OCR
RECOGNISING ACHIEVEMENT

GCE

Geology

Advanced GCE

Unit **F794:** Environmental Geology

Mark Scheme for January 2013

Oxford Cambridge and RSA Examinations

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Annotations

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

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

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	Marks	Guidance
1	(a)	(i)	Kimmeridge Clay	1	**ALLOW** Speeton Clay **OR** Brent Group shales / clay **OR** Jurassic / Lias shales / mudstones / clays
		(ii)	**QWC** mark for correct use and spelling of **unconformity / stratigraphic / stratigraphical** as the technical term	1	
		(iii)	any **two** from • sandstone is a reservoir rock **OR** sandstone is porous / permeable; • chalk / clay is a cap rock **OR** chalk / clay is impermeable **OR** there is a cap rock above **OR** the surrounding rocks are impermeable; • the oil rises to the top of the reservoir rock due to low density **OR** oil rises upwards as it less dense than water (in the pore space) **OR** the oil migrates down the hydraulic gradient; • the oil is concentrated in one place at the top of the reservoir rock (immediately below the unconformity); • there was a suitable source rock containing plankton	2	**MAX 1** for 2 correct points without any reference to rocks shown on diagram **DO NOT ALLOW** oil is less dense than rock
		(iv)	any **one** from • the oil has escaped up along the fault **OR** the oil has escaped through the fault **OR** the fault is unsealed **OR** the rocks are faulted; • the rocks above the sandstone are permeable **OR** the rocks above the sandstone do not form a cap rock; • the oil migrated up dip from the west and could not get to **B OR** there was no route for oil migration from the source rock to the sandstone **OR** the rocks below the sandstone are impermeable; • the oil migrated up dip after the unconformity formed and location **B** is too deep **OR** the oil is too deep and has denatured	1	**DO NOT ALLOW** escaped down the fault

Question			Answer	Marks	Guidance
	(b)	(i)	any **three** from • a (production) well **OR** borehole is drilled into the reservoir rock / trap / through the cap rock; • directional / deviation / slant drilling techniques are used to withdraw oil from a large area; • the well needs to be capped off to prevent blowouts **OR** the well needs to be capped off to prevent oil spills; • the oil comes to the surface under natural pressure **OR** forms a gusher **OR** release of pressure causes oil to rise; • the pressure is the result of gases coming out of solution **OR** the result of expansion of the gas above **OR** the result of water pushing up from under the oil **OR** the result of hydrostatic pressure; • as the pressure reduces the oil is pumped out using nodding donkeys **OR** using submersible pumps; • 20–30% of the oil can be recovered **OR** 70–80% of oil is left in the reservoir	3	**ALLOW** correct named rocks from diagram in part **(a)** **MUST** describe how the blowout is prevented **ALLOW** one correct number within the range
		(ii)	to increase **OR** maintain the pressure	1	**ALLOW** oil is pushed up by water
		(iii)	**use of detergents** reduces the surface tension of the oil **OR** loosens the oil from the grains which makes it easier to recover; **use of bacteriological techniques** bacteria / microbes digest oil **OR** breakdown oil **OR** metabolise large hydrocarbon molecules which lowers the viscosity of the oil **OR** lower viscosity oil flows better	1 1	**MUST** explain how each technique works **MAX 1** if not clear which technique is described
			Total	**11**	

Question			Answer	Marks	Guidance
2	(a)	(i)	**definition** a rock with (high) porosity and permeability **OR** porous rock in which water can be stored **OR** permeable rock into which water can flow and be extracted from **OR** a rock that can store **AND** yield groundwater; **explanation** limestone is well-jointed which increases permeability **OR** fractures increase permeability	1 1	**ALLOW** joints / fractures increase water flow
		(ii)	**QWC** mark for correct use and spelling of **recharge zone** as the technical term	1	
		(iii)	allows rain water / surface water to enter / refill the aquifer **OR** is the area of the aquifer open to the atmosphere **OR** is the area of the aquifer allowing replenishment of (ground)water	1	**ALLOW ECF** for correct function if technical term given in part **(ii)** is a spring
		(iv)	**hydraulic gradient** – difference in hydrostatic pressure divided by the distance between two points **OR** difference in hydrostatic head divided by the distance between two points	1	**ALLOW** hydraulic pressure / head for hydrostatic pressure / head
		(v)	(120 - 100) / 200 = 0.1	1	**ALLOW** ratio 1:10 **OR** 10%
	(b)	(i)	**description** water is removed from the pore space **OR** water is removed from between the grains **OR** the pore fluid pressure is reduced; **explanation** grains are no longer supported **OR** weight of overlying rocks causes the rock to collapse downwards **OR** compaction occurs	1 1	

Question			Answer	Marks	Guidance
		(ii)	**name** salt water **OR** sea water **OR** saline **OR** salination **AND** encroachment **OR** intrusion **OR** incursion **OR** inflow; **explanation** pumping water reduces the pressure so sea water enters the aquifer **OR** pumping water disturbs the fresh water-salt water interface **OR** salt water is denser than fresh water and flows in underneath **OR** less dense groundwater forms a lens floating on the more dense salt water **OR** salt water enters the aquifer by capillary action	1 1	**MUST** have one term for salt and one term for encroachment **MUST** explain not just describe
	(c)		**advantage** readily accessible / easy to extract / cheaper to extract as reduces pumping costs / doesn't always need to be pumped **OR** doesn't take long to refill **OR** treated water can be put back **OR** dam and reservoir can be used for other purposes, eg recreation, H.E.P. generation; **disadvantage** water will be polluted / contaminated / require treatment **OR** requires sufficient rainfall in catchment **OR** loss of water through evaporation **OR** water supply may be seasonal **OR** dams are expensive to build **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	1 1	**MUST** qualify economics with discussion **ALLOW** description of any other correct environmental problem

Question			Answer	Marks	Guidance
	(d)		water is pumped into the ground for storage until needed **OR** controlled flooding spreads water over the ground so it can infiltrate into the ground for storage **OR** stored groundwater is pumped into rivers to maintain river flow in dry periods **OR** sediment traps are used to ensure the groundwater is free of sediment prior to discharge into river **OR** weirs are used to ensure the groundwater is oxygenated prior to discharge into river	1	
			Total	**13**	

Question			Answer	Marks	Guidance
3	(a)	(i)	granite areas / 40ºC/km – geothermal gradient plotted correctly as a straight line (0km=10°C, 1km=50°C, 2km=90°C, 3km=130°C, 4km=170°C, 5km=210°C); sedimentary basins / 30ºC/km – geothermal gradient plotted correctly as a straight line (0km=10°C, 1km=40°C, 2km=70°C, 3km=100°C, 4km=130°C, 5km=160°C)	1 1	**MAX 1** if both lines are correct but not labelled **MAX 1** if both lines are correct but start at 0°C **OR** points are 10°C out **MAX 1** if all points plotted correctly for both but not joined with lines **ALLOW** two correct points plotted and joined with a straight line for each gradient
		(ii)	granite areas = 2.2 km + / - 0.1 km **AND** sedimentary basins = 3 km + / - 0.1km	1	**BOTH** must be correct for 1 mark **ALLOW ECF** from graph
		(iii)	granite contains (a higher proportion of) radioactive minerals **OR** granite contains (a higher proportion of) radioactive elements **OR** granite contains (a higher proportion of) uranium / thorium / potassium (sedimentary rocks do not); radioactive decay produces heat **OR** granite is heated by radioactivity	1 1	**ALLOW** correct comparison of granite areas and sedimentary basins

Question			Answer	Marks	Guidance
	(b)		any **three** from granite batholith drawn and labelled; two boreholes drawn **OR** cold water is pumped down one borehole **OR** hot water **/** steam rises up second borehole; granite is artificially fractured using explosives **OR** granite is artificially fractured using high pressure water; granite is impermeable **OR** fractures increase permeability; water is passed through heat exchanger **OR** steam used to drive a turbine	3	**MARK** labels as text **MAX 2** for drawing and labels without explanation one label must include enough detail to explain for **MAX** marks **MAX 2** if the diagram shows a volcanic source or a geothermal aquifer
	(c)		**advantages** • renewable **OR** sustainable as there is a continuous supply of heat from the Earth **OR** magma is continually rising **OR** water can be re-injected to maintain pressure / get rid of waste; • reduces reliance on fossil fuels **OR** does not produce carbon dioxide **OR** does not produce greenhouse gas emissions; • can work continually day and night **OR** is not affected by changing weather conditions; • in the right location geothermal energy can be cost effective; **disadvantages** • if it is a low enthalpy system **OR** a geothermal aquifer it cannot be used to drive turbines **OR** it cannot be used to generate electricity; • requires suitable geology **OR** geographical areas are limited **OR** each geothermal well is only viable for 20-30 years **OR** needs to be near an area of population; • extraction of water / steam can cause subsidence **OR** trigger earthquakes; • groundwater is saline **OR** groundwater is corrosive / toxic **OR** salts may precipitate out and block pipes	3	**MUST** discuss, not list **MAX 2** for advantages only **MUST** have an explanation for renewable / sustainable **MAX 2** for disadvantages only
			Total	**11**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>4</td><td>(a)</td><td></td><td>
<table>
<tr><th>description</th><th>term</th></tr>
<tr><td>the amount by which a metal is concentrated to make an ore deposit</td><td><u>concentration factor</u></td></tr>
<tr><td>a useful and valuable material</td><td><u>resource</u></td></tr>
<tr><td>the amount of metal present in the ore</td><td><u>grade</u></td></tr>
<tr><td>the amount of ore that can be extracted at a profit</td><td><u>reserves</u></td></tr>
</table>
</td><td>4</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>(ocean – ocean) convergent plate margin OR subduction zone OR island arc</td><td>1</td><td>ALLOW (ocean – ocean) destructive plate margin
IGNORE ocean – continent</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><u>any two from</u>
• source of magma is (partial) melting of subducted plate / subducted crust OR dewatering of subducted plate / subducted crust causes (partial) melting of overlying mantle wedge / base of crust;
• magma rises as low density diapirs (on island arc side) OR (partial) melting increases the silica content of magma OR the magma becomes intermediate / silicic OR magma mixing occurs OR magma rises up the faults;
• (some) magma cools at depth / within the crust to form granite intrusions;
• (some) magma reaches the surface to form volcanoes / magma is erupted to form volcanic rocks</td><td>2</td><td>ALLOW Indonesia is an island arc / convergent plate margin if not given in part (i)</td></tr>
</table>

Question			Answer	Marks	Guidance
	(c)	(i)	**hydrothermal fluid** – hot **OR** high temperature, aqueous fluid **OR** water containing (dissolved) metals / minerals / ions / salts (in solution)	1	**MUST** include hot, water and metals / minerals / ions / salts
		(ii)	**support of hypothesis** • the metals tin, lead and zinc are characteristic of hydrothermal deposits; • hydrothermal deposits are associated with granite intrusions **OR** the granite intrusions are the source of the hydrothermal fluids **OR** granite magmas are rich in water **OR** granite magmas are rich in volatiles **OR** the granites are the source of the heat, water and metals; • faults are zones of permeability **OR** the hydrothermal fluids moved along the faults	2	**MAX 2** for hypothesis answers **MUST** use evidence from the map
			description of formation • (as the hydrothermal fluids cooled) the (hydrothermal) minerals / metals precipitate / crystallise along the faults; • hydrothermal minerals / metals precipitate / crystallise in order of temperature / solubility; • high temperature / least soluble minerals / cassiterite precipitate / crystallise first **OR** closest to intrusion; • low temperature / most soluble minerals / galena / sphalerite precipitate / crystallise last **OR** furthest from intrusion	1	**MAX 1** for formation

Question			Answer	Marks	Guidance
	(d)		any **three** from (pre-existing) mineral veins at surface – are the source; weathering – releases the minerals **OR** allows the minerals to be transported; weathering / erosion – separates the ore into individual grains; transport – separates ore minerals from gangue minerals **OR** sorts the minerals **OR** winnows the minerals; tin minerals / cassiterite is hard / has hardness of 6–7 / has no cleavage – so survives abrasion and attrition / erosion / transport; tin minerals / cassiterite is insoluble / chemically resistant – so is not dissolved / taken into solution; the tin minerals / cassiterite is (preferentially) deposited – because it is dense; tin minerals / cassiterite is transported downstream and deposited on inside of meander bends / point bar / in plunge pools of water falls / upstream of projections into river bed / downstream of confluences – where the current velocity slackens	3	each marking point **MUST** contain both description and explanation **ALLOW** heavy
	(e)	(i)	any **two** from • leaching solution is acidic **OR** leachate contains (dissolved) toxic / poisonous / heavy metals **OR** leaching solution can contain cyanide which is poisonous; • leakage may cause surface water pollution **OR** affect aquatic ecosystems **OR** may cause ground water pollution **OR** may contaminate aquifers; • wildlife / birds are at risk of poisoning **OR** habitats could be harmed; • leakage could cause soil contamination	2	

Question			Answer	Marks	Guidance
		(ii)	**crushing ore / tailings** crushing produces fine grained tailings which are difficult to dispose of **OR** tailings may contain toxic metals **OR** tailings may contain 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 into rives / groundwater / aquifers **OR** crushing produces dust **smelting ore** causes atmospheric pollution / acid rain / releases sulphur 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	1	environmental problem described **MUST** match correct named mineral processing technique **ALLOW** discussion of environmental consequence of any other correct named mineral processing technique
			Total	**17**	

Question			Answer	Marks	Guidance
5			**geological factors** any **four** from • rocks underlying the road / embankment need to be competent / strong / have high load bearing strength / suitable rock named; • foundations / embankments need to be on stable ground / no caves / no underground mine workings; • hard rocks will be expensive / difficult to cut through; • weathered rock in cuttings will be weak; • permeable rock allows water in which adds weight / lubrication leading to instability in cuttings; • embankments must be made of uniform materials **OR** cut and fill techniques may be employed; • angle of cutting depends on rock type – competent rock / correct named rock can have steep sides / will be stable **OR** incompetent rock / correct named rock needs shallow sides / are prone to failure; • if beds dip into cutting may get landslips **/** slumping / may be unstable; • if rocks are jointed / faulted / unconsolidated may get rock falls; • needs a local / cheap supply of aggregate for roadstone **OR** needs a local / cheap supply of aggregate for embankment fill; • description of suitable properties of roadstone – at least 2 points;	4	**MARK** labelled diagrams as text but **DO NOT** credit repetition on diagrams **ORA** for horizontal beds / beds dipping away

Question			Answer	Marks	Guidance
			stabilisation techniques any **four** from • slope modification – slope is reduced to lower angle **OR** benches are cut; • retaining wall – constructed of concrete **OR** gives toe support; • gabions – wire mesh boxes filled with rocks **OR** gives toe support **OR** prevents slumping; • rock bolts – used in competent rocks to prevent rock falls **OR** to pin loose rock to sound rock behind **OR** steel rods are cemented into rock faces **OR** rock bolt plates prevent rocks breaking out along joints; • rock drains – can be used to remove water **OR** reduce pore fluid pressure; • shotcrete – is sprayed concrete **OR** increases strength **OR** reduces permeability **OR** protects surfaces from weathering; • wire netting – fixes surfaces in places **OR** catches small rock falls; • vegetation – fixes soil in place **OR** reduces infiltration of water	4	**MAX 1** for list of stabilisation techniques – **MUST** have minimum of 3 techniques listed for each **MUST** describe technique or explain its purpose
			Total	**8**	

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553