energy **OR** they absorb wave energy **OR** walls support the cliffs behind **OR** they protect the base / toe of the cliff from erosion **;** description 2 rip rap / rock armour / gabions / rock buttresses / artificial reefs / breakwaters – blocks of rock piled up on the beach **OR** can be offshore **OR** cages of rock **OR** are parallel to coast **;** explanation 2 reduce erosion from wave action **OR (**spaces between blocks) are effective at absorbing wave energy **OR** protect the base / toe of the cliff from erosion **;** description 3 revetments – can be made of wood / geotextile / sandbags / rock **OR** parallel to coast **OR** have sloping front **;** explanation 3 reduce erosion from wave action **OR** trap sediment to help build up the beach **OR** effective at absorbing wave energy **OR** protect the base / toe of the cliff from erosion **;** description 4 groynes – made of wood / blocks of rock **OR** groynes extend out at 90^{o} / perpendicular to coast / at high angle to coast **;** explanation 4 prevent loss of sediment by longshore drift **OR** allow sediment build up on up drift side **OR** trap sediment to build up beach **;**	8	**ANY four methods** **MAX 1** for list of four correct methods with no descriptions / explanations **MUST** describe each method **AND** explain its purpose (1 mark for description and 1 mark for explanation) **MARK** labelled diagrams as text but **DO NOT** credit repetition on diagrams

Question			Answer/Indicative content	Mark	Guidance
			<u>description 5</u> beach nourishment – using imported sand **OR** moving sand **;** <u>explanation 5</u> builds up the level of the beach **OR** replaces material transported away **OR** protects the base / toe of the cliff from erosion **OR** reduces erosion from wave action **;** <u>description 6 – slope stabilisation</u> soil nails / rock bolts – fixed into cliff **OR** holds rock in place **OR** wire netting – attached to the cliff face **OR** shotcrete – sprayed liquid concrete **OR** drainage / rock drains – removes water from rock **OR** pipes placed in rock **OR** reprofiling – reduces angle of slope **OR** slope / dune stabilisation – using vegetation **OR** marram grass**;** <u>explanation 6</u> stabilises the slope / cliff **OR** helps reduce slippage of rocks (dipping towards sea) **OR** reduces slumping **OR** stops rock falls from cliff **OR** reduces material falling from cliff **OR** protects cliff face from weathering **OR** fixes rock / material in place **OR** prevents saturation **;**		
			Total	**8**	

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