



---

# A-level ENVIRONMENTAL SCIENCE 7447/1

Paper 1

---

Mark scheme

June 2025

---

Version: 1.0 Final



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](http://aqa.org.uk)

#### **Copyright information**

AQA retains the copyright on all its publications. However, registered schools/colleges for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to schools/colleges to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Copyright © 2025 AQA and its licensors. All rights reserved.

## 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 typical 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.

The notes for answers provide indicative content. Students' responses may take a different approach in relation to that which is typical or expected. It is important to stress that examiners must consider all a student's work and the extent to which this answered the question, irrespective of whether a response follows an expected structure. If in doubt the examiner should contact their team leader for advice and guidance.

### 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 / spec                |
|----|------|---------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------|--------------------------|
| 01 |      | <b>Exploitation of water source or water management</b> | <b>Name of method</b>                                                                             | 5           | AO1 1a<br>KII<br>3.2.2.5 |
|    |      |                                                         |                                                                                                   |             |                          |
|    |      |                                                         | estuary / tidal<br>barrage                                                                        |             |                          |
|    |      |                                                         | inter-basin<br>transfer/water<br>transfer<br>scheme                                               |             |                          |
|    |      |                                                         |                                                                                                   |             |                          |
|    |      |                                                         | water extracted/pumped<br>from groundwater/<br>porous/permeable/<br>geology / sedimentary<br>rock |             |                          |
|    |      |                                                         | metering                                                                                          |             |                          |
|    |      |                                                         |                                                                                                   |             |                          |
|    |      |                                                         | reuse of domestic<br>wastewater / named<br>water use eg shower<br>water and watering plants       |             |                          |

|                            |          |
|----------------------------|----------|
| <b>Question 01 total =</b> | <b>5</b> |
|----------------------------|----------|

| Qu | Part | Marking guidance                                                                                                                    | Comments                                                                                                                      | Total marks | AO / spec       |
|----|------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------|
| 02 | 1    | <ul style="list-style-type: none"> <li>increasing trend</li> </ul> <b>AND</b> <ul style="list-style-type: none"> <li>28%</li> </ul> | <ul style="list-style-type: none"> <li>eg from 0% (in 2000), then increasing in percentage supply to 28% (in 2050)</li> </ul> | 1           | AO3 1a<br>MS3.1 |

| Qu | Part | Marking guidance                                                                      | Comments                                         | Total marks | AO / spec    |
|----|------|---------------------------------------------------------------------------------------|--------------------------------------------------|-------------|--------------|
| 02 | 2    | <ul style="list-style-type: none"> <li>54 (%)</li> </ul> <b>A:</b> range from [53-55] | 2020 = 29%<br>2050 = 83%<br><br>difference = 54% | 1           | AO2<br>MS3.1 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Total marks | AO / spec                                        |
|----|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------------------------------|
| 02 | 3    | <b>Three from:</b><br>(Changes in) <ul style="list-style-type: none"> <li>• efficiency of technology/accessibility of new (non-renewable) reserves/innovation/new discoveries/technologies of energy resources</li> <li>• uncertainty over climatic conditions/intermittent supplies</li> <li>• relative price (between fossil fuels and renewables)/economic competitiveness</li> <li>• availability of subsidies/grants</li> <li>• agreements/ targets/policies/legislation to reduce GCC/fossil fuels/maintain/increased use of non-renewables</li> <li>• types/levels of industries</li> <li>• locational/planning constraints preventing further expansion of some energy sources public opposition</li> <li>• developments in energy storage</li> <li>• war/political conflict (disrupting supplies)</li> <li>• availability/accuracy of data/modelling of predictions</li> </ul> | 3           | AO2<br>3.2.1.2,<br>3.2.4.2,<br>3.3.3,<br>3.3.4.1 |

|                     |   |
|---------------------|---|
| Question 02 total = | 5 |
|---------------------|---|

| Qu | Part | Marking guidance                                                                                                                                                                                                                                             | Comments | Total marks | AO / spec                   |
|----|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|-----------------------------|
| 03 | 1    | <b>Contamination</b> <ul style="list-style-type: none"> <li>• physical contact/carried away</li> </ul> <b>Exposure</b> <ul style="list-style-type: none"> <li>• absorption of radiation (due to being within close enough distance of the source)</li> </ul> |          | 2           | AO1 1a<br>KII<br>3.4.3.2.14 |

| Qu | Part | Marking guidance                                                       | Comments                | Total marks | AO / spec    |
|----|------|------------------------------------------------------------------------|-------------------------|-------------|--------------|
| 03 | 2    | <ul style="list-style-type: none"> <li>• 8</li> <li>• 1/225</li> </ul> | Must have the numerator | 2           | AO2<br>MS0.3 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                    | Comments | Total marks | AO / spec                            |
|----|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|--------------------------------------|
| 03 | 3    | <ul style="list-style-type: none"> <li>(dose/intensity) inversely proportional to the square of the distance</li> </ul> <b>OR</b> <ul style="list-style-type: none"> <li><math>(\text{dose/intensity}) = 1 \div \text{distance}^2 / 1 \div d^2</math><br/>A: example to illustrate e.g. at 2 m distance, dose = <math>\frac{1}{4}</math></li> </ul> |          | 1           | AO1 1a<br>KII<br>3.4.3.2.14<br>MS0.3 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Comments                                                                             | Total marks | AO / spec         |
|----|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|-------------|-------------------|
| 03 | 4    | <p><b>Advantages</b></p> <p><b>Max three</b> from:</p> <ul style="list-style-type: none"> <li>• no/less GHG/CO<sub>2</sub> emissions</li> <li>• produces large amounts of energy/more energy than is used/(very) high energy density</li> <li>• reliable/not intermittent/controllable/could provide baseload electricity</li> <li>• abundant supply of fuel (deuterium and tritium from sea water)</li> <li>• (blanket of lithium) can be used to breed more fuel (using neutron bombardment of lithium)</li> <li>• No/less radioactive waste with (long half-lives)</li> <li>• cannot be used to make weapons (as in U and Pu reactors)</li> <li>• no risk of ‘melt down’ (as a chain reaction is not involved)</li> </ul> <p><b>Disadvantages</b></p> <p><b>Max three</b> from:</p> <ul style="list-style-type: none"> <li>• very high temperatures required (for nuclei to collide)</li> <li>• high costs of R and D/set-up/feature of infrastructure</li> <li>• could not meet peaks in demand</li> <li>• magnetic field required to maintain plasma stability</li> <li>• technology still under development</li> <li>• public opposition</li> </ul> | For <b>five</b> marks both advantages and disadvantages must be stated<br>3+2 or 2+3 | 5           | AO1 1b<br>3.3.4.1 |

|                     |    |
|---------------------|----|
| Question 03 total = | 10 |
|---------------------|----|

| Qu | Part | Marking guidance                                                                                                                                                                                                                   | Comments                                                                                                                                          | Total marks | AO / spec                           |
|----|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------|
| 04 | 1    | <p>Any <b>two</b> from<br/>(carbon dioxide)</p> <ul style="list-style-type: none"> <li>• longest residence time</li> <li>• highest concentration</li> <li>• highest increase/rate of increase</li> </ul> <p><b>A:</b> converse</p> | <p>Must have comparative statements (not just descriptive)</p> <p>CO<sub>2</sub> in ppb has the highest overall increase, and annual increase</p> | 2           | AO3 1b<br>3.2.1.2<br>PS1.2<br>MS0.1 |

| Qu                                                                                                                                                                                                  | Part | Marking guidance                                                                                                                                                                                                                                       | Comments | Total marks | AO / spec                                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|---------------------------------------------------------|
| 04                                                                                                                                                                                                  | 2    | <ul style="list-style-type: none"> <li>increasing CO<sub>2</sub> (from y-axis)</li> <li>decreasing CH<sub>4</sub> (from y-axis)</li> <li>CO<sub>2</sub> levelling off/CH<sub>4</sub> (decreasing to) zero (linked to the change in Fig. 3a)</li> </ul> |          | 3           | AO3 1a,<br>AO3 1b,<br>AO3 1c<br>MS3.1<br>PS3.1<br>PS3.2 |
| <p>Contribution to warming in the troposphere</p> <p>Key</p> <p>— Carbon dioxide</p> <p>---- Methane</p> <p>x Contribution to warming in the troposphere in 2023 for carbon dioxide and methane</p> |      |                                                                                                                                                                                                                                                        |          |             |                                                         |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Comments | Total marks | AO / spec         |
|----|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|-------------------|
| 04 | 3    | <p><b>Three</b> from:</p> <ul style="list-style-type: none"> <li>reduction in waste to landfill/collection of methane from landfill/sewage sludge/slurry</li> <li>agricultural practices e.g drainage of water-logged fields, reduced meat/rice production/change livestock diets</li> <li>selective breeding/GM of livestock/rice</li> <li>fix leaking gas pipes/reduce mining of coal/improved gas recovery</li> <li>reduction in seafloor/peatbog disturbance</li> <li>method (to reduce GCC) to reduce permafrost melting e.g reduced combustion of fossil fuels, use of renewables</li> <li>named legislation to reduce CH<sub>4</sub>/GHGs e.g Landfill Directive, Paris Agreement.</li> </ul> |          | 3           | AO1 1b<br>3.2.1.2 |

| Qu | Part | Marking guidance                                           | Comments                                    | Total marks | AO / spec                |
|----|------|------------------------------------------------------------|---------------------------------------------|-------------|--------------------------|
| 04 | 4    | <ul style="list-style-type: none"> <li>1.5 (°C)</li> </ul> | $(0.8 + 0.5 + 0.1 + 0.1 - 0.2 + 0.2) = 1.5$ | 1           | AO3 1a<br>MS3.1<br>PS3.2 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                | Comments                                                                      | Total marks | AO / spec                                  |
|----|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|-------------|--------------------------------------------|
| 04 | 5    | <b>Aerosols</b> <ul style="list-style-type: none"> <li>they reflect UV radiation/increase albedo</li> <li>leading to decreased radiation reaching the surface resulting in cooling</li> </ul> <b>Greenhouse gases</b> <ul style="list-style-type: none"> <li>absorb Infrared energy</li> <li>converted to heat/reradiation back to surface/less (IR) lost to space leads to increase in temperature.</li> </ul> | Must have direction of surface temperature for 2 <sup>nd</sup> marking point. | 4           | 2xAO2<br>2xAO1 1b<br>3.2.1.2,<br>3.4.3.2.4 |

| Qu | Part | Marking guidance                                                                                                        | Comments                   | Total marks | AO / spec                                                                  |
|----|------|-------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------|----------------------------------------------------------------------------|
| 04 | 6    | <ul style="list-style-type: none"> <li>2011–2012 / 2014–2015 / 2016–2017</li> <li>the SD bars do not overlap</li> </ul> | A: ref to range/error bars | 2           | AO3 1b<br>AO2<br>3.2.1.2<br>MS1.10<br>MS1.3<br>MS3.1<br>PS3.1,<br>3.2, 3.3 |

|                     |    |
|---------------------|----|
| Question 04 total = | 15 |
|---------------------|----|

| Qu | Part | Marking guidance                                                 | Comments | Total marks | AO / spec                    |
|----|------|------------------------------------------------------------------|----------|-------------|------------------------------|
| 05 | 1    | <ul style="list-style-type: none"> <li>B – Z, X, Y, W</li> </ul> |          | 1           | AO3 1b<br>3.2.5.2<br>3.2.5.3 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Comments | Total marks | AO / spec      |
|----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|----------------|
| 05 | 2    | <p>Any <b>two</b> from mulching</p> <ul style="list-style-type: none"> <li>intercepts rainfall/wind which reduces soil particle movement/ rain splash/reduces (kinetic) energy of precipitation</li> <li>prevents the soil from drying out which prevents loss of cohesion/structure</li> <li>leads to organic material formation/which binds soil particles/leading to improved soil structure/ped formation</li> </ul> <p>loam soil</p> <ul style="list-style-type: none"> <li>is cohesive/binding/better structure</li> <li>less liable to compaction</li> <li>(mixed particle size) leads to water/ nutrient retention/drainage</li> <li>increased pore systems leading to plant growth/OM/burrowing/soil biota/binding</li> </ul> |          | 2           | AO2<br>3.2.5.3 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Comments | Total marks | AO / spec                                                                                                                   |
|----|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|-----------------------------------------------------------------------------------------------------------------------------|
| 05 | 3    | <p>Up to <b>two</b> marks for sampling</p> <ul style="list-style-type: none"> <li>• transect / systematic sampling</li> <li>• named time intervals e.g. weeks/months/seasons/years</li> <li>• multiple/10 or more samples for reliable mean</li> </ul> <p>Up to <b>two</b> marks for methods to collect data</p> <ul style="list-style-type: none"> <li>• methods to measure soil eg, erosion pins / height/depth of (top)soil</li> <li>• recreate slope angles in laboratory</li> <li>• collection (tanks / troughs) at base of field/slope</li> <li>• (dry) mass/volume of eroded soil / turbidity of run-off</li> </ul> <p>Up to <b>two</b> marks for variables</p> <ul style="list-style-type: none"> <li>• sample at same time to prevent named variable impacting result e.g. wind, rain</li> <li>• same management</li> <li>• same soil type / texture / organic matter</li> <li>• same sized droplets/volume/intensity water</li> <li>• fields in proximity/same field (if lab expt.)</li> <li>• same length of slope</li> <li>• same mass/volume of soil (if lab expt.).</li> </ul> <p><b>AND</b></p> <p><b>One</b> mark for test of difference</p> <ul style="list-style-type: none"> <li>• T-test / Mann Whitney U Test</li> </ul> <p><b>A</b> overlap of standard deviation</p> |          | 5           | <p>AO2<br/>3.2.5.2<br/>3.7.1,<br/>3.7.2.1,<br/>3.7.2.2,<br/>PS 1.4,<br/>PS 2.3,<br/>PS 4.1,<br/>Me2, Me3,<br/>Me 4, ST3</p> |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                         | Comments | Total marks | AO / spec      |
|----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|----------------|
| 05 | 4    | <b>Soil texture</b> <ul style="list-style-type: none"> <li>Increasing proportion sand due to wind/reduction in OM</li> </ul> <b>OM</b> <ul style="list-style-type: none"> <li>upper soil layers removed reducing (the limited formation of) organic matter/limited rainfall /drought/lack of vegetation/soil biota limits the formation of OM</li> </ul> |          | 2           | AO2<br>3.2.5.2 |

|                     |    |
|---------------------|----|
| Question 05 total = | 10 |
|---------------------|----|

| Qu | Part | Marking guidance                                                 | Comments | Total marks | AO / spec         |
|----|------|------------------------------------------------------------------|----------|-------------|-------------------|
| 06 | 1    | <ul style="list-style-type: none"> <li>photosynthesis</li> </ul> |          | 1           | AO1 1a<br>3.2.1.1 |

| Qu | Part | Marking guidance                                                                                                                                              | Comments | Total marks | AO / spec      |
|----|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|----------------|
| 06 | 2    | <ul style="list-style-type: none"> <li>increased temperature with height / temperature inversion</li> <li>UV absorbed by ozone / molecular oxygen.</li> </ul> |          | 2           | AO2<br>3.2.1.1 |

| Qu | Part | Marking guidance                                                                                                                                                                                   | Comments | Total marks | AO / spec                 |
|----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|---------------------------|
| 06 | 3    | <ul style="list-style-type: none"> <li>cirrus clouds (formed of ice) have high albedo/act as GHGs</li> <li>reflect IR back to surface (leading to warming)/absorb IR converting to heat</li> </ul> |          | 2           | AO2<br>3.2.1.1<br>3.2.1.2 |

|                     |  |  |  |   |
|---------------------|--|--|--|---|
| Question 06 total = |  |  |  | 5 |
|---------------------|--|--|--|---|

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                              | Comments                                                                                                                                                                     | Total marks | AO / spec                |
|----|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------|
| 07 | 1    | <ul style="list-style-type: none"> <li>B = 18 squares</li> <li>A = 7 squares</li> </ul> <p>OR</p> <ul style="list-style-type: none"> <li>B = 1 800/180 000</li> <li>A = 700/70 000</li> </ul> <ul style="list-style-type: none"> <li>2.6 : 1</li> </ul> <p>Allow <b>one</b> mark for ecf.</p> | <p><b>Two</b> marks for 2.6 with no working<br/>Max <b>one</b> mark for 2.57</p> <p><b>One</b> mark for area of each<br/><b>One</b> mark for ratio</p> <p>18/7 = 2.57...</p> | 2           | AO3 1a<br>MS0.3<br>PS3.2 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                           | Comments | Total marks | AO / spec                         |
|----|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|-----------------------------------|
| 07 | 2    | <p>Any <b>two</b> from</p> <ul style="list-style-type: none"> <li>rock <b>A</b> and <b>B</b> not evenly distributed over the area/area size of the sites is different</li> <li>data may not be representative of different proportions/deposits may occur in areas not sampled</li> <li>number of samples sites should be equal</li> </ul> |          | 2           | AO2<br>PS2.1<br>Me1, Me2<br>MS1.5 |

| Qu | Part | Marking guidance                                                                                                                                                         | Comments                      | Total marks | AO / spec                |
|----|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-------------|--------------------------|
| 07 | 3    | <ul style="list-style-type: none"> <li>greater depth of coarse AND medium sediment in site <b>6</b> /greater depth/quantity of fine sediment in site <b>4</b></li> </ul> | Must have comparative comment | 1           | AO3 1b<br>MS3.1<br>PS3.1 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                    | Comments | Total marks | AO / spec                 |
|----|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|---------------------------|
| 07 | 4    | <ul style="list-style-type: none"> <li>site 6 - closer to river</li> <li>more deposition</li> </ul> <p>A: converse (site 4 – further from river, less deposition)</p> <p>OR</p> <ul style="list-style-type: none"> <li>(river flow through rock <b>B</b> toward rock <b>A</b>), rock <b>B</b> may have more of quartz</li> <li>greater erosion of quartz at rock B sites (and subsequent deposition).</li> </ul> <p>A: converse</p> |          | 2           | AO2<br>3.2.3.2<br>3.2.5.2 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                | Comments | Total marks | AO / spec            |
|----|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|----------------------|
| 07 | 5    | <b>Named method</b> <ul style="list-style-type: none"> <li>soil sieving</li> </ul>                                                                                                                                                                                                                                                                                                                                                              |          | 1           | AO2<br>AO1 1b<br>ST3 |
|    |      | And <b>two</b> from <ul style="list-style-type: none"> <li>(dried soil sample) weighed</li> <li>use mesh of different sizes and shake</li> <li>weigh/measure proportions</li> </ul> <b>OR</b> <ul style="list-style-type: none"> <li>Sedimentation</li> </ul> And <b>two</b> from <ul style="list-style-type: none"> <li>place soil sample in measuring cylinder, add water</li> <li>shake</li> <li>measure proportion of sediments.</li> </ul> |          | 2           |                      |

|                     |    |
|---------------------|----|
| Question 07 total = | 10 |
|---------------------|----|

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Comments | Total marks | AO / spec                |
|----|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|--------------------------|
| 08 | 1    | <p>Any <b>two</b> from:</p> <ul style="list-style-type: none"> <li>reliable/not intermittent/supply rate can be controlled/can be used to meet peaks in demand</li> <li>higher energy density</li> <li>biofuels can be stored</li> <li>can be used with existing technologies/infrastructure/ cheaper to produce due to named cost</li> <li>can use waste materials (eg crop waste, landfill, sewage)</li> <li>locational factors may make other renewables less viable</li> <li>removes CO<sub>2</sub> from the atmosphere/carbon neutral</li> <li>no need for conversion to other energy forms.</li> </ul> <p><b>Accept</b> converse statements about other renewables</p> |          | 2           | AO2<br>3.3.2,<br>3.3.4.1 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                          | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Total marks | AO / spec                |
|----|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|--------------------------|
| 08 | 2    | <ul style="list-style-type: none"> <li><math>3.9 \times 10^{11}</math>/<br/>390 000 000 000</li> <li><math>2.96 \times 10^{10}</math>/<br/>29 629 629 630</li> <li><math>1.60 \times 10^5</math>/<br/>160 000</li> </ul> <p><b>Accept</b> alternative powers of 10<br/><b>Accept</b> correct answers to any sig figs / decimal places</p> | <p><b>Total production of sugar cane</b><br/> <math>5\,000\,000\text{ ha} \times 78\,000\text{ kg ha}^{-1}</math><br/> <math>= 3.9 \times 10^{11}\text{ kg}</math><br/> <math>= 390 \times 10^9\text{ kg}</math></p> <p><b>Mass of sugar cane converted to ethanol</b><br/> <math>800 \times 10^9\text{ MJ} \div 27\text{ MJ kg}^{-1}</math><br/> <math>= 2.96 \times 10^{10}\text{ kg}</math></p> <p><b>Total energy supplied per hectare</b><br/> <math>800 \times 10^9\text{ MJ} \div 5\text{ million ha}</math><br/> <math>= 1.6 \times 10^5\text{ MJ ha}^{-1}</math></p> | 3           | AO3 1a<br>MS 0.1,<br>0.3 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Total marks | AO / spec                 |
|----|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------------|
| 08 | 3    | <ul style="list-style-type: none"> <li>1700</li> <li>10 625 000</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>15 625 000</li> <li>10 625 000</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>2.125</li> <li>10 625 000</li> </ul> <p><b>OR</b></p> <ul style="list-style-type: none"> <li>3.125</li> <li>10 625 000</li> </ul> <p><b>AND</b></p> <ul style="list-style-type: none"> <li><math>11 \times 10^6 / 1.1 \times 10^7</math></li> </ul> <p>A: correct answer using their value from 08.2</p> <p>Max 1 ecf for two errors</p> <p>Max 2 for ecf if standard form and 2 sig figs correct for their calculation</p> <p><b>A:</b> 3 marks for correct answer with no calculations</p> | <p>2500 PJ needed, 800 PJ produced<br/>Difference = 1700 PJ</p> <p><math>1700 \times 10^9 \text{ MJ} \div 1.6 \times 10^5 \text{ MJ ha}^{-1}</math><br/>= 10 625 000</p> <p>Total land required<br/>= <math>2500 \times 10^9 \text{ MJ} \div 1.6 \times 10^5 \text{ MJ ha}^{-1}</math><br/>= 15 625 000<br/>Extra land required =<br/><math>15\,625\,000 - 5\,000\,000 = 10\,625\,000</math></p> <p><math>1700 \text{ PJ} \div 800 \text{ PJ} = 2.125</math><br/><math>2.125 \times 5 \text{ million ha} = 10\,625\,000</math></p> <p><math>2500 \text{ PJ} \div 800 \text{ PJ} = 3.125</math><br/><math>3.125 \times 5 \text{ million ha} = 15\,625\,000</math><br/>Extra land required =<br/><math>15\,625\,000 - 5\,000\,000 = 10\,625\,000</math></p> <p>Standard form and 2 sig figs</p> | 3           | AO3 1a<br>MS0.1,<br>MS0.2 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                      | Comments | Total marks | AO / spec      |
|----|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|----------------|
| 08 | 4    | Any <b>two</b> from: <ul style="list-style-type: none"> <li>(fossil fuels needed for) machinery for harvesting transport processing</li> <li>(fossil fuels needed for) fertilisers/pesticides</li> <li>less land for growing crops so more food has to be imported (increasing fossil fuel use)</li> <li>deforestation for biofuel production removes carbon sequestration</li> </ul> |          | 2           | AO2<br>3.3.4.1 |

|                     |    |
|---------------------|----|
| Question 08 total = | 10 |
|---------------------|----|

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Comments                                                                                                      | Total marks | AO / spec                |
|----|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|-------------|--------------------------|
| 09 | 1    | Any <b>two</b> from:<br>e.g. <ul style="list-style-type: none"> <li>NH has fewer fluctuations between 2007 and 2022</li> <li>2007–2010 – steady rise in NH concentrations (390 DU to 460 DU) however a relative fall in SH (230–210 DU)</li> <li>sharp decrease in NH levels 2010–2011 (460–340) but only steady fall in SH (210 DU – 180 DU)</li> <li>period 2012–2017 much larger fluctuations in SH than in NH</li> <li>between 2018–2019 a sharp rise in Southern Hemisphere but minor fall in Northern Hemisphere.</li> </ul> | Must use change in concentration over time period from each location (or comparative statement) for each mark | 2           | AO3 1c<br>PS3.1<br>MS3.1 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Comments                                                                        | Total marks | AO / spec         |
|----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-------------|-------------------|
| 09 | 2    | <p>Unusual atmospheric conditions in Southern Hemisphere high latitude locations:</p> <p>Up to <b>three</b> from:</p> <ul style="list-style-type: none"> <li>very low temperatures (below <math>-78^{\circ}\text{C}</math>)</li> <li>formation of stratospheric clouds</li> <li>ice crystals provide a surface for reactions</li> <li>polar vortex winds stop the removal of cold air/prevents mixing of air</li> <li>lower temperatures persist for longer in SH hence greater impact</li> </ul> <p>Breakdown of ozone:</p> <p>Up to <b>three</b> from:</p> <ul style="list-style-type: none"> <li>UV provides energy for reactions to occur</li> <li>reactive chlorine/chlorine monoxide/chlorine free radicals</li> </ul> <p>(Cl breaks down ozone):</p> <ul style="list-style-type: none"> <li><math>\text{Cl} + \text{O}_3 \rightarrow \text{ClO} + \text{O}_2</math></li> </ul> <p>(Cl prevents formation of ozone)</p> <ul style="list-style-type: none"> <li><math>\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2</math></li> <li>One chlorine atom repeats the cycle/persistence of chlorine/CFCs causes further depletion</li> </ul> | <p>Max 3 for only statements on breakdown of ozone</p> <p>A: word equations</p> | 4           | AO1 1b<br>3.2.1.3 |

| Qu | Part | Marking guidance                                                                                                                                                                                           | Comments                                                                                                                                     | Total marks | AO / spec                                 |
|----|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------|
| 9  | 3    | <p><b>eg</b><br/><b>Ozone Depletion</b><br/>Montreal protocol (1987)</p> <p>Banning of CFCs</p> <p>Use of HCFCs</p> <p>Introduction of HFCs</p> <p><b>A:</b> refs to alternative methods and materials</p> | <p>Not enforced in every country</p> <p>Still an ODS, subsequently banned</p> <p>Lack of uniformity in phasing of ODS/phased out by 2030</p> | 9           | AO1<br>AO2<br>AO3<br>3.2.1.3<br>3.4.3.2.2 |

|  |  |                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                             |  |  |
|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
|  |  | <p><b>Climate change</b></p> <p>Kyoto Protocol (target to reduce CO<sub>2</sub>)</p> <p>Paris Agreement (keep warming within 1.5)</p> <p>COP meetings / consensus of change in climate</p> <p>Global methane pledge 2026</p> <p>Other methods to reduce GHG:<br/>e.g</p> <p>Renewable energies<br/>Electric vehicles<br/>Afforestation</p> | <p>Reduction in CO<sub>2</sub> of 12.5%<br/>Only ratified by 192 countries<br/>Some suggest reductions were due to collapse of USSR.</p> <p>Set targets to keep warming within 1.5°C (but not on that pathway currently – 2.7°C</p> <p>Aims to reduce methane by 30% between 2020-2030.</p> |  |  |
|--|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|

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   | <p>A comprehensive response to the question, with the focus sustained.</p> <p>A conclusion is presented in a logical and coherent way, fully supported by relevant judgements.</p> <p>A wide range of knowledge and understanding of natural processes/systems is applied. The answer clearly identifies relationships between environmental issues.</p> <p>Relevant environmental terminology is used consistently and accurately throughout, with no more than minor omissions and errors.</p>                                                                                                                                                          |
| 2     | 4–6   | <p>A response to the question which is focussed in parts but lacking appropriate depth.</p> <p>A conclusion may be present, supported by some judgements, but it is likely not all will be relevant.</p> <p>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.</p> <p>Environmental terminology is used, but not always consistently.</p>                                                                   |
| 1     | 1–3   | <p>A response to the question which is unbalanced and lacking focus. It is likely to consist of fragmented points that are unrelated.</p> <p>A conclusion may be stated, but it is not supported by any judgments and is likely to be irrelevant.</p> <p>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.</p> <p>Limited environmental terminology is used, and a lack of understanding is evident.</p> |
|       | 0     | Nothing written worthy of credit.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

|                     |    |
|---------------------|----|
| Question 09 total = | 15 |
|---------------------|----|

| Qu | Part | Marking guidance                                                        | Comments | Total marks | AO / spec                  |
|----|------|-------------------------------------------------------------------------|----------|-------------|----------------------------|
| 10 | 1    | <ul style="list-style-type: none"> <li>incomplete combustion</li> </ul> |          | 1           | AO2<br>3.3.3,<br>3.4.3.2.1 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Comments | Total marks | AO / spec                                                 |
|----|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-------------|-----------------------------------------------------------|
| 10 | 2    | <p><b>Wind</b></p> <ul style="list-style-type: none"> <li>distance the PM travels/how quickly dispersed/what direction it takes/away from source</li> </ul> <p><b>Temperature</b></p> <ul style="list-style-type: none"> <li>temperature inversions prevent PM from dispersing/higher temperatures make PM more buoyant/rise with convection currents</li> </ul> <p><b>Precipitation</b></p> <ul style="list-style-type: none"> <li>prevents PM rising/washes out/to ground level/attaches to PM and settles by gravity</li> </ul> <p><b>R:</b> ref to human activities affected by these factors</p> |          | 3           | AO1 1b<br>3.4.2.1.,<br>3.4.2.2<br>PS2.1,<br>PS2.3,<br>Me5 |

| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Comments                                                        | Total marks | AO / spec                                        |
|----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|-------------|--------------------------------------------------|
| 10 | 3    | <p>Any <b>two</b> from:</p> <ul style="list-style-type: none"> <li>• use of wood-burners as main heating / less connection to mains gas/availability of wood/multi-use e.g. cooking, water heating</li> <li>• colder in rural areas/urban heat island effect</li> <li>• burning of wet/unseasoned wood</li> <li>• energy inefficient wood-burners</li> <li>• less regulation/'policing' of wood sold / Clean Air Act</li> <li>• no dust suppressant sites/road coatings to adsorb PM</li> </ul> <p><b>Accept</b> converse statements</p>                                                                                                                                                                                                                                               |                                                                 | 2           | <p>AO2<br/>3.4.3.1<br/>3.4.3.2.1<br/>3.2.5.2</p> |
| Qu | Part | Marking guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Comments                                                        | Total marks | AO / spec                                        |
| 10 | 4    | <p><b>Rural sites</b><br/>Any <b>two</b> from:<br/>eg</p> <ul style="list-style-type: none"> <li>• ploughing loose/dry/clay soils/harvesting</li> <li>• wildfires/bonfires</li> <li>• holiday traffic emissions</li> <li>• mining</li> <li>• pollen</li> <li>• transboundary dust</li> <li>• barbecues/burning of charcoal/coal</li> </ul> <p><b>Urban sites</b><br/>Any <b>two</b> from:<br/>eg</p> <ul style="list-style-type: none"> <li>• barbecues</li> <li>• dust from named source/transboundary dust</li> <li>• industry/factories/power generation</li> <li>• chemical reactions with other pollutants</li> <li>• tyre residues</li> <li>• diesel train/shipping emissions</li> </ul> <p><b>R:</b> road traffic emissions e.g.cars, buses<br/><b>A:</b> any valid answers</p> | <p>Answers must be different to those given for rural sites</p> | 4           | <p>AO2<br/>3.4.3.1<br/>3.4.3.2.1<br/>3.2.5.2</p> |

|                     |    |
|---------------------|----|
| Question 10 total = | 10 |
|---------------------|----|

| Qu | Part | Marking guidance | Total marks | AO                              |
|----|------|------------------|-------------|---------------------------------|
| 11 | 1    |                  | 25          | AO1 = 10<br>AO2 = 10<br>AO3 = 5 |

| Reduced impacts of storage and conservation technologies                                                                                                                                                                                                                                                                                                          | Technologies                                                                                                                                                                              | Discussion: examples of negative impacts, other limitations/issues                                                                                                                                                                                                                                              | Spec refs          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Storage                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                 |                    |
| <p>Impacts reduced:<br/>Extraction/mining of resources (habitat loss/damage, dust, noise, AMD/toxic leachate, GHGs etc)<br/>Transport and processing (GHG emissions leading to GCC, CO, particulates etc)</p> <p>Combustion of fossil fuels (GHGs, SO<sub>2</sub>, smogs, particulates/P M10, impacts on human and ecosystem health)</p> <p>Storage overcomes</p> | <ul style="list-style-type: none"> <li>Pumped storage HEP</li> </ul>                                                                                                                      | Reservoir impacts (habitat change, CH <sub>4</sub> release, changes to river flow etc).<br>Locational constraints.                                                                                                                                                                                              | 3.3.4.1<br>3.6.4.1 |
|                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Tidal barrages/lagoons</li> </ul>                                                                                                                  | Impacts on tidal range, build up pollutants, barriers to migration.<br>Locational constraints.                                                                                                                                                                                                                  |                    |
|                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Rechargeable batteries</li> </ul>                                                                                                                  | Exploitation of minerals needed (eg nickel, lithium, lead) causes environmental impacts (but less than non-rechargeable batteries). Increased production of electric cars will increase demand for minerals.                                                                                                    |                    |
|                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Fuel cells</li> </ul>                                                                                                                              | Energy needed for electrolysis of hydrogen. Unless this comes from renewable sources, impacts on climate, air quality, habitats etc will increase.                                                                                                                                                              |                    |
|                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Compressed gas</li> </ul>                                                                                                                          | Energy needed for compression of gas. Unless this comes from renewable sources, impacts on climate, air quality, habitats etc will increase.                                                                                                                                                                    |                    |
|                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Thermal storage: molten salt, high volume hot water stores/low surface area: volume storage of hot fluids, high thermal mass materials.</li> </ul> | Long term storage sometimes difficult as thermal energy is lost through conduction and convection.<br>Molten salt only really useful where very high temperatures are reached eg CSP                                                                                                                            |                    |
|                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>Vehicle to grid systems (V2G)</li> </ul>                                                                                                           | Relies on vehicles being connected to the grid for long periods of time.<br>Consumer co-operation required to ensure vehicles are disconnected when they will be needed.<br>Only reduces environmental impacts if electricity from the grid is from renewable sources or is being used when there is a surplus. |                    |

|                                                                                               |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| problems of intermittency of many renewables (increasing peak storage/ability to meet demand) | • Power to grid systems (P2G)                                                                                                                                                                                                                                                                                                                   | Energy required to electrolyse water to produce hydrogen which can be converted to methane for gas distribution. Methane is a GHG.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                               |
|                                                                                               | • The 'hydrogen economy' (fuel cells, compressed gas, metal hydride systems)                                                                                                                                                                                                                                                                    | Could replace fossil fuels for eg powering vehicles, but relies on renewable energy sources for conversion etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
|                                                                                               | • Kinetic fly wheels                                                                                                                                                                                                                                                                                                                            | Temporary store of energy                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                               |
|                                                                                               | • Super capacitors                                                                                                                                                                                                                                                                                                                              | High energy density but not used to store energy on a large scale at the moment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                               |
| Conservation                                                                                  |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 3.3.4.2                       |
| Transport: Vehicle design                                                                     | <ul style="list-style-type: none"> <li>• Aerodynamics/ Hydrodynamics</li> <li>• Low mass</li> <li>• Tyre/wheel design</li> <li>• Engine design</li> <li>• Kinetic energy recovery systems (KERS)/regenerative braking</li> <li>• Electric vehicles</li> <li>• Use of low embodied energy materials</li> <li>• Bulk transport systems</li> </ul> | <p>Issues include:</p> <p>Consumer choice of vehicle</p> <p>Availability of EV charging points, charging time of batteries, efficiency of the storage cycle, cost, distance that can be travelled, safety issues with batteries etc.</p> <p>Relative price of energy resources (eg electric trains being temporarily replaced with diesel trains if the price of electricity is &gt;gas)</p> <p>Safety e.g tyre design – tread needed</p> <p>Infrastructure changes needed may be significant and cost too much (eg improved public transport routing and timing, EV charging points)</p> <p>Bulk transport – lack of convenience to passengers (timing and routes of journeys), some goods need to be transported quickly (eg perishable items), fuel tax levies, GHG emissions if not using renewable fuels.</p> | 3.3.4.2<br>3.3.4.2.1          |
| Transport: infrastructure and management systems                                              | <ul style="list-style-type: none"> <li>• Integrated transport systems road/rail/cycle</li> <li>• Active Traffic Management (ATM)/Smart Motorways</li> <li>• Congestion charging, LEZs, ULEZs</li> </ul>                                                                                                                                         | <p>Depend upon local, regional and national policies, economics, consumer and government co-operation/incentives</p> <p>Variable speed limits aim to maintain a smoother flow of traffic, but not all road networks have been developed in this way</p> <p>ALR ('all lane running' – hard shoulder opened as a lane in busy times) systems no have been phased out due to safety concerns.</p> <p>Some drivers willingly pay a fine</p>                                                                                                                                                                                                                                                                                                                                                                            | 3.3.4.2                       |
| Transport: Vehicle design for end of life                                                     | <ul style="list-style-type: none"> <li>• Use of recyclable materials</li> <li>• Easier component identification</li> </ul>                                                                                                                                                                                                                      | <p>Requires regulation</p> <p>Energy/labour needed for each requirement</p> <p>Availability of recyclable components</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 3.3.4.2<br>3.2.3.7<br>3.6.4.1 |

|                                                                          |                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                               |           |
|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
|                                                                          | <ul style="list-style-type: none"> <li>• Use of reusable components for new vehicles</li> <li>• Easy dismantling</li> <li>• material separation</li> </ul>                          |                                                                                                                                                                                                                                                                                                                                                                                                               |           |
| Buildings: design                                                        | <ul style="list-style-type: none"> <li>• Orientation/features for passive solar gains</li> <li>• Low surface area: volume ratio</li> <li>• High thermal mass materials</li> </ul>   | <p>Energy efficient design features are easier to build into new buildings than to retrofit<br/>Many designs still not applied on a large scale (eg large developments)<br/>Economically still prohibitive for many prospective owners<br/>Planning laws may mean it may be difficult to get planning permission</p> <p>Weak government regulations re: incorporation of energy efficient design features</p> | 3.3.4.4.2 |
| Buildings: materials/ construction methods with low embodied energy      | <ul style="list-style-type: none"> <li>• Low embodied energy materials eg rammed earth, limecrete, straw</li> <li>• Earth sheltered buildings</li> </ul>                            | <p>Availability of materials (locally)</p> <p>Planning regs<br/>Locational constraints</p>                                                                                                                                                                                                                                                                                                                    |           |
| Buildings: Use of materials with low thermal conductivity/ transmittance | <ul style="list-style-type: none"> <li>• Double/triple glazing/Low emissivity glass/Vacuum/ inert gas double/triple glazing/Wall/floor/ roof insulation</li> </ul>                  | <p>Affordability<br/>Embodied energy of triple glazing vs double glazing may outweigh the energy savings</p> <p>Energy required to produce glazing, insulation etc. Mining / quarrying impacts for materials for glass</p>                                                                                                                                                                                    |           |
| Buildings: Energy management technologies                                | <ul style="list-style-type: none"> <li>• Occupancy sensors/Improved insulation/ Automatic/solar ventilation/Heat exchangers</li> </ul>                                              | Not cheap to install                                                                                                                                                                                                                                                                                                                                                                                          |           |
| Buildings: Low energy appliances                                         | <ul style="list-style-type: none"> <li>• Lighting: CFL, LED/'Low energy' white goods</li> </ul>                                                                                     | <p>Generally do reduce energy use (and hence environmental impact).<br/>Can encourage extra (unnecessary) use, negating the benefits.</p>                                                                                                                                                                                                                                                                     |           |
| Industry: Heat management                                                | <p>Heat management</p> <ul style="list-style-type: none"> <li>• Bulk storage of hot fluids/Use of heat exchangers/Combined heat and power systems (CHP)/District heating</li> </ul> | Technology and finance availability                                                                                                                                                                                                                                                                                                                                                                           | 3.3.4.2.3 |
| Industry: Electricity infrastructure management                          | <ul style="list-style-type: none"> <li>• High voltage grid</li> <li>• ICT to co-ordinate data on electricity supply and demand and plan supply changes</li> </ul>                   | <p>Unightly pylons and HV cables/bird deaths, EM effects on human health<br/>As above in storage</p>                                                                                                                                                                                                                                                                                                          | 3.3.2     |

|  |                                                                                                                             |                                                                                                                               |  |
|--|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--|
|  | <ul style="list-style-type: none"> <li>Locational factors affecting development of new generating infrastructure</li> </ul> | Requires new infrastructure and could have impacts such as wind farms, tidal, increased transport links, grid connections etc |  |
|--|-----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--|

| Qu | Part | Marking guidance | Total marks | AO                              |
|----|------|------------------|-------------|---------------------------------|
| 11 | 2    |                  | 25          | AO1 = 10<br>AO2 = 10<br>AO3 = 5 |

| Type of pollution                           | Control technology                                                                                                                                                                                                                                                         | Discussion point                                                                                                                                                                                                                                                                                                               | Spec refs                       |
|---------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                                             |                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                | Sustainability 3.6.4<br>3.6.4.1 |
| CO <sub>2</sub> – ocean acidification       | <ul style="list-style-type: none"> <li>Renewable energies, nuclear fission, hydrogen, energy conservation technologies, CCS</li> </ul>                                                                                                                                     | Many are successful in reducing CO <sub>2</sub> emissions but acidification in oceans continues (CO <sub>2</sub> has a long residence time etc). CO <sub>2</sub> emissions have not dropped significantly – LEDCs etc still using coal (cheap), slow move to use electric cars<br>CCS – as yet not used on a global/wide scale | 3.2.1.2<br>3.2.4.2              |
| Mine waste – AMD, toxic leachate, turbidity | <ul style="list-style-type: none"> <li>Passing through (crushed) limestone to neutralise acidity and to precipitate out heavy metals</li> <li>Sedimentation lagoons</li> </ul>                                                                                             | Effective – will this continue with increased exploitation of mineral resources                                                                                                                                                                                                                                                | 3.2.3.6<br>3.4.3.2.10           |
| Hydraulic fracturing                        | <ul style="list-style-type: none"> <li>Collection and treatment of waste water (neutralisation and sedimentation of heavy metals)</li> <li>Strong concrete casing in drilling wells to prevent methane release into aquifers</li> <li>Venting of excess methane</li> </ul> | Large volumes of water needed to produce fracturing.<br><br>Increased cost, so may not be carried out.<br><br>GHG so increase GCC                                                                                                                                                                                              | 3.3.3<br>3.3.4.1                |
| Phosphates                                  | <ul style="list-style-type: none"> <li>Tertiary sewage treatment</li> </ul>                                                                                                                                                                                                | Effective but sewage releases into rivers and the sea still occur                                                                                                                                                                                                                                                              | 3.2.4.4<br>3.4.3.2.9            |

|                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                      |                                 |
|--------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Not all treatment plants have tertiary treatment                                                                                                                                                                                                     |                                 |
| Nitrates                                               | <ul style="list-style-type: none"> <li>Nitrates</li> <li>Use of drainage ditches / buffer strips in agriculture</li> <li>Drones / satellites to monitor fertiliser application (and therefore reduce excess application)</li> <li>Improvements in weather monitoring to reduce fertiliser application before rain</li> <li>Use of artificial fertiliser alternatives e.g legumes, organic fertiliser</li> <li>Use of filter feeders in aquaculture to remove organic matter</li> <li>Development of antibiotics</li> </ul> | <p>Relies on farmers' co-operation/local monitoring of water courses</p> <p>Affordability of technology</p> <p>Reluctance to change methods/profit margins</p> <p>Issues with bacterial resistance</p>                                               | <p>3.2.4.3</p> <p>3.4.3.2.9</p> |
| Acidification of lakes and rivers (acid precipitation) | <p>Control of SO<sub>2</sub> – desulfurisation of natural gas, crude oil, coal, FGD</p> <p>Control of NO<sub>x</sub> – low temp combustion, catalytic converters, urea sprays</p> <p>Alternative fuels</p>                                                                                                                                                                                                                                                                                                                 | <p>Effective only in those regions where the technology is applied/is affordable</p>                                                                                                                                                                 | <p>3.4.3.2.2</p>                |
| Thermal pollution                                      | <p>Cooling towers, heat exchangers</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p>Not used in every thermal power station.</p> <p>Temperature of effluent water is reduced but not to that of the original water, impacts may still occur – deoxygenation, effects on aquatic organisms, increased niches for invasive species.</p> | <p>3.4.3.2.6</p>                |
| Oil pollution                                          | <p>Recycling of waste lubrication oil, double hulls, twin engine/rudder/fuel tanks, separate oil and ballast tanks, inert gas systems, use of GPS etc), oil interceptors, bund walls, clean up technologies (booms, skimmers etc)</p>                                                                                                                                                                                                                                                                                      | <p>Effective technologies reflected in fewer oil spills/tanker casualties etc. Some technologies harmful (dispersants/solvents/steam cleaning) to the marine environment.</p> <p>Clean up technologies very dependent on the features off the</p>    | <p>3.4.3.2.7</p>                |

|                    |                                                                                                                                                                                                                                                                                                                                            | environment/weather conditions/ remoteness                                                                                                                                                                                                                                  |                                         |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|
| Microplastics      | Legislation, eg ban on single use plastics<br>Use of biodegradable plastics and bioplastics Technologies to capture and dispose of microplastics in wastewater treatment plants. Use of bacteria that break down plastics.                                                                                                                 | Discussion point about the sheer amount of plastics being manufactured and slow take up of biodegradable and bioplastic in packaging.                                                                                                                                       | Not on spec but a highly relevant issue |
| Pesticides         | Development of non-persistent, more specific, systemic pesticides<br>Spraying technologies that use smaller droplets                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>• Use of sterile male technique</li> <li>• GM organisms to be pest resistant</li> <li>• Monitoring technologies to improve timing of application of pesticides</li> <li>• Biosecurity in greenhouses / indoor aquaculture</li> </ul> | 3.4.3.2.8,<br>3.5.1.1,<br>3.5.1.3       |
| Heavy metals       | Lead – alternatives used in water pipes, petrol, solder, paint, fishing weights, shotgun pellets<br>Mercury – alternatives used in thermometers, removed from effluents by reverse osmosis/activated carbon filters/ion exchange filters, removal at high pH<br>Cadmium – disposal in hazardous waste landfill, or recycling of batteries. | Introduction of alternatives and disposal methods is effective. Persistence of many heavy metals means that historic disposal can still be a problem                                                                                                                        | 3.4.3.2.11                              |
| Solid wastes       | Landfill – polymer liner, collection and treatment of leachate<br>Spoil heaps – phytoremediation, collection and treatment of leachates, neutralisation of leachate (to remove heavy metals)                                                                                                                                               | Water pollution can be reduced through these methods if careful engineering applied.                                                                                                                                                                                        | 3.4.3.2.12                              |
| Ionising radiation | Encapsulation, vitrification (high level waste), cement slurry (intermediate level waste), filtration/ion exchange (low level liquid waste)                                                                                                                                                                                                | Radioactive wastes highly regulated but reactor incidents (rare) can make any regulation obsolete eg Fukushima (contamination of ocean waters)<br><br>High level wastes (with long half-lives) are just stored – geological/seismic activity                                | 3.4.3.2.14                              |

|  |  |                                    |  |
|--|--|------------------------------------|--|
|  |  | could release radiation into water |  |
|--|--|------------------------------------|--|

| Level | Marks | Descriptors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5     | 21–25 | <p>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.</p> <p>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.</p> <p>Where conclusions are made, these are fully supported by judgements and presented in a logical and coherent way.</p> <p>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.</p> |
| 4     | 16–20 | <p>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.</p> <p>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.</p> <p>Where conclusions are made, these are supported by judgements which are mostly coherent and relevant.</p> <p>Relevant environmental terminology is used consistently and throughout, with no more than minor errors.</p>                                                                                                                         |
| 3     | 11–15 | <p>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.</p> <p>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.</p> <p>Where conclusions are made, it is not always clear how they relate to the judgments given and are likely to contain errors.</p> <p>Relevant environmental terminology is used, but not consistently and there may be errors.</p>                                                                           |
| 2     | 6–10  | <p>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.</p> <p>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.</p> <p>Any conclusions are likely to be asserted, with no supporting judgements and fundamental errors.</p> <p>Environmental terminology is used, but not always appropriately and sometimes</p>                                                                                                                                                  |

|   |     |                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   |     | with clear errors.                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 1 | 1–5 | <p>Fragmented points, whose relevance to the question and relationships to each other are unclear.</p> <p>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.</p> <p>It is unlikely that a conclusion will be present.</p> <p>There is an attempt to use environmental terminology, but seldom appropriately.</p> |
|   | 0   | Nothing written worthy of credit.                                                                                                                                                                                                                                                                                                                                                                                                                   |

|                            |           |
|----------------------------|-----------|
| <b>Question 11 total =</b> | <b>25</b> |
|----------------------------|-----------|