OCR
Oxford Cambridge and RSA

GCE

Geology

Unit **F794:** Environmental Geology

Advanced GCE

Mark Scheme for June 2014

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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
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
	Unclear
BOD	Benefit of doubt given
CON	Contradiction
	Incorrect response
ECF	Error carried forward
I	Ignore
R	Reject
NBOD	Benefit of doubt not given
^	Omission mark
	Correct response
SEEN	Point has been noted, but no credit has been given
PD	Poor diagram

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td>area where permeable rocks outcrop at surface labelled</td><td>1</td><td>MUST indicate entire surface area as far north as water table intersection OR point D
DO NOT ALLOW any area to north of D</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><table><tr><td>aquiclude</td><td>B</td></tr><tr><td>confined aquifer</td><td>A</td></tr><tr><td>spring</td><td>D</td></tr><tr><td>unconfined aquifer</td><td>C</td></tr><tr><td>water table well</td><td>E</td></tr></table></td><td>3</td><td>0 -1 correct = 0 marks
2 correct = 1 mark
3 or 4 correct = 2 marks
5 correct = 3 marks</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>the water has been <u>naturally</u> filtered OR the water has been filtered by rocks OR the water has been filtered as it passes through the aquifer OR the water has passed through the pore space of rocks OR the water has passed between the grains
AND
removing impurities / pollutants / contaminants / bacteria / viruses / toxic chemicals / sediment / purifying it / cleaning it</td><td>1</td><td>MUST explain filtering by rocks AND removal of impurities</td></tr>
</table>

Question			Answer	Mark	Guidance
		(iv)	**similarity** • **F1** and **F2** are both artesian wells **OR** the water rises upwards at both **F1** and **F2 OR** both produce water; • they are in a confined aquifer **OR** there is impermeable rock above **OR** there is an aquiclude above (the aquifer); • the water is under hydrostatic pressure; **difference** • the water flows onto the surface at **F2 OR F2** will produce more water **OR F2** will produce water for a longer time without pumping; • **F2** is under higher hydrostatic pressure **OR** because there is a higher hydraulic gradient at **F2 OR F2** is further down hydraulic gradient**;** • **F2** is lower than the level of the water table **OR** the level of the water table is higher than the level of the land surface at **F2 OR** there is a higher hydrostatic head at **F2 OR** the weight of the overlying water is higher at **F2 OR** there is more overlying water at **F2 OR** because the land surface at **F2** is below the potentiometric / piezometric surface	1 1	**ALLOW AW** each point **MUST** have a description linked to an explanation using **ANY 2** marking points **ALLOW AW** each point **MUST** have a description linked to an explanation using **ANY 2** marking points **ORA** for **F1** **IGNORE** discussion of slope of land – **MUST** relate to position of water table **MUST** use terms such as higher / greater to compare the wells
1	(b)	(i)	surface separating <u>unsaturated</u> rock (above) from <u>saturated</u> rock (below) **OR** rock below has <u>100% / all water</u> filling pore space / joints / fractures **OR** surface separating <u>aeration zone</u> above from <u>saturation zone</u> below **OR** surface below which the rock is saturated with water **OR** surface below which the water is stored in rock	1	**DO NOT ALLOW** simplistic descriptions of level of water in rock
		(ii)	**<u>labelled</u> diagram** showing cone of depression **OR** lowering of water table in vicinity of well **OR** draw down between level of water in well and water table; **explanation** reduction / decrease in <u>hydrostatic pressure</u> (in vicinity of well) **AND** this causes water table to lower (in vicinity of well) **OR** hydraulic gradient is set up **OR** water flows into well **OR** draw down decreases hydrostatic head (weight of water)	1 1	**MUST** label water table correctly **OR** cone of depression correctly **explanation MUST** match situation shown on diagram **ALLOW AW** **MARK** labels as text **DO NOT CREDIT** repetition of text on diagram
			total	**10**	

Question			Answer	Mark	Guidance
2	(a)	(i)	reserves are the amount of the resource / coal that can be extracted at a profit / economically **OR** the amount of the resource / coal that can be extracted using existing technology	1	**DO NOT ALLOW** amount of resource left in crust / ground **ALLOW** how much / quantity / proportion / accumulation / area as alternatives to amount
		(ii)	(10.4 ÷ 17.8 x 100) = 58.4 %	1	
		(iii)	(400 ÷ 17.8) = 22.5 years	1	
	(b)		overburden is removed **OR** overburden is piled up to form spoil heap **OR** overburden is backfilled **OR** a stripping ratio of less than 20:1 is economic **OR** maximum depth of opencast mining is 200m **OR** blasting / (pneumatic) picks may be needed to break up (waste) rock; the sides of open cut must be at a stable angle **OR** benches are cut for stability **OR** correct named strategy to make quarrying safe, e.g. water pumping and drainage; a dragline excavator **OR** bucket (wheel) excavator remove coal **OR** dump trucks / conveyor belts transport coal	2	**ANY 2** **ALLOW AW** **ALLOW** diggers / bulldozers **DO NOT ALLOW** discussion of restoration after mining is completion

Question			Answer	Mark	Guidance
	(c)		**justification: ALLOW ORA** opencast mining is easier / cheaper / safer / more profitable / higher rates of coal production can be achieved / more of the coal can be extracted / more of the coal can be accessed / there are fewer problems **explanation: ALLOW ORA** • it requires a smaller workforce **OR** wages are lower **OR** it has less health and safety requirements **OR** specific safety detail given **OR** flooding is less of a problem **OR** (roof) collapse is less likely; • it requires less high tech equipment **OR** opencast machines are larger so can remove coal more quickly **OR** has no requirement for ventilation **OR** less affected by methane **OR** it has lower set up costs **OR** produces lower amounts of waste rock; • opencast techniques can extract thinner seams than underground mines **OR** lower rank coal can be mined at a profit from opencast mines; • opencast mining is less affected by faulting **OR** less affected by seam splitting **OR** less affected by steep <u>dip</u> of (coal) seams **OR** less affected by washouts	2	**MUST** qualify ease **OR** cost **OR** safety **OR** rate of production statements with explanations **ANY 2** explanations **MAX 1** for 2 explanations without justification **ALLOW** less specialised equipment as alternative to less high tech equipment
	(d)	(i)	**name:** <u>long-wall</u> (retreat) mining; **description:** a shaft is sunk **OR** coal is hoisted up a shaft **OR** adits / drifts can be used for access; (two) roadways / tunnels are driven out (from the shaft); ventilation to avoid gas / methane build up; the coal is cut from the coalface with a (mechanical) cutter **/** shearer; the coal falls onto / is transported by a conveyor belt; the hydraulic roof supports are <u>mobile / moved</u> (after the coal is cut); the mined-out area is allowed to collapse; mining takes places backwards / retreating (towards the shaft); geological conditions / presence of faults can be assessed in advance	1 2	**ALLOW** long-wall / longwall / long wall **ANY TWO** correct statements for **EACH MARK** **MUST** describe **ALLOW** any correct alternative word for movement

Question			Answer	Mark	Guidance
		(ii)	**faulting:** coal seam has been displaced **AND** may disrupt production **OR** fault is zone of weakness **AND** may cause collapse **OR** fault is zone of permeability **AND** may cause flooding **OR** shearer will encounter other rocks (in place of coal) **AND** they may be hard; **<u>seam splitting / thinning</u>** a thick seam has split into thin seams **OR** coal seam has split due to differential subsidence of delta **OR** there is lateral variation **OR** there is more sandstone **AND** it may be unworkable **OR** the seam may be unworkable **OR** less coal will be produced **OR** waste rock will be mixed with coal **OR** shearer can be damaged **OR** more permeable rock allows ingress of water	1 1	each point **MUST** have a description linked to an explanation **MAX 1** for general explanations of both faulting and seam splitting
		(iii)	**QWC mark** for correct use and spelling of **<u>subsidence</u>** as the technical term	1	
			total	**13**	

Question			Answer	Mark	Guidance
3	(a)	(i)	beds dip in towards the reservoir on south side **OR** the dip is steep on the south side **OR** dipping beds slip due to gravity; joints make the rocks weak **OR** the joints increase permeability; limestone is permeable (allowing water in) **OR** there are alternating layers of permeable and impermeable rock; clay is weak / incompetent / has low load bearing strength **OR** clay can absorb water / has a high porosity so stores water **OR** (wet) clay acts as a lubricant; there are thin alternating layers of limestone and clay **OR** alternating layers of competent limestone and incompetent clay; the boundary between the clay and the limestone acted as a slip plane	3	**ANY 3**
		(ii)	water adds weight **OR** the height of the water table rose; water increases the pore fluid pressure; the clay became saturated / waterlogged / absorbed water; the water acted as a lubricant **OR** caused loss of friction **OR** caused loss of cohesion	2	**ANY 2**

Question			Answer	Mark	Guidance
	(b)		**ANY 3 named geological materials from:** limestone / chalk **OR** clay / shale / mudstone **OR** gypsum **OR** crushed rock / aggregate **OR** sand / gravel; **ANY 1 description from**: limestone / chalk – composed of calcium carbonate **OR** can be crushed without producing too much dust **OR** must have uniform composition **OR** needs high purity **OR** must have low magnesium content; shale / clay / mudstone – provides aluminium and silica content **OR** is an alumino-silicate; gypsum – is added to prevent cement setting too quickly **OR** is (hydrated) calcium sulphate; sand / gravel / aggregate / crushed rock – must be clean **OR** contain no impurities / no clay / low fines value **OR** is sand size or above **OR** needs high or moderate strength / must be strong **OR** pebbles must be rounded **OR** poorly sorted	1 1	**ALLOW** cement **ANY 1**
3	(c)	(i)	**advantage:** clay and siltstone are impermeable / fine-grained **AND** leachate / fluids will not escape **OR** no leakage occurs **OR** no groundwater pollution can occur; **disadvantage:** the fault is permeable **OR** allows infiltration **OR** allows percolation **OR** allows seepage **OR** <u>fault plane</u> allows downwards movement **AND** leachate / fluids could escape / enter rocks below **OR** allowing leakage **OR** groundwater pollution can occur **OR** the fault could reactivate **AND** cause subsidence / settlement cracks to open up (allowing rainwater to infiltrate the waste) **OR** the clay and siltstone are weak / incompetent / have low load bearing strength / can be saturated **AND** (sides of quarry) may not be stable	1 1	each point **MUST** have a description linked to an explanation **ALLOW AW**

Question			Answer	Mark	Guidance
3	(c)	(ii)	sand and gravel is likely to be permeable **AND** leachate / fluids will leak from the site **OR** ground water pollution can occur; dipping beds **AND** allow leachate / fluids to migrate away (down dip) / escape **OR** will be unstable **OR** will allow landslips (on sides of quarry); sand and gravel is weak / has low load bearing strength **AND** is likely to collapse **OR** undergo subsidence (with weight of waste)	2	**ANY 2** each point **MUST** have a description linked to an explanation
		(iii)	grouting – (holes are drilled and) liquid cement pumped into ground; is impermeable / impervious; **OR** clay / geotextile / geomembrane / plastic (lining) is laid; is impermeable / impervious; **OR** drainage and pumping water; to lower the water table so water does not mix with the waste	2	**1 MARK** for description and **1 MARK** for explanation explanation **MUST** match description
			total	**13**	

Question			Answer	Mark	Guidance
4	(a)	(i)	(artificial) seismic waves / shock waves / vibrations are generated by explosions / a thumper truck / vibro truck / vibroseis / air gun **OR** seismic waves are shot; seismic waves (travel into the rock / Earth and) are reflected at layer boundaries / bedding planes **OR** seismic wave(s) with angle of incidence = angle of reflection and direction arrows correctly drawn on diagram; returning seismic waves are detected by <u>geophones / hydrophones</u> **OR** <u>geophones / hydrophones</u> receiving seismic waves correctly drawn on diagram	2	**ANY 2** **MARK** text first and look for additional credit on diagram **DO NOT CREDIT** repetition of text on diagram **ALLOW AW**
		(ii)	the (two way) travel times / time taken for the waves to return to surface is used to calculate depth (to reflective layers); a seismic profile / seismic section is plotted **AND** shows subsurface geology / underlying rocks **OR** computer processing **AND** allows 3D modelling of subsurface geology **OR** computer processing **AND** allows 3D modelling of underlying rocks; <u>seismic velocities</u> through rocks give information about composition / density / porosity / presence of oil / potential reservoir rocks can be identified / potential cap rocks can be identified; geological structures / anticlines / faults / unconformities which may be traps can be identified	2	**ANY 2** **ALLOW** correct answer given in **(i)** **ALLOW** speed **ALLOW** any correct named trap type

Question			Answer	Mark	Guidance
4	(b)	(i)	**trap type:** salt dome / salt diapir; **explanation:** there is a negative (gravity) anomaly **OR** there is a deficit of mass; salt / halite / evaporites have a lower density than surrounding rocks **OR** density of salt / halite / evaporites is 2.3 – 2.2 g/cm^3 **AND** surrounding rocks have higher density / density 2.5 – 3.0 g/cm^3;	1 1 1	**ALLOW** anticline trap for **MAX 2** anticline trap (1); anticline has resulted in lower density material surrounded by higher density material (1) **ALLOW** fault trap for **MAX 2** fault trap (1); where there is lower density material faulted against higher density material **OR** lower density material upthrown **OR** higher density material downthrown (1)
	(b)	(ii)	close to the 0 milligal line – **ALLOW** anywhere above / outside the -10 milligal line	1	**ALLOW** in centre of anomaly if salt dome trap is given in **(i) AND** refers to anticline above salt dome **ALLOW ECF** if anticline trap given in **(i)** – inside the -30 milligal line **DO NOT ALLOW ECF** if fault trap given in **(i)** – no mark possible **ALLOW ECF** if syncline given in **(i)** – anywhere above / outside the -10 milligal line (as oil could be found in any adjacent anticlines)
	(c)	(i)	**QWC mark** for correct use and spelling of **magnetometer** as the technical term	1	
		(ii)	all points plotted correctly; all points joined as a line graph with a labelled horizontal line at 4510 nanoTeslas	1 1	**ALLOW** half a grid square tolerance for plotted points **ALLOW** line graph as curve or joined from point to point
		(iii)	igneous intrusion shown and identified between 10 and 55 metres maximum **AND** contacts must extend to bottom axis	1	**ALLOW** tolerance within 10-20m for left side of intrusion and within 40-55m for right side **ALLOW** dip of contacts drawn at any angle

Question			Answer	Mark	Guidance
4	(c)	(iv)	**rock type:** dolerite / gabbro / peridotite **AND** **explanation:** because it has produced a positive magnetic anomaly **OR** because it is rich in iron / magnetite **OR** because it is rich in mafic minerals / pyroxene / augite / olivine **OR** because it is magnetic	1	**MUST** state rock type **AND** give explanation
	(d)		**description:** • (intense) <u>chemical</u> weathering / hydrolysis **OR** weathering in hot **AND** wet climate; • a residue / aluminium (oxides and hydroxides) / bauxite is left at or close to surface; • granite / impure limestone / volcanic ash / tuff is rich in aluminium; • laterite is formed from rocks rich in iron; • rock may be well-jointed and permeable **OR** requires groundwater with a pH of 4 to 10; **explanation:** • rocks / minerals / elements are broken down **OR** dissolved **OR** leached **OR** elements / ions removed in solution **OR** solutes are transported downwards; • aluminium (oxides and hydroxides) / bauxite are insoluble; • silica in granite / volcanic ash / tuff may become soluble **OR** calcium carbonate in limestone is soluble; • joints allow water into rock for hydrolysis / carbonation **OR** joints increase surface area available for chemical weathering	3	**MAX 2** for descriptions with no explanations **MAX 2** for explanations with no descriptions
			total	**16**	

Question			Answer	Mark	Guidance
5			• pre-existing mineral vein(s) – so there is a source of minerals / named mineral **OR** diagram showing mineral vein(s) as source; • weathering / erosion – breaks up rock **OR** releases / separates minerals **OR** allows the minerals to be transported; • cassiterite is hard / hardness 6-7 / has poor cleavage / is physically resistant **OR** diamond is hard / hardness of 10 / is physically resistant – so withstands transport / erosion / abrasion / attrition; • gold has no cleavage / is malleable – so rolls into nuggets **OR** so withstands transport / erosion / abrasion / attrition; • ore minerals are chemically inert / chemically resistant / unreactive / stable / insoluble – so they are not taken into solution / dissolved **OR** so they are not affected by (chemical) weathering; • transport – moves material **OR** separates ore minerals from gangue minerals **OR** sorts the minerals **OR** winnows the minerals **OR** removes less dense / less resistant gangue minerals (so the grade increases); • ore minerals are <u>dense</u> – so they are deposited; • on inside of meander bends (point bar) / in plunge pools of water falls / upstream of projections in river bed / downstream of confluences – current velocity slackens **OR** energy decreases; • labelled diagram of placer deposit forming on inside of meander bend **OR** on point bar; • labelled diagram of placer deposit forming in plunge pool at base of waterfall **OR** in potholes; • labelled diagram of placer deposit forming upstream of projection(s) in river bed; • labelled diagram of placer deposit forming downstream of confluence **OR** downstream of fast flowing tributary	8	each point **MUST** have a description linked to an explanation **MARK** labels as text **DO NOT CREDIT** repetition of text on diagrams **ALLOW MAX 1** for general description of 3 properties of placer minerals **MAX 1** for 2 simple diagrams **MAX 2** for 4 simple diagrams simple diagram – must include correct position of placer deposit shown in correct situation detailed diagram – must also include direction of flow and one additional correct label **MAX 6** if no diagrams
			total	**8**	

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