OCR
Oxford Cambridge and RSA

GCE

Geology

Unit **F794:** Environmental Geology

Advanced GCE

Mark Scheme for June 2016

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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.

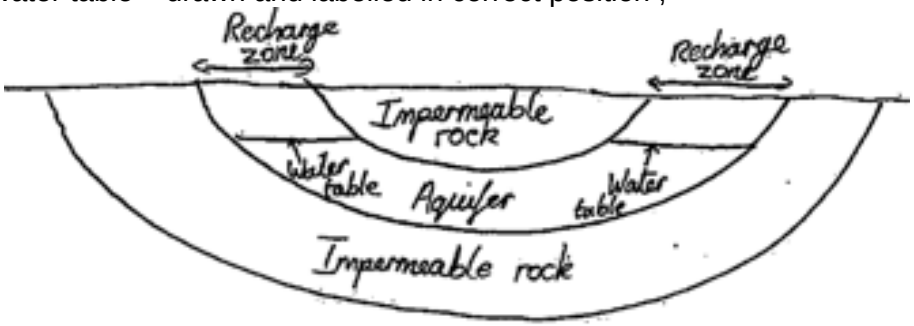
These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

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

Here is the mark scheme for this question paper.

Question			Answer/Indicative content	Mark	Guidance
1	(a)	(i)	syncline / synform / basin / dipping beds ;	1	
		(ii)	cross-section of aquifer correctly drawn and labelled as aquifer / porous / permeable / any correct named permeable rock **AND** impermeable rocks / aquicludes / any correct named impermeable rock(s) drawn and labelled above and below aquifer ; recharge zone(s) – drawn and labelled in correct position(s) where aquifer outcrops at surface ; water table – drawn and labelled in correct position ;  	1 1 1	**ALLOW** correct rock symbols in place of named rock(s) **ALLOW** correct labelling of a point within the recharge zone **ALLOW** water table drawn below the confining aquiclude provided it is approximately horizontal and only in the aquifer **DO NOT ALLOW** water table drawn through any impermeable rocks / aquicludes
		(iii)	487.1 – 431.4 / 431.4 x 100 = <u>12.91</u> **OR** <u>12.9</u> **OR** <u>13</u> (%) ;	1	
	(b)	(i)	18.3 / 100 x 160 = <u>29.28 **OR** 29.3 **OR** 29</u> (cm^3) ;	1	
		(ii)	any limestone **OR** sandstone **OR** arkose **OR** chalk **OR** conglomerate **OR** tuff **OR** unlithified / uncemented / partially cemented / unconsolidated rock **AND** is a porous rock **OR** has a large volume of pore space **OR** has a high porosity **OR** if oolitic limestone / desert sandstone has well sorted grains **OR** if fossiliferous / reef / bioclastic limestone has space between fossils ;	1	**ALLOW ECF** from **(b)(i)** – any suitable rock for porosity calculated but **MUST** be an appropriate aquifer rock **DO NOT ALLOW** greywacke **OR** <u>well</u> cemented sandstone **OR** <u>well</u> cemented limestone **ALLOW** discussion of permeability

Question			Answer/Indicative content	Mark	Guidance
	(c)		impermeable rock **OR** rock that does not transmit water **OR** rock that does not allow water to flow through it ;	1	**ALLOW AW** **DO NOT ALLOW** oil in place of water
1	(d)	(i)	**description** as grain diameter increases, permeability increases **OR** there is a positive correlation between grain diameter and permeability **OR** coarse grains have a higher permeability than fine grains ; **explanation** there is less resistance to flow around coarse grains **OR** there is less friction as water flows between coarse grains **OR** the pore spaces between coarse grains are larger allowing easier flow **OR** coarser grains increase the amount of interconnected pore space **OR** fine grains fill up the pore space reducing flow ;	1 1	**ORA** **DO NOT ALLOW** positive correlation with no description **ALLOW** answers comparing correct numeric values taken from the graph **ORA** **DO NOT ALLOW** rocks with coarse grains have more pore space explanation **MUST** refer to permeability / water flow
		(ii)	granite **OR** basalt **OR** cemented sandstone **OR** cemented / crystalline limestone **AND** is jointed / fractured causing permeability **OR** joints / fractures allow water flow ;	1	**ALLOW** any correct named competent rock that is jointed / fractured **ALLOW** shale with a correct explanation
	(e)		**ANY** 2 from: • (allows calculation of) how much water can be stored in the aquifer **OR** (calculation of) the volume of water in the aquifer **OR** (calculation of) capacity of the aquifer ; • (allows calculation of the rate of) flow of water through the aquifer **OR** (calculation of the rate of) recharge of the aquifer **OR** (calculation of) rate water can be abstracted from the aquifer ; • allows hydrogeologists to decide correct technique for sinking a borehole / lining a well / extracting the water **OR** whether it is economic to sink a borehole / well **OR** whether the aquifer is suitable for water abstraction **OR** whether water abstraction will be sustainable **OR** whether there will be over extraction ; • allows hydrogeologists to decide when secondary extraction methods are needed, e.g. acid solution or artificial fracturing ;	2	**ALLOW AW** **DO NOT ALLOW** oil in place of water **DO NOT ALLOW** definitions of porosity or permeability with no relevant explanations

Question			Answer/Indicative content	Mark	Guidance
	(f)	**(i)**	where boundary between sandstone and shale intersects with land surface ; where northern contact between igneous dyke and limestone intersects with land surface ; where the unconformity between slate and limestone intersects with land surface ;	**2**	3 correct = 2 marks **ANY** 2 correct = 1 mark 1 correct = 0 marks arrows must be within 1mm of boundaries **ALLOW** symbols other than arrows if in correct positions **DO NOT ALLOW** arrow on southern contact of the igneous dyke
1	**(f)**	**(ii)**	**ANY** 2 from: • where the water table intersects the (land / topographic) surface **OR** where an aquifer outcrops at the surface ; • at the boundary between permeable and impermeable (sedimentary) rocks **OR** at boundary between permeable sandstone above and impermeable shale below **OR** shale / igneous rock / slate act as an impermeable barrier ; • at the contact between the dyke / igneous intrusion and the sedimentary rock / limestone ; • at the <u>unconformity</u> (between the slate and the limestone) ; • springs require (high) hydrostatic pressure ;	**2**	
			Total	**17**	

Question			Answer/Indicative content	Mark	Guidance
2	(a)	(i)	**ANY** 2 from: clay is incompetent **OR** weak **OR** has low load bearing strength ; boundary between the limestone and clay is a zone of weakness / forms a slip plane **OR** bedding planes in the clay are weaknesses allowing slippage ; clay becomes saturated / waterlogged / stores water **OR** wet clay acts as a lubricant **OR** wet clay loses cohesion **OR** clay can absorb water **OR** clay has a high porosity **OR** clay will swell **OR** clay develops high pore fluid pressure ; the rocks / beds dip down the slope **OR** the rocks / beds are steeply dipping **OR** the rocks / beds dip to the east **OR** dip of rock / beds creates a slip plane ;	**2**	**DO NOT ALLOW** discussion of problems within the limestone **DO NOT ALLOW** discussion of problems within the tunnel **ALLOW** correct dip measurement taken from cross-section (55-60°) **ALLOW** beds dip in to tunnel

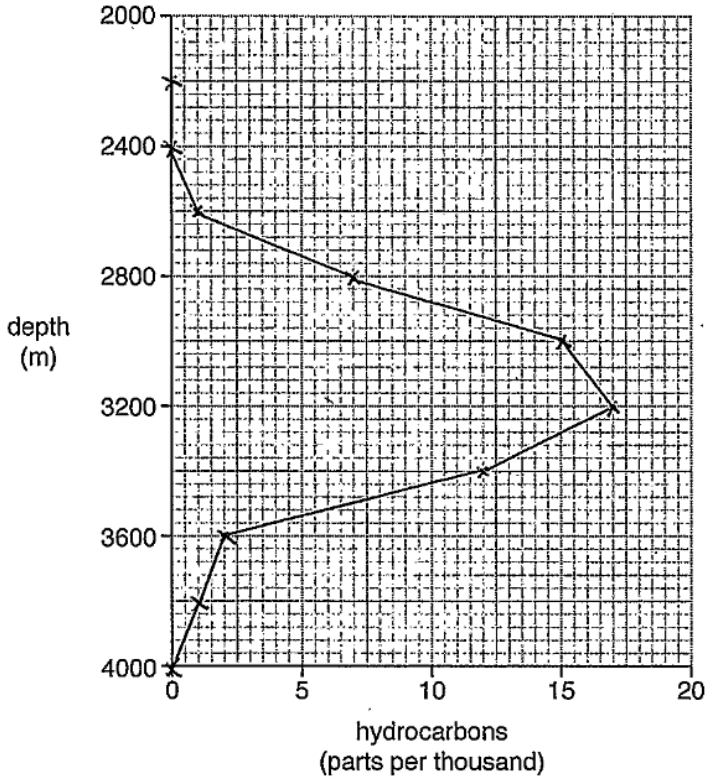
Question			Answer/Indicative content	Mark	Guidance
2	(a)	(ii)	**ANY** one from: slope modification **OR** correct named slope modification method **AND** to lower the angle of the slope above the portal **OR** to increase stability ; concrete retaining wall **OR** gabions **AND** to provide support above the tunnel portal ; rock drains **AND** to remove water which adds weight **OR** to remove water which acts as a lubricant **OR** to lower the pore fluid pressure ; vegetation **OR** geotextile **OR** shotcrete **AND** fixes clay in place **OR** reduces infiltration of water **OR** prevents weathering ; soil nails **OR** ground anchors **OR** bored piles **AND** stabilises the slope **OR** reinforces the slope above the portal ; chemical stabilisation methods **OR** NaCl / salt **OR** lime **OR** lime and salt **OR** cement **OR** lime and cement **OR** fly ash **OR** sodium hydroxide **OR** enzymes **AND** binds the clay together ;	1	explanation **MUST** match named ground improvement strategy **ALLOW** any other suitable named ground improvement method with a correct explanation **DO NOT ALLOW** strategies for stabilising inside the tunnel, e.g. steel rings or concrete lining **DO NOT ALLOW** rock bolts **OR** any other strategy used for competent rocks **IGNORE** grouting **DO NOT ALLOW** increases strength of rock **ALLOW** any correct named chemical with correct explanation

Question			Answer/Indicative content	Mark	Guidance
2	(a)	(iii)	**ANY** one description **AND** matching explanation from: **description 1** strike slip fault **OR** tear fault **OR** wrench fault **OR** dextral fault **OR** NNW-SSE trending fault **OR** fault has two different rock types on either side **OR** fault cuts through rocks **OR** fault has displaced rocks ; **explanation 1** fault is a zone of weakness **OR** there could be seismic activity **OR** there could be earthquakes **OR** fault could be reactivated **OR** if the fault moves the road will be displaced / damaged **OR** there could be differential subsidence on either side of fault ; **OR** **description 2** dolerite / hard dyke **OR** N-S trending dyke **OR** dyke cuts through rocks **OR** discordant igneous intrusion **OR** cross-cutting igneous intrusion ; **explanation 2** dolerite will be difficult to cut through **OR** drilling and blasting will be required to cut through the dolerite **OR** ground stabilisation methods will be required in the road cutting **OR** waste material from road cutting will require disposal ;	**2**	explanation **MUST** match description description **MUST** include the word fault **AND** a minimum of one other descriptor **ALLOW** N-S trend **DO NOT ALLOW** flooding as the problem **ALLOW** requirement of any suitable ground improvement method for a cutting in competent rock **DO NOT ALLOW** repeat of credited ground improvement method named in **(a) (ii)** **DO NOT ALLOW** discussion of costs unless qualified with geological reason
	(b)	**(i)**	**QWC mark** for correct use and spelling of **aggregate** as the technical term ;	**1**	

Question			Answer/Indicative content	Mark	Guidance
2	(b)	(ii)	dolerite would be (most) suitable **AND** it is strong / hard **OR** competent **OR** has high load bearing strength **OR** has high impact strength **OR** has high crushing strength **OR** is made of interlocking crystals **OR** is impermeable **OR** is resistant to mechanical weathering **OR** is resistant to chemical weathering / corrosion **OR** is made of more than one mineral of different hardness **OR** does not polish **OR** is skid resistant **OR** bonds well with bitumen ;	1	**MAX 2** if no statement(s) of suitability
			sandstone may / may not be suitable **AND** is made of grains **OR** (may be permeable so) is susceptible to mechanical weathering / frost shattering **OR** may not be cemented **OR** may be monominerallic so is all the same hardness **OR** (may be monominerallic so) will polish **OR** is strong **OR** is competent **OR** has high load bearing strength **OR** has high impact strength **OR** has high crushing strength **OR** is resistant to chemical weathering / corrosion ;	1	**DO NOT ALLOW** contradiction between suitability and description of characteristic(s)
			limestone may / may not be suitable **OR** limestone is least suitable **AND** is made of grains **OR** is soft / hardness = 3 **OR** (is permeable so) is chemically reactive / is susceptible to chemical weathering / corrosion / solution / carbonation **OR** (is permeable so) is susceptible to mechanical weathering / frost shattering **OR** is monominerallic so is all the same hardness **OR** (is monominerallic so) will polish **OR** is strong **OR** is competent **OR** has high load bearing strength **OR** has fairly high crushing strength ;	1	**DO NOT ALLOW** contradiction between suitability and description of characteristic(s) **DO NOT ALLOW** large scale features such as jointing **OR** large scale problems
			Total	9	

Question			Answer/Indicative content	Mark	Guidance
3	(a)	(i)	coal is made from the remains of (terrestrial) vegetation / plants / trees **AND** oil is made from the remains of plankton / (marine) microorganisms ;	1	**ALLOW** use of the terms petroleum **OR** hydrocarbons in place of oil **DO NOT ALLOW** macroscopic marine organisms for oil
		(ii)	**ANY** 2 from: coal forms in a deltaic / delta top / swamp / marsh / bog / floodplain / terrestrial environment / tropical rainforest **AND** oil forms in a <u>deep</u> marine / <u>deep</u> sea floor environment / low energy marine ; in coal formation the rate of deposition / sedimentation / burial is fast / rapid / high **AND** in oil formation the rate of deposition / sedimentation / burial is slow ; both coal **AND** oil form in anoxic / anaerobic / low oxygen / reducing / stagnant conditions ; both coal **AND** oil formation requires the presence of anaerobic bacteria ; both coal **AND** oil formation require the organic matter to be buried in fine sediment ;	2	coal **AND** oil / both **MUST** be considered for each marking point **ALLOW** use of the terms petroleum **OR** hydrocarbons in place of oil **DO NOT ALLOW** description of climate rather than environment for coal **ALLOW** alternative words to deep **MAX 1** if one correct description for coal and one correct description for oil from different marking points

Question			Answer/Indicative content	Mark	Guidance
3	(b)	(i)	**physical differences** **ANY** two for one mark from: • anthracite has higher hardness ; • anthracite has higher density ; • anthracite has higher reflectance ; • bituminous coal contains layers / cleats / has bands / is banded **AND** anthracite does not / is massive / has conchoidal fracture ; • bituminous coal is dull / dull and shiny **AND** anthracite is shiny / glassy / vitreous / iridescent ; • bituminous coal may contain (plant) fossils **AND** anthracite does not ; **chemical differences** **ANY** two for one mark from: • anthracite has a higher carbon content ; • anthracite has a higher calorific value **OR** produces more heat energy per kg when burnt **OR** produces less ash when burnt **OR** produces less smoke when burnt ; • anthracite contains fewer volatiles **OR** less of any correct named volatile ; • anthracite contains less water ; • anthracite contains fewer impurities **OR** less sulfur / pyrite / iron sulfide ;	**1** **1**	**ORA** **MUST** compare bituminous coal and anthracite **ALLOW** correct answers give in order of increasing rank **ALLOW** numerical comparisons of differences **MAX 1** if one correct physical difference **AND** one correct chemical difference stated
		(ii)	**name** coalification / diagenesis / lithification / compaction ; **description** **ANY** two for one mark from: • organic matter is compressed / compacted ; • sediment accumulates on top / is buried ; • subjected to weight of overburden / overlying sediment ; • is put under <u>load / confining</u> pressure ; • temperature increases ; • loss of volatiles / water occurs ; • thickness of seam reduces ;	**1** **1**	**DO NOT ALLOW** maturation

Question			Answer/Indicative content	Mark	Guidance
3	(c)	(i)	mudstone **OR** shale **OR** clay **OR** black / dark coloured and fine-grained rock **AND** high / rich in organic matter **OR** contains abundant plankton **OR** has high total organic carbon content ;	1	**ALLOW** alternative words to high that are quantitative **ALLOW** percentage of organic carbon greater that 8%
		(ii)	**QWC mark** for correct use and spelling of **maturation** as the technical term ;	1	
		(iii)	points plotted and joined with a line – line may be drawn point to point **OR** as a curve ;  	2	at least **8 points** plotted correctly = **1 mark** points joined with a line = **1 mark**

Question			Answer/Indicative content	Mark	Guidance
		(iv)	3200 m **OR** 3.2 km ;	**1**	**MUST** have correct units for mark **ALLOW ECF** from graph in **(c)(iii)**
		(v)	3.2 x 30 + 15 = 111 (°C) ;	**1**	**ALLOW ECF** from **(c)(iv)**
	(d)		**ANY** 2 from: oil migrates down pressure gradient / hydraulic gradient **OR** migrates from high pressure to low pressure (which is usually upwards) **OR** moves in response to hydrostatic pressure ; oil is less dense than water (in pore space so migrates / percolates upwards) ; oil will migrate upwards until it meets a cap rock **OR** oil will migrate upwards until it meets an impermeable rock **OR** oil will migrate upwards through permeable rocks **OR** oil will flow upwards through permeable rocks / unsealed faults ;	**2**	
3	**(e)**		**origin** **ANY** one from: (the source rock is) coal **OR** terrestrial vegetation **OR** plant matter ; **explanation of accumulation** **ANY** 2 for 1 mark from: • gas migrated (from the source rock) **OR** moved through permeable rocks **OR** moved through pore spaces / joints; • into permeable rocks **OR** into a reservoir rock **OR** correct named reservoir rock ; • under cap rocks / impermeable rocks / evaporites **OR** correct named cap rock ; • in a suitable trap **OR** any correct named trap ;	**1** **1**	 **ALLOW** one mark if incorrect origin but explanation includes coal **AND** one other correct marking point
			Total	**17**	

Question			Answer/Indicative content	Mark	Guidance
4	(a)		**environmental consequence** **ANY** one from: • hydroelectric power is a renewable energy source **OR** the water supply is renewable ; • hydroelectric power plant does not produce carbon dioxide / greenhouse gas emissions when in operation ; • manufacture of the cement / concrete used in dam construction produces large volumes of carbon dioxide / greenhouse gases ; • large areas of land may be flooded for reservoir **OR** habitat loss due to flooding ; • reservoir will silt up **OR** clear water erosion downstream of dam ; • damage to river / aquatic ecosystems / habitats **OR** changes in water depth / water temperature / dissolved oxygen content of water (will affect ecosystems) **OR** prevents salmon / fish swimming upstream / to their breeding grounds ; • weight of water in reservoirs may trigger earthquakes / seismic activity ; **social consequence** **ANY** one from: • the dam and reservoir can be used for other uses **OR** the dam and reservoir can be used for any other correct named use, e.g. water supply, recreation ; • produces cheap electricity **OR** once hydroelectric power plant is in operation the running costs are very low ; • hydroelectric power plant may not be able to work all the time as it requires sufficient rainfall in catchment **OR** it requires sufficient water in reservoir **OR** it may be seasonal ; • people / villages / farmers may be displaced when the dam / reservoir is built ; • possibility of failure of dam causing downstream flooding / death of people ; • people / communities downstream of the dam and reservoir receive less water ;	**1** **1**	**ALLOW** description of any other correct environmental problem associated with dams and reservoirs **DO NOT ALLOW** discussion of <u>marine</u> ecosystems / habitats **OR** ecosystems / habitats with no qualification **ALLOW** tectonic activity **ALLOW** any other sensible suggestion **DO NOT ALLOW** employment opportunities **DO NOT ALLOW** unsightly / visual pollution

Question			Answer/Indicative content	Mark	Guidance
4	(b)		**ANY** 2 from: there are no active volcanoes in the British Isles **OR** the British Isles are not in a suitable plate tectonic setting so it would not be feasible ; the geothermal gradient in most parts of the British Isles is too low **OR** there are only low enthalpy systems in the British Isles **OR** there are no high enthalpy systems in the British Isles so it would not be feasible ; there are granites which are hot, dry rocks in the British Isles **OR** there are granites / hot, dry rock sources in southwest England / northern England / Eastern Highlands / Scotland which could be developed **OR** past attempts to develop hot, dry rock sources in the British Isles were abandoned as uneconomic ; granites / hot, dry rock sources have geothermal gradients of 40°C / km **OR** granites / hot, dry rock sources are heated by radioactive decay **OR** (steam from) granites / hot, dry rock sources could be used to drive turbines / generate electricity ; there are geothermal aquifers in the British Isles **OR** the Hampshire basin / East Yorkshire basin / Lincolnshire basin / Cheshire Basin / Northern Ireland basin / Midland Valley of Scotland contain suitable geothermal aquifers that could be developed ; geothermal aquifers (in the British Isles) could not be used for electricity generation **OR** geothermal aquifers (in the British Isles) could be used for space heating / hot water supply / greenhouses / any correct named use **OR** ground source heating can be installed in individual homes ; some places / Southampton / Cleethorpes / Crewe are already extracting geothermal energy on a small scale so it is feasible ;	**2**	**DO NOT ALLOW** discussion of costs unless qualified with geological reason **DO NOT ALLOW** discussion of opposition on environmental grounds **ALLOW** any other correct named geographic area in the British Isles **ALLOW** any other correct named geographic area in the British Isles **ALLOW** any other correct named place in the British Isles

Question			Answer/Indicative content	Mark	Guidance
4	(c)	(i)	**ANY** 2 from: uranium is leached / dissolved (from rocks) **AND** because its soluble **OR** uranium is leached / dissolved / soluble **AND** in oxidising conditions **OR** uranium undergoes chemical weathering **AND** is leached / dissolved / taken into solution **OR** uranium is dissolved **AND** so it can be carried in solution ; (dissolved) uranium is transported / percolates **AND** by groundwater **OR** through aquifers **OR** through fossil river channels **OR** through permeable sandstones ; uranium ore is precipitated **OR** curved **/** roll-type **/** roll-front deposits form **AND** at redox boundaries **OR** where conditions change (from oxidising) to reducing **OR** at / immediately below the water table ; uranium is found in association with wood / organic matter **AND** due to presence of sulfur-reducing / sulfur-fixing / sulphur-respiring bacteria ;	**2**	each marking point **MUST** contain a description **AND** a matching explanation **DO NOT ALLOW** deposited

Question			Answer/Indicative content	Mark	Guidance
4	(c)	(ii)	**ANY** 3 from: must be a tectonically stable area **OR** aseismic area **OR** have no earthquakes **OR** away from plate margins **OR** away from active faults **OR** away from volcanic activity **AND** so repository won't collapse / be damaged **OR** repository will remain intact / stable / won't fracture / won't break **OR** so radioactive materials won't leak out ; rocks must be competent **OR** strong **OR** igneous **OR** metamorphic **AND** so the repository / large cavities can be excavated **OR** so the repository won't collapse / won't fracture / won't break **OR** so the repository can withstand earthquakes / natural hazards ; rocks must be impermeable **OR** dry **OR** crystalline **OR** unjointed **OR** have no faults **OR** water table needs to be as low as possible **AND** so radioactive materials won't leak out **OR** so water cannot enter **OR** so containers do not corrode / rust **OR** as waste needs to be isolated for at least 250,000 years rocks must be crystalline **OR** cemented **OR** compacted **OR** dense **AND** so radiation is absorbed **OR** so radiation can't escape ; description of named unsuitable rock type with correct explanation, e.g. granite is unsuitable as it contains a higher concentration of radioactive elements or releases radon which is radioactive **OR** evaporites dissolve and produce salty water that will corrode containers ;	**3**	**ORA** each marking point **MUST** contain a description of a geological factor **AND** a matching explanation explanations **MUST** be specific to the storage of nuclear waste in an underground repository, e.g. leakage or groundwater contamination with no qualification is insufficient
			Total	**9**	

Question			Answer/Indicative content	Mark	Guidance
5			**metallic mineral deposits in mafic (gabbro) intrusions** **MAX ANY** 4 from: • form by gravity settling **OR** magmatic segregation **OR** magmatic differentiation **OR** fractional crystallisation ; • magnetite crystallises early **OR** magnetite forms at a high temperature **OR** magnetite has a high melting point ; • mafic magma is fluid **OR** mafic magma has low viscosity **OR** mafic magma is rich in iron ; • magnetite / ore mineral is <u>dense</u> and sinks / settles down through the magma ; • magma cools / crystallises slowly allowing time for gravity settling to occur ; • magnetite / ore mineral forms a <u>cumulate</u> layer **OR** magnetite / ore mineral forms a layer at the base of the intrusion **OR** magnetite / ore mineral is concentrated at the base of the intrusion ; • ore deposits may form as a result of liquid immiscibility **OR** sulfide and silicate liquids do not mix **OR** immiscible droplets of sulfide minerals can coalesce together to form a cumulate layer **OR** sulfide liquids can be injected into fractures **OR** sulfide liquids can form veins ;		**MAX 4** if correct descriptions of ore deposit types associated with each type of intrusion are transposed **DO NOT ALLOW** descriptions of any other ore deposit types **MARK** labelled diagrams as text **DO NOT CREDIT** repetition of text on diagram **DO NOT ALLOW** gravity filtering **DO NOT ALLOW** precipitate **ALLOW** any correct named ore mineral that forms by gravity settling **ALLOW** heavy **ALLOW** are deposited

Question			Answer/Indicative content	Mark	Guidance
			metallic mineral deposits in and around silicic (granite) intrusions **MAX ANY** 4 from: • form by hydrothermal processes **OR** form during final crystallisation of watery / residual magma **OR** form as a result of late stage processes **OR** water / volatiles / incompatible elements / metals that do not fit in silicate minerals collect at top of magma chamber ; • silicic / granite magmas are rich in water **OR** silicic / granite magmas are rich in volatiles **OR** silicic / granite magmas are the source of heat, water and metals **OR** hydrothermal fluid is a hot, watery / aqueous fluid with metals in solution ; • as intrusion cools cooling joints form **OR** cooling joints allow fluid to move out into country rock **OR** fluid moves through joints / bedding planes / faults / fractures / permeable rock **OR** veins form when crystallisation occurs in joints / bedding planes / faults / fractures ; • when fluid cools, ore minerals crystallise **OR** when fluid encounters chemically reactive country rock, ore minerals crystallise **OR** ore minerals crystallise in order of temperature **OR** ore minerals crystallise in order of solubility **OR** there is a zonation of metals around intrusion ; • cassiterite is a high temperature mineral **OR** cassiterite is the least soluble mineral **AND** crystallises first **OR** crystallises closest to intrusion **OR** crystallises on edge of vein ; • galena / sphalerite is a low temperature mineral **OR** galena / sphalerite is the most soluble mineral **AND** crystallises last **OR** crystallises furthest from intrusion **OR** crystallises in the centre of the vein ; • veins show a symmetrical pattern **OR** disseminations form when crystallisation occurs in pore space ;		**MARK** labelled diagrams as text **DO NOT CREDIT** repetition of text on diagram **IGNORE** lines of weakness **ALLOW** precipitate **DO NOT ALLOW** are deposited **DO NOT ALLOW** melting point **MAX 2** for discussion of correct named ore minerals
			Total	**8**	

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