A-level
ENVIRONMENTAL SCIENCE
7447/1

Paper 1

Mark scheme

June 2024

Version: 1.0 Final

2 4 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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

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.

<table>
<tr><th>Qu</th><th>Part</th><th>Marking guidance</th><th>Comments</th><th>Total marks</th><th>AO / spec</th></tr>
<tr><td>01</td><td></td><td>
<table>
<tr><td>Pollution control technology</td><td>Pollutant</td></tr>
<tr><td>Flue gas desulfurization</td><td>SO_x</td></tr>
<tr><td></td><td>CFCs
[A: HFCs/VOCs]</td></tr>
<tr><td>Catalytic converter(s)/improved combustion efficiency</td><td></td></tr>
<tr><td></td><td>CH_4/methane/ CO/carbon monoxide/ H_2 /hydrogen</td></tr>
<tr><td>Heating coal to remove tar/electrostatic precipitators/cyclone separators/bag filters/fabric filters/scrubbers/water sprays/diesel particulate filters</td><td></td></tr>
<tr><td></td><td>NO_2/NO_x/ ozone/O_3
[R: stratospheric ozone]</td></tr>
</table>
</td><td></td><td>5</td><td>AO1 1a

3.2.1.2, 3.2.1.3, 3.4.3.2.2, 3.4.3.2.3, 3.4.3.2.4, 3.4.3.2.5</td></tr>
</table>

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
02	1	**Two** from: • Increased need to reduce pollution from non-renewables (eg nuclear waste, smoke from coal, acid rain) /legislation to reduce pollution/increased awareness of GCC/ need for sustainability • Increased efficiency of renewable/storage technologies • Less strict planning regulations (have allowed development of renewables) • Targets set/legislation to reduce carbon emissions/named agreement eg Kyoto Protocol, COP26, Paris 15 • Grants/subsidies/investment for development of / costs of new technologies/'green' levies for energy bills • Non-renewable prices have increased/renewables have become cheaper/more competitive/ renewables more economically viable		2	AO2 3.3.4.1

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
02	**2**	• 216.372 TWh **OR** 75.6 x 10^3 GWh • 34.9(%)	**One** mark for unit conversion Award **two** marks for correct answer with no working Max 1 mark for ECF during conversion Max 1 mark for correct answer not to 3 sig figs	2	AO2 3.3.4.1 MS0.1 MS0.3

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
02	**3**	Any **two** from: • Blades rotate in any wind direction/can be used in areas of turbulent winds/no need for a motor (to turn to face the wind) • Quieter (as blades rotate more slowly /so suitable for use in urban areas) • Operate at lower wind (speeds) • No need for a tall/stronger tower/lower construction cost/embodied energy • More turbines/power output per unit area • Reduced **named** impact e.g. aesthetics, bird and bat deaths (due to smaller size)		2	AO1 1b 3.3.4.1

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
02	**4**	Any **two** from: • HEP/pumped storage HEP • Water stored as GPE/at higher level (behind a dam) • Compressed gas • Air compressed to produce thermal/heat energy • Power to gas (P2G) systems • Compression/electrolysis used to produce gaseous fuels/ hydrogen/ which can be converted to methane / natural gas • Molten salt • Stored as thermal/heat energy • Fly wheels • Stored kinetic energy • Hydrogen fuel cells/metal hydride systems • Stored as a gas in high pressure tanks/liquid at very low temperatures/adsorption onto metal matrix/derived from ammonia/electrolysis **R**: V2G systems (as uses battery storage)		4	AO1 1a AO1 1b 3.3.4.1

Qu	Part	Marking guidance	Comments	Total marks	AO/spec
03	**1**	**First** mark for factor (**must include direction**). **Second** mark for **any linked** developed reason applied to Site 1 or Site 2 eg • Denser vegetation/canopy cover/(deeper) roots • More interception so less rain splash erosion/surface runoff/less wind erosion • Organic matter • Improves soil structure/aggregation/soils structure/action of micro-organisms/more soil biota so less erosion • Lack of disturbance/time of establishment/growth • Greater root binding/ less exposure to named erosion factor e.g. wind, compaction, surface run off / more interception • Steepness/slope angle/gradient • Increased surface run off/kinetic energy of soil particles/reduced infiltration so less erosion • Topography • Higher wind speeds increase wind erosion • Proximity to river • Migration of channel/erosion of banks/soil/flooding increases erosion • Precipitation • High levels of precipitation increase rain splash erosion/surface run off • Impermeable soils/rocks • Decrease infiltration/percolation/increase surface run off R: refs to agriculture/residential zones No credit for stating plantation / natural forest as a reason Credit any valid developed reason.		4	AO2 3.2.5.2

Qu	Part	Marking guidance	Comments	Total marks	AO
03	2	• Natural forest – C = 0.24 • Plantation – A = 6.46 A: correct answers to more or less than 2 sig figs	19.35 / (1680×0.30×0.16×1.0) 1670×0.28×0.07×0.25×0.79	2	AO3 MS2.4

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
03	3	• **LS** 0.128 = 0.13	0.16 × 80% = 0.128	1	AO3 1a MS0.3
		• **K** 0.257(2125) **A** 0.3 x 0.95^3	After Y3 – 0.3 × 95% = 0.285 After Y6 – 0.285 × 95% = 0.27075 After Y9 – 0.27075 × 95% = 0.257(2125)	1	
		• **K** 0.26	ECF – 1 mark	1	

Qu	Part	Marking guidance	Comments	Total marks	AO
03	4	• Named crop management eg crop rotation, long term crops, cover crops **AND** link to how it reduces the C factor e.g. increased interception, reduces surface run off **A:** refs to forest management eg afforestation, selective logging		1	AO2 3.2.5.2

Qu	Part	Marking guidance	Comments	Total marks	AO /spec
04	**1**	• 66 (dB) A: 65 - 67 (dB)		1	AO3 1a 3.4.3.2.13 MS2.5 MS3.1

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
04	**2**	Any **two** from: • Rain/humidity affects noise as sound travels faster (through moist air)/amplifies noise • Wind speed/direction affects dispersal of noise • Temperature inversions amplify noise as dispersal is reduced • Surfaces/vegetation/buildings/embankments absorb/reflect/deflect sound/act as a barrier • Topography/relief absorbs/deflects noise/acts as a barrier • Water body amplifies noise as no barrier/colder air above	For each mark a factor **AND** how the factor affects noise levels	2	AO2 3.4.3.2.13

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
04	**3**	Any **two** from: eg • Wheel noise **AND** track polishing/lubrication/sound absorbing materials (ballast) on track/wheel lubrication/improved (carriage) suspension/rail pads/dampeners • Engine noise **AND** (sound absorbing) suspension/ insulation of engine compartment/replace diesel engines with electric engines/acoustic casing. • Pantograph turbulence **AND** aerodynamic fairing/design • Brakes **AND** use of composite material brakes eg ceramics, steel, rubber • Air turbulence/friction/noise associated with movement **AND** aerodynamic design/bullet train/Maglev		2	AO1a 3.4.3.2.13

Qu	Part	Marking guidance	Comments	Total marks	AO
04	**4**	Any **three** from • Level/frequency/volume/intensity (of noise) • Level of background noise/no background noise • Calibrated sound meter • Distance of sound meter from source/distance of source to insulation • Type/material of insulation • Reflective or absorbent surfaces • Size/shape/material of object to be insulated • Height/position of microphone/same microphone / microphone sensitivity.		3	AO2 3.4.3.2.13 PS2.3

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
04	**5**	• Spearman Rank/Pearson		1	AO2 MS1.9 Me6

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
04	**6**	• (*p*-value =) 0.01 [**A**: 99%]		1	AO3 1c MS 1.9

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
05	**1**	• (nitrate) test strips • comparison of reaction to colour chart • photometer/colorimeter/spectrometer • absorption of UV light • ion selective electrodes • electronic probe measures ion concentration	**One** mark for named technique **One** mark for description of technique	2	AO1 1a AO1 1b PS4.1 ST1 3.7.2.1

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
05	**2**	• Sampled in different seasons/ months/ <u>regular</u> intervals across year **AND** **one** from: • Same depth/regular intervals across/along river/grid sampling • Multiple samples / get mean value	1 mark for temporal change 1 mark for relevant sampling approach	1 1	AO1 1b PS1.4 Me2 Me3 Me5

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
05	**3**	• 74 285 714 • 51 000 000 / 51 × 10^6 (2 significant figures)	7600 million – 2400 million = 5200 million 5200 million ÷ 70 = 74 285 714 74 285 714 – 22 857 143 Award **two** marks for correct answer with no working ECF – 1 mark	2	AO3 1a MS3.6

Qu	Part	Marking guidance	Comments	Total marks	AO/ spec
05	**4**	Advantages eg • Increased yield • Due to increase in growth rate/biomass/ Productivity/ • Specific to crop requirements • Named plant nutrients eg nitrates, NPK, ammonium ions • High solubility/accessibility of inorganic nutrients • Rapid uptake • Increased food security / prevents food shortage • Higher yields/increased rate of production Disadvantages eg • Eutrophication • Oxygen depletion/reduced photosynthesis (due to algal blooms)/death of aquatic organisms • Soil degradation/reduced soil structure • Soil erosion/pH change (acidification)/reduced fertility/reduced soil biota/reduced yield • Increases GHGs/ high embodied energy • NOx release from soil /Haber (Bosch) process/ • Exposure to artificial fertilisers eg drinking water • Named health issue eg, blue baby syndrome • Cost • Profit/challenge in decision making/dependency • Unsustainable use of phosphates • Limited resource/finite/impacts of mining Credit any valid developed reason	1 mark for stated advantage/ disadvantage 2nd mark for impact	4	AO1 1a AO1 1b 3.2.4.3

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
06	**1**	• Greatest uncertainty before 1850 • Reduced uncertainty after 1850/1900-1950 • Decreasing trend in uncertainty (allow converse) • Uncertainty almost eliminated by 1990 (accept 1970 - 2000)/no uncertainty by 2020.	Max 1 if no data used	2	AO3 1a 3.2.1.2 MS3.1

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
06	**2**	• Limited accuracy/reliability/gaps in record **One** from • need multiple proxies (to cross reference estimates) • reference to a disadvantage of a named method eg, differences in tree ring width may not be due to climate/may be a result of disease/ • locational constraints.		2	AO2 3.2.1.2

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
06	**3**	**Two** from (uncertainty linked to physical process) eg • climate processes and their interconnections eg El Nino, ice melt • ecological impacts • impact of unexpected physical events eg large scale eruptions. • impact of feedback mechanisms under/overestimated/correct ref to positive/negative feedback mechanisms/fluctuations <u>temporally</u>. • thresholds/tipping points • time delay (cause and effect) • varied future human action eg implementation of climate policy, level of emissions • issues with climate modelling		2	AO1 1b 3.2.1.2

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
06	4	**Increased ocean acidification** • Increased CO_2 concentrations/warmer climate leads to increased dissolved CO_2 AND **one** from • (dissolved CO_2) reacts with water molecules to form carbonic acid • (carbonic acid/H_2CO_3) dissociates to form bicarbonate/HCO_3^- and hydrogen ions/H^+ (decrease seawater pH) • bicarbonate/HCO_3^- dissociates to form H^+ and CO_3^-/carbonate ions • increased hydrogen ions (decrease seawater pH) **Increased forest fires** • Warmer atmospheric conditions lead to increased periods of drought/heatwaves/reduced precipitation/reduced transpiration/evapotranspiration/increasing storms eg lightning strikes AND **one** from • combustible fuel (wood/peat/dry leaf litter) R: forests drying out (on its own) • wind causes fires to spread.	One mark for link to future climate change One mark for developed/linked reason	4	AO2 3.2.1.2

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
07	**1**	Any **two** from: • perforated disc/mesh to allow the organisms to fall through • heat/light sensitivity forces organisms to move (into collecting vessel) • leave for a standardised/appropriate time for the organisms to move (down) • named liquid in vessel for collecting/preserving **AND** • organisms counted / identified		3	AO1 1b PS4.1 ST4

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
07	**2**	Any **two** from: • burrowing organisms/detritivores mix organic matter/increasing surface area/spreading nutrients • burrowing organisms increase aeration for (aerobic) decomposition/root penetration • burrowing organisms improve drainage supplying nutrients/ preventing denitrification/increasing aerobic respiration • decomposers/detritivores/microbes break down dead organic matter and release nutrients to soil • micro-organisms/bacteria fix nitrogen/nitrification which increases nitrate availability • breakdown/bioremediation of pollutants increases availability of nutrients. • Breakdown soil particles / form peds which increase addition of (adsorption) of nutrients Credit any valid developed reason		2	AO2 3.2.5.1

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
08	**1**	• D – 30 000 m^2		1	AO3 1a MS0.4

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
08	**2**	Any **one** from • magnetometry • seismic surveys • gravimetry • resistivity / conductivity • IR spectroscopy / satellite imagery		1	AO1 1a KII 3.2.3.4

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
08	**3**	**Four** from • (Rising) magma/magma chamber/metamorphism (pressure +temperature) • creation of fissures/dykes/intrusions • superheated water/release of hot fluids from rocks/ heating of groundwater. • minerals in solution along dykes/along fissures (away from batholith/intrusion) • cooling (of solutions) and precipitation/crystallisation of hydrothermal mineral veins • fractional crystallisation / order of solubility		4	AO2 3.2.3.2

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
08	**4**	• Central location • (Reduced cost because) fewer shafts/easier access/remove deposit in both directions/less machinery • Deposit is closer to the surface at B/deeper at A • Overburden is smaller at site B/less waste disposal/less drilling • Faults near site B • Rock is more accessible/weaker/moved deposit towards surface • Deposit is thicker near site B • Can access greater amount of deposit (with less effort) Credit any valid developed reason	**One** mark for each stated reason **One** mark for each linked explanation **Max 2** for stated reasons with no explanation	4	AO2 3.2.3.3 3.2.3.5

Qu	Part	Marking guidance	Comments	Total marks	AO
09	1	**Three** from: • Atmospheric dust [**R**: air] • Soil • Water • Food (milk, vegetables, meat) • Fish, molluscs • Seaweed • Vegetation		3	AO1 1b 3.4.3.2. 14

Qu	Part	Marking guidance	Comments	Total marks	AO /spec
09	2	• $(½)^5 = 1/32$ [**A**: 0.03125 / 3.125%]	Half-life = 2 years 10 years passed so 5 half-lives	1	AO3 1a MS0.3

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
09	3	**Three** from: • age • diet • gender • (muscle) mass • general health / disease / malnutrition / pregnancy • genetics/species		3	AO2 PS2.3

Qu	Part	Marking guidance	Comments	Total marks	AO /spec
09	4	**Three** from: • Negative correlation/as radio caesium levels increase, WBC counts decrease • Many data points conform to the correlation/ recognises anomalies/ weak correlation • Lower exposures have greater variability/higher exposures have less variability • Ref to data points (WBC counts and radioactive caesium) to evidence one or more of the points above		3	AO3 1a MS1.7 PS2.2

Qu	Part	Marking guidance	Comments	Total marks	AO
10	**1**	**Agreement** • **1990 – 2000** reductions in ODSs (1 300 000 – 450 000) and ozone concentration (125 to 100) suggesting not connected **Disagreement** • **1980 to 1989** increases in ODSs (1 000 000 - 1 300 000) led to falling ozone concentrations (230 to 135) which suggests a connection • **Since 2000** reductions in ODSs (450 000 – 180 000) have led to fluctuating / slightly increasing levels in ozone concentrations suggesting a partial connection **A**: a different range of years if ODS/ozone data are correct	Award **one** mark for one agreement Award **one** mark for one disagreement Award **one** mark for use of data from Figure 10. Max 1 if no evaluation (i.e. just described)	3	AO3 a/c

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
10	**2**	Name • Student t-test (A: Mann Whitney U Test) Description • set Null Hypothesis/Alternative Hypothesis • complete test to compare <u>mean</u> values (before/after 1987) • compare test result to critical value/table of significance levels • If result is higher than critical value = statistically significant difference. • accept/reject (null hypothesis) at significance $p = 0.05$ (95%)		1 2	AO2 MS1.9 Me6

Qu	Part	Marking guidance	Comments	Total marks	AO / spec
10	**3**	Indicative content: **Montreal Protocol (1987)** • Protocol banned ODS • Eg CFCs • **Use of alternative processes** Pump action sprays / roll on deodorant • **Use of alternative materials** HCFC Use of propane / butane HFCs HFAs Disposal of CFCs • **Implementation**	Evaluation • Ozone depleting gases decreasing eg chlorine (HCl), CFCs • Some gases increasing eg halons and HCFCs • Cost • Availability varies by location • HCFCs, initially introduced to replace CFC in refrigeration, still cause ozone depletion • HCFCs phased out by 2020 / developing countries have until 2030. • HFCs were introduced to replace HCFCs but high cost. • HFCs being phased out (because of need to reduce CO_2). • Assuming compliance with Montreal Protocol • Change in ODS temporally giving variable readings. • Lag between implementation of policies and outcomes • Some ODS have not been banned • Ozone layer projected to recover by 2050. • 98% reduction in ODS compared to 1990 values.	9	AO1- 4 AO2- 3 AO3- 2 3.2.1.3

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 focussed 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 relationship 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	Total marks	AO
11	**1**		**25**	AO1 = 10 AO2 = 10 AO3 = 5

	Anthropogenic factors	**Environmental factors**
Dispersal and severity	**Activities producing emissions or discharges** eg: • Combustion of wood, fossil fuels • Smelting of sulphide ores • Fertiliser use • Condenser water from thermal power stations • Oil tanker collisions / groundings • Oil tank washing • Pipeline leaks • Use of pesticides • Use of inorganic fertilisers • Organic wastes • Acid mine drainage • Heavy metals • Solid wastes • Radioactive wastes • Noise • Over-ploughing	**Environmental factors** eg: • Air current velocity and direction • Water current velocity and direction • Temperature • Light • Oxygen/dissolved oxygen • pH • Presence of other chemicals/pollutants • Presence of adsorbent materials • Topography eg temperature inversions, sheltered/exposed coastlines (oil spills) • Food chains/webs leading to bioaccumulation and biomagnification (pollutants can disperse through movement/migration)
	Emission location eg: • Fossil fuel / biomass combustion in valleys (smogs occur with temperature inversions) • Building chimney stacks higher than inversion layer • Discharge of polluted water into enclosed water bodies (or into water where dispersal will reduce severity) • Discharge of condenser water • Siting of airports / industry to reduce noise • Release of treated sewage effluent • Landfill sites away from residential areas (odours, litter) • Storage of high level nuclear waste to prevent emissions of radiation • Military aircraft may avoid sensitive ecological areas or vary flight paths to avoid nuisance to residential areas • Airport location / engine test areas away from residential areas	**Properties of the pollutants** eg: • State of matter • Energy form • Density • Persistence • Biodegradability • Photodegradability • Toxicity • Reactivity • Adsorption • Solubility (lipids / water) • Bioaccumulation • Biomagnification

	Emission timing eg: • Restriction of burning fossil fuels, biofuels during temperature inversions • Pesticide applications on still days, at night • Inorganic fertiliser applications avoided in heavy rain • Aircraft night flight restrictions	
	Other controls of sources above eg: • Technological • Legal • Cultural / societal • Economic	
	Critical pathway analysis	**Properties of the pollutants** eg: • Synergism
	Critical group monitoring	**Biodiversity of polluted area** High biodiversity – higher severity of impact of pollution

Qu	Part	Marking guidance	Total marks	AO
11	**2**		**25**	AO1 = 10 AO2 = 10 AO3 = 5

Anthropogenic factors	**Environmental factors**
Activities requiring energy eg: • Agriculture • Fishing • Industry • Electricity generation • Transport • Domestic use • Telecommunications and IT	**Features of energy resources** eg: • Renewable / non-renewable / depletable / non-depletable • Abundance • Intermittency • Predictability • Ease of storage
Factors affecting energy consumption eg: • Affluence • Relative cost of energy • Type of industry • Population growth • Level of technological development of the resource • Political / economic influences • Need to meet peaks in demand • Climate (need for cooling/heating) • Social/environmental awareness	**Locational constraints** eg: Fossil fuels: • Existence of economically exploitable deposits • Condensing cooling water supplies • Suitable construction site • Transport infrastructure (for delivery of fuel) Nuclear power: • Condensing cooling water • Suitable site • Transport infrastructure for construction/workers/waste

<table>
<tr>
<td>Public concerns / social and environmental awareness eg:
• safety of nuclear fission
• GCC (sea level rise, extreme weather events)
• Atmospheric pollutants and direct effects on human health (NOx, tropospheric O_3, dust)</td>
<td rowspan="2">Solar power:
• High light intensity
• Low cloud cover
• Large available area (for solar farms)
Wind power:
• Areas with strong, reliable winds (the sea, coastal areas open plains, upland areas)
• Low land use conflicts (ecologically sensitive areas, areas of scenic importance, interference with radar/telecommunications)
• Suitable topography for access/construction
• Close to grid (if large-scale)
• Large areas (for HAWTs)
Wave power:
• Coastal areas
• Long fetch
• Strong reliable (prevailing) winds
Tidal power:
• Large tidal range (for barrages)
• Estuaries/headlands (to focus the tidal currents/increase velocity)
• Avoidance of ecologically sensitive areas
HEP:
• High reliable rainfall evenly distributed throughout the year
• Low water turbidity
• Narrow exit to large basin
• Large catchment area
• Impermeable bedrock
• Stable geology
• No serious land-use conflicts
• Close to consumers/grid
Biofuels:
• Nearby forest areas
• Farmland for biofuel crops or crop/livestock waste
• Fertile soil/climate/topography for cultivation (for growing crops)
• Urban areas for food waste/sewage
Geothermal:
• Hot rocks near ground surface (greater than 150 ^{o}C)
• Recent volcanic activity</td>
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<tr>
<td>Habitat loss and damage eg:
Coal:
• Land take, turbid drainage water, spoil heaps, acid mine drainage
• Oil and gas:
• Oil spills/leaks, pipeline construction
Shale gas:
• Contamination of aquifers
Nuclear:
• Land take, turbid drainage water, radioactive contamination
Solar:
• Land take
HEP:
• Land take, downstream changes in flow velocity, turbidity, dissolved oxygen, barriers to migration of aquatic organisms, loss of spawning/feeding sites
Wind power:
• Land required for HAWTs is large but does not conflict with agriculture (land can still be used for grazing)
Biofuels:
• Monocultures/agrochemicals reduce biodiversity
Tidal power:
• Land take etc from extraction of materials for barrage
• Changes in sedimentation, turbidity, tidal range, increase in pollutant concentration
Geothermal:
• Steam and hot water pipes can be obstacles to movement of large animals
• Contamination of aquatic habitats from salts and heavy metals</td>
</tr>
</table>

Pollution caused by use of energy resources eg: • Atmospheric pollution (CO_2, NO_x, smoke etc) • Water pollution (oil, nuclear) • Ionising radiation • Noise (wind turbines)	
Development of new transport technologies eg: electric and hydrogen	
International / national agreements eg: COP26	
Energy conservation methods eg: • transport (increased fuel efficiency, choice of vehicles – electric, hybrid) • buildings (solar PV, air source heat pumps, ground source heat pumps etc) • industry (energy recovery systems, CHP, integrated manufacturing etc) • Local / regional strategies to reduce the use of energy resources (car share schemes, congestion charging)	

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. U 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.