A-level

ENVIRONMENTAL SCIENCE

7447/1

Paper 1

Mark scheme

June 2023

Version: 1.1 Final

2 3 6 A 7 4 4 7 / 1 / M S

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Qu	Part	Marking guidance	Comments	Total marks	AO
01	1	<table><tr><th>Name of process</th><th>Number</th></tr><tr><td>Weathering</td><td>2</td></tr><tr><td>Absorption/uptake</td><td>4</td></tr><tr><td>Decomposition/decay</td><td>7</td></tr><tr><td>Runoff</td><td>3</td></tr><tr><td>Mountain building</td><td>1</td></tr></table>		4	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
01	2	• Addition/use of organic fertiliser/matter/DOM/manure/mulch/guano deposits.		1	AO1 1b
			Total =	**5**	

<table>
<tr><th>Qu</th><th>Part</th><th colspan="2">Marking guidance</th><th>Comments</th><th>Total marks</th><th>AO</th></tr>
<tr><td>02</td><td>1</td><td colspan="3">
<table>
<tr><th>Name of survey technique</th><th>Description of how it works</th></tr>
<tr><td>Seismic survey</td><td>The use of reflected sound waves to produce data about the density and shape of rock strata at great depth</td></tr>
<tr><td>Resistivity</td><td>Measurement of the difficulty/ease of the passage of an electric current through rock</td></tr>
<tr><td>Gravimetry/
gravimetric surveys
A: Seismic surveys</td><td>Technique used to measure or map variations in density of crustal rocks</td></tr>
</table>
</td><td>1
1
1</td><td>AO1 1a</td></tr>
</table>

Qu	Part	Marking guidance	Comments	Total marks	AO
02	2	Drones: • larger area covered per unit time/large amount of data per unit area/lower cost per unit area/survey inaccessible areas/doesn’t require direct access/less labour intensive/reduction of <u>named</u> environmental impact Trial drilling: • define extent/boundaries/purity/quality of mineral ore deposit from core samples/only method of obtaining rock samples/test rock stability/confirm safe to drill.		1 1	AO2

<table>
<tr><th>Qu</th><th>Part</th><th>Marking guidance</th><th>Comments</th><th>Total marks</th><th>AO</th></tr>
<tr><td>02</td><td>3</td><td colspan="2">One mark for impact and a linked explanation of how reduced.

Max 5 impacts and linked explanation.
eg

Impact – (increase in) noise pollution

Explanation of how impact reduced
- use of acoustic insulation (of machinery) absorbs sound/baffle mounds/embankments/walls/vegetation/buffer zone deflects/reflects/contains sound.
- operations, eg blasting at less annoying times/time zoning, eg allocated days and times.
- maintenance/lubrication of machinery to get rid of squeaks
- transport routes away from sensitive areas, eg densely populated

Impact – (increase in) dust pollution

Explanation of how impact reduced
- aid settling by creating heavier dust particles by use of water
- sprays/sprinklers/bowsers/road/tyre washing
- compacted dust less prone to wind erosion
- covered loads prevent dust loss by air currents
- use of filters/face masks/electrostatic precipitator/cyclone separator remove dust particles

Impact –Turbid (drainage) water pollution

Explanation of how impact reduced
- sedimentation lagoons allow settling

Impact – Aesthetics (of site including spoil/waste)/visual/loss of amenity

Explanation of how impact reduced
- use of landscaping/trees as visual barriers/screens

Impact – Unstable spoil heaps/landslips/slides/subsidence

Explanation of how impact reduced
- use of landscaping to reduce gradients/improve stability by vegetation covering/avoid waterlogging
- backfilling/support beams

Impact – (Acidic) leachate/mine water/heavy metal pollution

Explanation of how impact reduced
- raise pH by passing leachate over limestone filter bed
- bioremediation (of heavy metals)</td><td>5</td><td>AO1 1b</td></tr>
</table>

		Impact - Habitat loss/damage/land take **Explanation of how impact reduced** - restoration/creation/rewilding/relocation - deep shaft mining/directional drilling **Impact –** <u>named</u> greenhouse gas emissions from vehicles/machinery **Explanation of how impact reduced** - hybrid/electric vehicles - catalytic converters (for NO_x)		
		Total =	**10**	

Qu	Part	Marking guidance	Comments	Total marks	AO
03	1	• sandy clay		1	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
03	2	• highest sand content/lowest clay content • larger pore spaces between sand grains/smaller pore spaces in clay soils/crumb structure compared to platy structure/more porous		1 1	AO3 1a AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
03	3	Max **two** features Max **two linked** impacts on nutrients Features: **Two** from • Drainage rate – sandy soils increased water loss/clay soils retain water • Aeration/pore spaces - sandy soils have large pore spaces /more aeration, clay soils have small spaces/less aeration • Root penetration – sandy soils have larger pores spaces increasing root penetration/clay soils have small particles/particles held together so decreased root penetration • Clay has (negative) charges on particles Impacts: **Two** from • Sandy soils - increases nutrient loss by leaching/clay soils decreases nutrient loss by leaching • Sandy soils - increased decomposition/DOM, clay soils -decreased decomposition/DOM • Sandy soils – increased nitrification/bacterial oxidation increasing nutrient levels/clay soils decreased		4	AO1 1b

		nitrification/bacterial oxidation decreasing nutrient levels • Clay soils – adsorption on particle surface/cation exchange Allow 1 mark for a named texture and linked appropriate nutrient level e.g.clay soils have higher nutrient levels			

Qu	Part	Marking guidance	Comments	Total marks	AO
03	**4**	• 13 **or** 437 • 2.9 ecf Award 2 marks for correct answer with no working	450 – 437 13/450 x 100 = 2.88… **or** 437/450 x 100 = 97.11, 100 – 97.11 = 2.9%	**1** **1**	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
03	**5**	• Particles trapped in mesh/lost as dust/attracted to sieve sides and mesh, **eg** static so cannot be removed and weighed		**1**	AO3 1b
			Total =	**10**	

Qu	Part	Marking guidance	Comments	Total marks	AO
04	**1**	Up to **two** marks for trend description. Up to **two** marks for linked explanation. **Trend (must link to variable)**: e.g. • low slope gradient (< five) no soil loss • more soil lost (eroded) from farmland(than from bare/forest)/least soil from forest (compared to bare and farmland). • as gradient increases mass of sediment collected/eroded increases (in all areas) • less sediment collected/eroded from forests than farmland • in forest exponential soil loss but uniform in farmland and bare soil as gradient increases • forest has a slower rise in the rate of soil loss compared bare soil / farmland. **R** the same trend repeated **Explanation**: **e.g.** • force of gravity < cohesive forces between soil particles • increased surface run off/speed of run off • particles more easily moved by downward flow of water/kinetic energy of soil particles increase/due to rainsplash • exposure to wind (higher velocity) leads increases erosion rate (on open surfaces) • more interception provided by canopy cover/allows time for water to infiltrate so less runoff/less time for water to infiltrate so more runoff/reduces rainsplash • protective effect of canopy reduced as gradient increases • root binding by long term/deep rooted trees/so less soil disturbance • leaf litter (from trees) increases OM content of soil and increases water holding capacity of soil so less runoff • more soil disturbance due to ploughing/crop rotation/lower levels of soil OM		**2** **2**	AO3 1a = 2 AO3 1b = 2

Qu	Part	Marking guidance	Comments	Total marks	AO
04	2	**Two** marks for variables. **Two** marks for linked explanation. **eg** • soil texture • infiltration/permeability affects runoff rates • length of slope • affects volume/speed of runoff • volume of water falling at each site over year • affects amount of runoff/rain splash erosion • wind velocities/direction/duration • wind energy moves/dislodges particles/scouring • soil depth • greater soil depth affects water holding capacity • temperature • affects evaporation /drying rates Allow 1 mark for valid comparison of variables e.g. higher rainfall areas will have more erosion/ref to keeping named variable the same/similar		4	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
04	3	Any **two** from: Sedimentation reduces • flow capacity /causes downstream flooding • biodiversity of aquatic/coral reefs/fish nursery grounds • depth/volume reduced (for aquatic organisms) Turbidity • reduces photosynthesis • blocks fish gills • inhibit filter feeders • reduces visibility of food source/prey/predator • Increased nutrients lead to eutrophication/eutrophication leads to algal blooms/deoxygenation • Pesticides cause toxicity/bioaccumulation/biomagnification		2	AO1 1b
		Total =		**10**	

Qu	Part	Marking guidance	Comments	Total marks	AO
05	**1**	• 1005 + 16 305 + 684 + 7172 **or** 25 166 • 49 078 – 25 166 **or** 23 912 ecf from 1st mpt (their 25 166) • (23 912/60 000) x 100 ecf from 2nd m.pt (their 23 912) • 39.9% Max 3 marks for one ecf Max 2 marks for two ecf Award 4 marks for correct answer with no working	Total electricity generated in 2019: 1005 + 16 305 + 684 +7172 = 25 166 MW Increased electricity that needs to be generated by 2050: 49 078 – 25 166 = 23 912 MW as % of 60 000 MW available (23 912/60 000) x 100 = 39.853 to 1 dp	**4**	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
05	2	**Five** from: • fewer locational constraints of large HEP projects, **eg** suitable valleys/ micro HEP suitable for isolated/inaccessible areas • can be used in areas where water drop is over short distance • can be used for lower velocities/flow rate • Micro HEP schemes don't dam rivers/(divert water) so less flooding • reduction of **named** environmental impact **eg** habitat loss/allow fish (organisms) to pass without damage • less infrastructure needed/only connect to local community • local community maintenance and repair/less dependent on larger companies for support/other **named** reduced cost **eg** installation • sufficient for low demand/smaller population • less wasted energy • reduced **named** impact on local community **eg** fisheries • (Kaplan can) rotate to max amount of kinetic energy harnessed/(Kaplan and) helical turbines have high efficiency • helical turbines can use turbid water without damaging blades • water wheels do not suffer from screen blockages		**5**	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
05	3	**One** from: • named conflict/objection, **eg** aesthetics, land use/ownership, path of connecting cables, planning not granted/disputes between local villages about installation/ecologically sensitivity (designated areas/species protection)/blocking transport routes for boats • responsibility/expertise for maintenance lacking • lack of local funding/lack of local policies on renewables • lack of (affordable) generators/equipment/spare parts/infrastructure to transport electricity • accessibility problems.		**1**	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
05	**4**	• 10.3%	0.67/6.5 x 100 = 10.3% of max flow rate	**1**	AO3 1a
		• 42 % efficiency (A: figures in the range 40% - 44%)	Accept correct reading from graph using their figure from mpt 1 10.3% (or their figure) flow rate = 42 % efficiency	**1**	
		• 48.8 kW (A: 46.5 kW – 51.2 kW) Award 3 marks for correct answer with no working Max 2 marks for one ecf Max 1 marks for two ecf	0.67 flow rate = 100 x 42/86 = 48.83	**1**	

Qu	Part	Marking guidance	Comments	Total marks	AO
05	**5**	**Two** from: • wildlife habitat change/creation/destruction (due to flooded areas) • barrier to migratory fish species (reducing population numbers) • loss of named land use **eg** farming, forestry • anaerobic conditions increase methane (due to OM decomposition) • changed abiotic factor **eg** increased wind speeds, temp extremes reduced, humidity • reduced nutrients downstream (due to less sediment transfer) • loss of land due to (potential) increased bank erosion downstream • reservoir induced seismicity/instability due to mass of water • sedimentation build-up behind dam causing stress on dam • reduced water flow downstream for habitats, land use **eg** farming, fisheries, water provision • reduced water flow downstream leading to rivers drying up / drought conditions.		**2**	AO1 1b
		Total =		**15**	

Qu	Part	Marking guidance	Comments	Total marks	AO
06	**1**	**Advantage**: • (base load) production as reliable/predictable/consistent **Disadvantage**: • cannot respond quickly to sudden peaks/increased demand		**1** **1**	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
06	**2**	Three from • (surplus electricity used to) pump water up/to top reservoir • stored as gravitational potential energy/GPE/peak shaving • water released (to match fluctuations in demand.) • quick/rapid response		**3**	AO2
			Total =	**5**	

Qu	Part	Marking guidance	Comments	Total marks	AO
07	1	• 17	(land) X = 107 – (19 + 71) = 17 **or** (oceans) X = 434 – (398 + 19) = 17	1	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
07	2	**One** mark for selecting correct figures for use in RT calculation • 4.5 + 11 = 15.5 **and** 398 + 107 or 434 + 71 = 505	Volume in reservoir: 4.5 +11 = 15.5 x 10^{15} **and** annual rate of flow in or out: 398 +107 = 505 or 434 + 71 = 505 x 10^{15}	1	AO3 1a
		One mark for calculation of RT • 0.03(069307) year	15.5 x 10^{15}/505 x 10^{15} = 0.03069307 year	1	
		One mark for final answer in days • 11 days Max 2 marks for 1 ecf Max 1 mark for 2 ecf Award 3 marks for correct answer with no working	0.03069307 x 365 days = 11.2 days = 11 days to nearest whole day	1	

Qu	Part	Marking guidance	Comments	Total marks	AO
07	3	• more interception/more (evapo)transpiration/less infiltration/more (root) uptake (so less water percolates down)/less runoff		1	AO2
			Total =	5	

Qu	Part	Marking guidance	Comments	Total marks	AO
08	1	• 500 minutes [A: 450 – 550 minutes] • 8 hours 20 minutes [A: correct conversion of value from MP1] Award 2 marks for correct answer with no working		1 1	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
08	2	**Two** from: e.g • stress • ulcers • high blood pressure • heart disease • tinnitus • psychological issues/aggression/irritability • sleeplessness. R: brain damage, cancer		2	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
08	3	**Five** from: **Two** marks: • calibrated/standardised sound level meters • calibrated/standardised sound emitter **One** mark: • systematic sampling/regular/equal intervals **Two** marks: • 10 or more sampling sites / 50m intervals to 500m • transect length at least 500 m /to the houses/residents **Two** marks from reliability: • same wind direction/velocity/humidity/rainfall • same height of sound meter from source • same topography/same place/same reflective or absorbent surfaces nearby • repeating readings (at each site) to obtain a mean • same height of barrier.		5	AO3 1a

Qu	Part	Marking guidance	Comments	Total marks	AO
08	**4**	**One** from: • double/triple glazing and absorbs noise/(gas in gap) reduces noise transmission • acoustic insulation to deflect/absorb noise • living areas/gardens/windows positioned at the opposite side of the house to increase distance from source • (acoustic) barriers, **eg** vegetation/embankments to absorb/deflect/contain noise • (planned) increased distance of building from source as noise reduction is inversely proportional to distance from source/inverse square law.		**1**	AO1 1b
		Total =		**10**	

Qu	Part	Marking guidance	Comments	Total marks	AO
09	**1**	**One** mark for volume • 1254 m^3 **One** mark for mass • 1191.300 kg **One** mark for mass in tonnes (2 sig figs) • 1200 Max 2 marks for one ecf Max 1 mark for two ecf Award 3 marks for correct answer with no working	Any valid method, **eg** **1)** Area covered = 3.3 km^2 = 3.3 x 10^6 m^2 Depth of oil = 0.38 mm = 0.38 x 10^{-3} m Volume = area x depth = (3.3 x 10^6 m^2) x (0.38 x 10^{-3} m) = 1254 m^3 Mass of oil spilled = volume x density = 1254 m^3 x 950 kg m^{-3} = 1191300 kg = 1191.300 tonnes = 1200 tonnes (2 sig figs) **2)** Area covered = 3.3 km^2 = 3.3 x 10^6 m^2 = 3.3 x 10^{12} mm^2 Depth of oil = 0.38 mm Volume = area x depth = (3.3 x 10^{12} mm^2) x (0.38 mm) = 1.254 x 10^{12} mm^3 (10^9 mm^3 in a m^3 so ….) = 1.254 x 10^3 m^3 Mass of oil spilled = volume x density = 1254 m^3 x 950 kg m^{-3} = 1191300 kg = 1191.300 tonnes = 1200 tonnes (2 sig figs)	**3**	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
09	**2**	**Two** from: • (large amounts of data) can be collected quickly • continuous data collection (over time)/ extent of spread can be accurately measured • wider area can be covered • can detect spills quickly/planes have to respond to known spills		**2**	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
09	3	**Two** from: • reduces light available for <u>photosynthesis</u> • reduces dissolved oxygen for respiration (by coral polyps) • toxic effects on coral/food sources of polyps • reduces filter feeding/clogs cilia of polyps • **named** example of species interdependence **eg** food source of coral eg, plankton, reducing nutrients		**2**	AO1 1b

Qu	Part	Marking guidance	Comments	Total marks	AO
09	4	**Three** from: • improved shipping routes/shipping routes moved away from coastlines where possible • improved navigation systems/GPS/AIS • inert gas systems/cooled exhaust gas to fill tanks after unloading • recirculating oil in oil tanks rather than washing of oil tanks (sludges not discharged) • oily waste water disposal/oil separated from water at terminal • double hulls/gap between hulls (so damage to outer hull reduces risk of oil leaking)/reinforced/strengthened hulls • twin engines/rudders/fuel tanks (if one fails there is a back-up to avoid collisions) • separate oil and ballast tanks (avoid oily water being discharged when cargo is loaded) • fewer but larger oil tankers/fewer but larger oil spills.		**3**	AO2
			Total =	**10**	

Qu	Part	Marking guidance	Comments	Total marks	AO
10	**1**	**Four** from: • reversal/weakening of the trade winds • reversal/change of direction of (surface) current • <u>warm</u> (surface) waters towards the coast of Peru • no upwelling/cold dense water does not rise • nutrients do not rise • no food for anchovy as phytoplankton blooms/food chains collapse.		**4**	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
10	**2**	**Two** from: Increased: • temperatures • humidity • rainfall/flooding/(tropical) storms • landslides/soil/coastal erosion • ice melt • plant growth/crops • disease, **eg** malaria.		**2**	AO2

Qu	Part	Marking guidance	Comments	Total marks	AO
10	**3**	For L3 students must evaluate the success of a range of these measures and include descriptions of both methods and strategies.		**9**	AO1 4 1a 2 1b 2 AO2 3 AO3 2 1b 1 1c 1

Greenhouse gases	General methods/strategies	Specific methods/strategies	Evaluation of success (Examples)
ALL	Legislation – Kyoto Protocol 1997/Paris Agreement 2015 (plus Montreal Protocol 1987 for CFCs and other ODSs that are GHGs)	Targets for reduction in emissions/methods to limit GMST increase to 2^0 C	Not all countries signed up (Kyoto, Paris) Success of Paris not yet known Montreal successful – alternatives available, fewer ways in which ODSs used
CO_2	Technological methods	Carbon capture and storage Afforestation/reforestation Geoengineering (examples) Increased efficiency of combustion, **eg** in vehicle engines (MOT tests) Alternative energy resources (**eg** named renewables, nuclear fission)	CCS still under-developed Afforestation/reforestation will act as immediate carbon sinks Geo-engineering – less impact so far than other methods Transport – CO_2 emissions have been reduced Low carbon energy resources very successfully used (examples of expansion of wind and solar in UK and worldwide etc, massive reduction in coal fired-power stations UK
	Energy conservation (could also be considered as technological methods)	Domestic, **eg** insulation, heat recovery systems, double glazing, low energy appliances Industry, **eg** insulation, heat recovery systems, high volume storage, CHP/District Heating	Govt schemes to increase conservation and industrial conservation have been successful Govt targets to phase out fossil fuel vehicles by 2030 – too early to evaluate success

		Transport: bulk transport, vehicle design (lower mass materials etc)	
	Behavioural methods	Car sharing, turning heating down, buying locally produced food, turning off lights etc	Individual behaviour varies – cheap food not locally produced still prevalent in supermarkets, out of season food transported globally, car sharing not convenient. Less successful
CH_4	Technological methods	Collecting methane from landfill for energy production Reducing livestock production – low meat diets Reducing organic waste going to landfill (waste food collection/composting) Improving coal mine ventilation/collection of methane from coalmine ventilation Increased maintenance of gas pipelines to reduce methane leaks R: reduce production of rice (as this has not been used – ethical issues?)	Increased electricity production from landfill gas EU landfill directive/landfill tax reducing waste to landfill
	Behavioural methods	Changing to low/no meat diets Composting of food waste	More people becoming vegetarian/vegan More opportunities and willingness to recycle, compost etc
NO_x	Technological methods	Alternative energy resources (for electricity generation and vehicles) Catalytic converters Urea sprays Low temperature combustion	Successful implementation of alternative energy resources (but still a long way to go). Catalytic converters have reduced NO_x from petrol engines but not diesel
	Energy conservation methods	Domestic, **eg** insulation, heat recovery systems,	See CO_2

	(could also include technological methods)	double glazing, low energy appliances Industry, **eg** insulation, heat recovery systems, high volume storage, CHP/District Heating Transport: bulk transport, vehicle design (lower mass materials etc)	
	Behavioural methods	Car sharing, not buying diesel vehicles, turning heating down, buying locally produced food, turning off lights etc	See CO_2
CFCs	Technological methods	Alternative processes (trigger/pump action sprays, roll on deodorants) Alternative materials (alcohols, propane, butane, isobutene, HCFCs, HFCs) Collection and incineration of CFCs	Successful as production was quickly banned – alternatives available
Tropospheric ozone	Any method that reduces NO_x		Still problematic in areas of the world where catalytic converters not a legal requirement on petrol engines
		Total =	**15**

Examiners are reminded that AO1, AO2 and AO3 are regarded as interdependent. When deciding on a mark all should be considered together using the best fit approach. In doing so, examiners should bear in mind the relative weightings of the assessment objectives. More weight should therefore be given to AO1 than AO2 and AO3.

Level	Marks	Descriptor
3	7–9	A comprehensive response to the question, with the focus sustained. A conclusion is presented in a logical and coherent way, fully supported by relevant judgements. A wide range of knowledge and understanding of natural processes/systems is applied. The answer clearly identifies relationships between environmental issues. Relevant environmental terminology is used consistently and accurately throughout, with no more than minor omissions and errors.
2	4–6	A response to the question which is focused in parts but lacking appropriate depth. A conclusion may be present, supported by some judgements, but it is likely not all will be relevant. A range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there may be a few inconsistencies, errors and/or omissions. The answer attempts to identify relationships between environmental issues, with some success. Environmental terminology is used, but not always consistently.
1	1–3	A response to the question which is unbalanced and lacking focus. It is likely to consist of fragmented points that are unrelated. A conclusion may be stated, but it is not supported by any judgments and is likely to be irrelevant. A limited range of knowledge and understanding of natural processes/systems is shown. There is an attempt to apply this to the question, but there are fundamental errors and/or omissions. The answer may attempt to identify relationships between environmental issues, but is rarely successful. Limited environmental terminology is used, and a lack of understanding is evident.
	0	Nothing written worthy of credit.

Qu	Part	Marking guidance	Comments	Total marks	AO
11	**1**	Students should be able to demonstrate their knowledge of pollutant properties, their impacts on the environment and methods used to reduce those impacts by using appropriate examples.		**25**	AO1 = 10 AO2 = 10 AO3 = 5

Topic area/ spec ref	**Properties of pollutants**	**Impact on Environment**	**Methods/strategies to reduce impact**
3.4.1 The properties of pollutants 3.4.2.1 Factors that affect dispersal 3.4.2.2 Environmental factors that affect rates of degradation 3.4.3.1 Principles of control 3.4.3.2 Control technologies	State of matter: Solid/liquid/gas **eg** lead dust, acid mine water drainage, sulfur dioxide, CFCs	Gaseous and liquid pollutants have potential to travel further- depends on velocity of wind/currents and direction. **eg** of transboundary pollutants **eg** acid rain in Scandinavia, Cs-137 Chernobyl. Denser pollutants **eg** lead source (unless mobile though food chains)	The following can be applied for most pollutants. 1) Monitoring: a) to identify and predict pollutant mobility post discharge: critical pathway analysis b) to identify health risks from pollutants and those members of public at greatest risk; critical group monitoring 2) Control technologies to: reduce production and release 3) Development of alternatives, substitutes to perform the same function as original.
	Energy from **eg** noise, heat, light, ionising radiation	Noise, light may have local/restricted impacts Ionising radiation – local, regional, transboundary	
	Persistence **eg** high persistence - CFCs, organochlorine insecticides -DDT low persistence- sewage, pyrethroid insecticides	Affected by environmental conditions such as abiotic factors: oxygen availability, temperature (thermal degradation), light (photo degradation), pH, presence of other pollutants, topography, temperature inversions and biotic factors such as presence of bacteria (biodegradation).	
	Reactivity/chemical stability **eg** CFCs low reactivity except in the presence of UV light NOx, ozone, hydrocarbons high	Reactive pollutants may degrade quite quickly **eg** sewage or react with other pollutants to produce more toxic secondary pollutants. **eg** as in photochemical smog Rate of degradation/reactivity affected by abiotic factors: oxygen, temperature, light, pH Chemically stable pollutants may remain in the environment for a long time	
	Adsorption Attachment to soil or sediments	Can immobilise pollutants until disturbed **eg** PCBs	

	Solubility in lipids/water **eg** DDT in lipids, nitrates in water	Water soluble pollutants easily dispersed. Liposoluble pollutants can bioaccumulate and biomagnify Impact on living organisms and food chains/webs	
	Synergism Two pollutants interact to cause a more serious effect.	Examples to illustrate **eg** ozone and sulfur dioxide in acid rain damaging coniferous forests.	
	Specificity Variations in toxicity to different groups	**eg** Pyrethroid insecticides have high toxicity to insects and low toxicity to mammals	
	Toxicity How poisonous a substance is. **eg** CO , lead, cyanide	Inhibits enzyme action CO binds to haemoglobin instead of O_2. Lead inhibits enzyme action in nerve cells Cyanide inhibits aerobic respiration enzymes	
	Carcinogenic action Mutagens that cause cancer **eg** asbestos, radon	Cause uncontrolled cell division in various tissues to produce an undifferentiated mass of cells known as a tumour.	
	Mutagenic action Cause change in DNA structure – mutations **eg** ionising radiation/UV/PCBs	Gonadic effects – abnormality in offspring Somatic effects - cancers	
	Teratogenic action Normal gene expression inhibited affecting foetal development. **eg** mercury	Cause birth abnormalities in offspring. The birth abnormality cannot be inherited by future generations because the DNA structure is not affected	
		Total =	**25**

Qu	Part	Marking guidance	Comments	Total marks	AO
11	**2**	Students should be able to demonstrate their knowledge of energy resource properties, the impact of their use on the environment and methods used to reduce those impacts by using appropriate examples.		**25**	AO1 = 10 AO2 = 10 AO3 = 5

Topic area/ spec ref	Properties of energy resources	Impact on Environment	Methods/strategies to reduce impact
3.3.2 Properties/ features of energy resources 3.3.3 Sustainability of current energy resource exploitation 3.3.4 Strategies to secure future energy supplies. 3.3.4.1 Evaluation of improved extraction, harnessing and processing technologies.	Renewable/non depletable **eg** wind turbines Non renewable **eg** fossil fuels/ depletable **eg** wood/felled forests not replaced	All energy resource exploitation has impacts. Students need to consider the scale, type and timing of impacts. **eg** construction of wind turbines may involve use of fossil fuels re metal exploitation, manufacture and construction on site but once operational impacts are less, more local, not global. **eg** visual pollution, bird/bat strikes **eg** use of coal in power stations involves release of CO_2 and SO_2 causing atmospheric pollution having a larger/global impact.	Students should illustrate these by using specific examples. **eg** wind turbines - careful location to avoid bird flight paths, stopping of turbines if raptors in vicinity. Aerodynamic design and direct drive to reduce noise levels. **eg** coal fired power stations – use of scrubbers to remove SO_2. Carbon capture technology to potentially remove CO_2. Coal gasification, liquefaction. $1^O/2^O/3^O$ oil recovery New designs and technologies **eg** in solar and wind make them cheaper and fossil fuels have less of a competitive edge, so impacts reduced.
	Intermittency **eg** wind, solar Intermittent but predictable **eg** tidal	As above. Need for other energy resources to 'plug the gap' when turbines and solar not operational.	Development of energy storage technologies to reduce dependency on fossil fuels and associated environmental problems. **eg** converted to thermal energy, chemical energy, or gravitational potential energy **eg** hydrogen
	Energy density Higher – need less of fuel, reach higher temperatures	As above for fossil fuels. The low energy density of most renewable energy resources increases the amount of	Use of energy storage to convert surplus energy from renewables to high

	eg fossil fuels, nuclear	equipment needed. **eg** greater land take re output of wind farms needed compared to nuclear power station. Nuclear power produces nuclear waste	energy density secondary fuels **eg** hydrogen. Develop extraction techniques from other uranium sources for nuclear industry to minimise exploitation of ores **eg** polymer adsorption, phosphate mining and extraction of uranium from coal ash
	Abundance/resource availability/locational constraint	Abundant but less accessible resources little environmental impact **eg** deep water oil reserves. Coal seams at surface can be accessed by open cast but greater impacts.	New technologies re directional drilling, GPS positioned ships allow for minimising impacts as technology develops. Open cast mining: techniques to reduce dust, water, noise pollution, restoration of habitats post mining.
	Form of energy	Need for conversion to increase usefulness, **eg** chemical energy in fossil fuels to electrical energy, kinetic energy in wind to electrical energy	Minimise the number of energy conversions needed, to reduce the potential impacts/energy losses
	Ease of storage	Fossil fuels and nuclear can be stored, renewables generally cannot (exceptions, biofuels as chemical energy, tidal power in lagoons, HEP as GPE etc), hydrogen can be stored in fuel cells Non-renewable – habitat damage/destruction from exploitation of the resource Atmospheric pollution and nuclear waste from use Biofuels may create land-use conflicts when land needed for food production Tidal power has significant environmental impacts, **eg** loss of feeding grounds, increased concentration of pollutants, barriers to migrating species etc	Nuclear storage – strict controls on site to reduce radiation exposure/leaks Biofuels – develop energy mix policy, look at land used – not suitable for food crop but quick growing biomass. Tidal power- not developed in UK due to estuarine ecosystem impacts as well as costs.

		Environmental impacts of HEP – habitat/amenity loss, methane release, changes to downstream river flow, micro-climate changes etc	
	Ease of transportation	Usually high energy density bulk transport fuels. Transport from source to point of energy generation. Impacts of fossil fuel driven transport **eg** emissions Non renewables from point of origin to use need infrastructure such as cables. In accessible areas, habitat destruction – seabed cables etc	Maximise quantity transported for minimum energy expenditure – via rail network Infrastructure design re cabling – underground /overground. Through AONB areas, bird flightpath areas, etc
	Embodied energy	Examples of energy resources with high embodied energy – nuclear power (processing of U_{235}, manufacture of concrete for power plants); solar panels (extraction and processing of materials e.g. silicon, metals) etc	e.g. Alternatives to U_{235} e.g. thorium, renewables, plutonium (breeder reactors); new designs of solar/wind equipment that increases efficiency (so less extraction, transport etc)
		Total =	**25**

Level	Marks	Descriptors
5	21–25	A comprehensive response with a clear and sustained focus. Content is accurate and detailed. Relationships are identified, reflecting the holistic nature of environmental science and the answer as a whole is coherent. A wide range of relevant natural processes/systems and environmental issues are described and articulated clearly. These are applied systematically to the question, with clear relevance to the context. Where conclusions are made, these are fully supported by judgements and presented in a logical and coherent way. Relevant environmental terminology is used consistently and accurately throughout. If there are errors, these are very minor indeed and not sufficient to detract from the answer.

4	16–20	A response in which the focus is largely sustained, with content that is mainly accurate and detailed. Relationships are identified and the answer is largely coherent. A range of natural processes/systems and environmental issues are described and articulated clearly. In most cases, these are applied appropriately to the question but, in some, it is less clear why they are relevant. Where conclusions are made, these are supported by judgements which are mostly coherent and relevant. Relevant environmental terminology is used consistently and throughout, with no more than minor errors.
3	11–15	A partial response which is focused in parts. The content is mostly accurate but not always detailed. There is an attempt at identifying relationships, but the answer as a whole is not fully coherent. A range of natural processes/systems and environmental issues are described, most are articulated clearly. In some cases, these are applied appropriately to the context but, in most, it is less clear why they are relevant. Where conclusions are made, it is not always clear how they relate to the judgments given and are likely to contain errors. Relevant environmental terminology is used, but not consistently and there may be errors.
2	6–10	An unbalanced response, lacking in focus. The content may be inaccurate and lacking detail. There is some attempt at identifying relationships, but the answer is not coherent. A limited range of natural processes/systems and environmental issues are described but not articulated clearly and likely to contain errors and/or omissions. There is a limited attempt to apply them to the context. Any conclusions are likely to be asserted, with no supporting judgements and fundamental errors. Environmental terminology is used, but not always appropriately and sometimes with clear errors.
1	1–5	Fragmented points, whose relevance to the question and relationships to each other are unclear. A few natural processes/systems and environmental issues are listed, but unlikely to be described and many may be irrelevant. There is no clear attempt to apply them to the context. It is unlikely that a conclusion will be present. There is an attempt to use environmental terminology, but seldom appropriately.

	0	Nothing written worthy of credit.