

# Cambridge International AS & A Level

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**MARINE SCIENCE****9693/42**

Paper 4 A Level Data-handling and Investigative Skills

**May/June 2025****MARK SCHEME**Maximum Mark: 75

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**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

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This document consists of **18** printed pages.

**PUBLISHED****Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

**GENERIC MARKING PRINCIPLE 1:**

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

**GENERIC MARKING PRINCIPLE 2:**

Marks awarded are always **whole marks** (not half marks, or other fractions).

**GENERIC MARKING PRINCIPLE 3:**

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

**GENERIC MARKING PRINCIPLE 4:**

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

**GENERIC MARKING PRINCIPLE 5:**

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

**GENERIC MARKING PRINCIPLE 6:**

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

**Science-Specific Marking Principles**

- 1 Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
- 2 The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
- 3 Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
- 4 The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
- 5 'List rule' guidance  
  
For questions that require ***n*** responses (e.g. State **two** reasons ...):
  - The response should be read as continuous prose, even when numbered answer spaces are provided.
  - Any response marked *ignore* in the mark scheme should not count towards ***n***.
  - Incorrect responses should not be awarded credit but will still count towards ***n***.
  - Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response.
  - Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

**6** Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g.  $a \times 10^n$ ) in which the convention of restricting the value of the coefficient ( $a$ ) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

**7** Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

**Annotations guidance for centres**

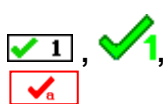
Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

**Annotations**

| <b>Annotation</b>                                                                   | <b>Meaning</b>                                                                                                                |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
|    | correct point or mark awarded                                                                                                 |
|    | incorrect point or mark not awarded                                                                                           |
|    | information missing or insufficient for credit                                                                                |
|    | allow or accept                                                                                                               |
|  | incorrect or insufficient point ignored while marking the rest of the response                                                |
|  | contradiction in response, mark not awarded                                                                                   |
|  | benefit of the doubt given                                                                                                    |
|  | error carried forward applied                                                                                                 |
|  | maximum mark reached                                                                                                          |
|  | benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied |

| Annotation                                                                         | Meaning                                                                                                                    |
|------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
|   | point already given                                                                                                        |
|   | power of ten error                                                                                                         |
|   | incorrect point or mark not awarded                                                                                        |
|   | rounding error                                                                                                             |
|   | point has been noted, but no credit has been given<br>or<br>blank page seen                                                |
|   | response is too vague or there is insufficient detail in response                                                          |
|   | marking point 1 or marking point a is awarded. Used to mark against a particular marking point from an extended answer MS  |
|   | used to highlight parts of an answer / incorrect idea / irrelevant to question                                             |
|   | used to highlight parts of an extended response / incorrect idea / irrelevant to question                                  |
|  | key point attempted / working towards marking point / incomplete answer / response seen but not credited / blank page seen |
| <b>ruler</b>                                                                       | allows lengths to be measured                                                                                              |
| <b>multi-line overlay</b>                                                          | overlays graphs                                                                                                            |

**This mark scheme will use the following abbreviations:**

|                  |                                                                               |
|------------------|-------------------------------------------------------------------------------|
| <b>;</b>         | separates marking points                                                      |
| <b>/</b>         | alternative responses for the same marking point                              |
| <b>R</b>         | reject the response                                                           |
| <b>A</b>         | accept the response                                                           |
| <b>I</b>         | ignore the response                                                           |
| <b>ECF</b>       | error carried forward                                                         |
| <b>AVP</b>       | any valid point / alternative valid point                                     |
| <b>ORA</b>       | or reverse argument                                                           |
| <b>AW</b>        | alternative wording                                                           |
| <b>underline</b> | actual word given must be used by candidate (grammatical variants excepted)   |
| <b>( )</b>       | the word / phrase in brackets is not required but sets the context            |
| <b>MAX</b>       | indicates the maximum number of marks that can be given                       |
| <b>+<br/>AND</b> | statements on both sides of the + or AND are needed for that mark             |
| <b>OR</b>        | separates two different routes to a mark point and only one should be awarded |

| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Marks    |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 1(a)(i)  | nucleus ;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>1</b> |
| 1(a)(ii) | 1 unbroken lines with no shading ;<br>2 at least same size as photograph ;<br>3 proportions of drawing correct ;<br><i>{nucleus and chloroplasts in proportion, gap between nucleus and cell wall in proportion}</i><br>4 nucleolus, cell wall and minimum of nine chloroplasts drawn ;                                                                                                                                                                                                                                                                                    | <b>4</b> |
| 1(b)(i)  | <i>any 2 of:</i><br>1 blue light is, absorbed / trapped, by chlorophyll (a / b) / pigments / <b>AW</b> ;<br>2 photosynthesis (occurs) ;<br>3 carbon dioxide, taken in / absorbed / used / <b>AW</b> ;                                                                                                                                                                                                                                                                                                                                                                      | <b>2</b> |
| 1(b)(ii) | <i>any 4 of:</i><br>1 blue / green light, penetrates deeper / <b>AW</b> / <b>ORA</b> ;<br>2 macroalga can use <u>all</u> colours / absorbs <u>all</u> colours / <b>AW</b> ;<br>3 macroalga has faster colour change (than aquatic plant) with, green / yellow / <b>ORA</b> ;<br>4 macroalga has slower colour change (than aquatic plant) with blue / red light / <b>ORA</b> ;<br>5 macroalga has, accessory / additional, pigments / fucoxanthin / <b>AW</b> ;<br>6 macroalga can photosynthesise / make glucose, in deep water / when no red light present / <b>AW</b> ; | <b>4</b> |

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| Question  | Answer                                                                                                                                                                                                                           | Marks    |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 1(b)(iii) | <i>any 2 of:</i><br><br>1 green light is not absorbed ;<br><br>2 no photosynthesis occurs ;<br><br>3 respiration occurs ;<br><br>4 so rate of production of carbon dioxide is higher than uptake of carbon dioxide / <b>AW</b> ; | <b>2</b> |
| 1(b)(iv)  | <i>any 1 of:</i><br><br>1 colour change is subjective ;<br><br>2 difficult to see differences between colours ;<br><br>3 the experiment measures photosynthesis minus respiration ;                                              | <b>1</b> |

| Question | Answer                                                                                                                                                                                                                                                                               | Marks    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(a)(i)  | <p><i>any 2 of:</i></p> <p>1 prevents bycatch / <b>AW</b> ;</p> <p>2 no loss of tackle on reefs / less damaging to reefs / habitats / seabed / <b>AW</b> ;</p> <p>3 prevents over-fishing / <b>AW</b> ;</p> <p>4 less chance of catching juveniles / immature fish / <b>AW</b> ;</p> | <b>2</b> |
| 2(a)(ii) | <p>2200 (%) ;;;</p> <p><b>Two marks for:</b></p> <p>2173.45....</p> <p><b>One mark for:</b></p> <p><math>\div 1017</math></p> <p><b>OR</b></p> <p>23 121 – 1017</p> <p><b>OR</b></p> <p>22014</p>                                                                                    | <b>3</b> |
| 2(b)(i)  | <p>1 practical method of counting lionfish ;</p> <p>2 divide number by area ;</p>                                                                                                                                                                                                    | <b>2</b> |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Marks    |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 2(b)(ii) | <p><i>any 3 of:</i></p> <ol style="list-style-type: none"> <li>1 populations fall in all reefs / <b>AW</b> ;</li> <li>2 reef area 1 and 2 increase after 2014 / reef area 3 decreases less steeply after 2014 / <b>AW</b> ;</li> <li>3 less breeding / reproduction / recruitment / loss of breeding stock / <b>AW</b> ;</li> <li>4 financial reward encourages, high rate of capture / <b>AW</b> ;</li> <li>5 fishing intensity may reduce after 2014 / <b>AW</b> ;</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>3</b> |
| 2(c)     | <p><i>any 4 of:</i></p> <ol style="list-style-type: none"> <li>1 lionfish have been successfully controlled / lionfish population has lowered / <b>AW</b> ;</li> <li>2 total <u>catch</u> increases until 2014 then decreases / highest catch in 2014 / <b>AW</b> ;</li> <li>3 (fewer lionfish means) reduced damage to native species / less damage to habitats / <b>AW</b> ;</li> <li>4 (however) there is a slight rise in population in 2014 (in two reef areas) (suggesting they are recovering) / <b>AW</b> ;</li> <li>5 price of lionfish decreases until 2014 / price of lionfish rises after 2014 / lowest prices between 2013 and 2014 / <b>AW</b> ;</li> <li>6 low / falling, price if many fish caught / <b>AW</b> ;</li> <li>7 fishing industry is not long-term / <b>AW</b> ;</li> <li>8 (loss of fishery) could result in loss of income / employment / sociological issues / poverty / <b>AW</b> ;</li> <li>9 <b>AVP</b> ;</li> </ol> | <b>4</b> |

| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Marks    |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 3(a)     | <p><i>any 2 of:</i></p> <p>1 forms carbonic acid / <math>\text{H}_2\text{CO}_3</math> / <b>AW</b> ;</p> <p>2 (dissociates) into <math>\text{H}^+</math> and <math>\text{HCO}_3^-</math> / results in high concentration of <math>\text{H}^+</math> / <b>AW</b> ;</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>2</b> |
| 3(b)(i)  | <p>0.22 to 0.25 ;;</p> <p><math>\mu\text{mol g}^{-1}\text{hr}^{-1}</math> ;</p> <p><b>One mark</b> for correct values of pH change and time</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>3</b> |
| 3(b)(ii) | <p><i>any 4 of:</i></p> <p>1 rate of calcium carbonate deposition is lower at pH 7.8 / <b>AW</b> ;</p> <p>2 as less carbonate (available) / <math>\text{CO}_3^{2-}</math> <b>AW</b> ;</p> <p>3 so weaker shells / <b>AW</b> ;</p> <p>4 lower survival / populations fall / easily predated / <b>AW</b> ;</p> <p>5 lower primary productivity (due to low pH) / less photosynthesis by producers / <b>AW</b> ;</p> <p>6 less food / biomass / energy to pass along food chain (for higher trophic levels) / <b>AW</b> ;</p> <p>7 algae populations could increase if fewer snails to consume them / <b>AW</b> ;</p> <p>8 range of points on graph overlap / large range of masses / points are far from lines of best fit / weak correlation / <b>AW</b> ;</p> <p>9 sample size is low ;</p> | <b>4</b> |

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| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                        |                                                                 |              |                          |                              | Marks    |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------|--------------|--------------------------|------------------------------|----------|
| 3(c)(i)   | <b>year</b>                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>number of days that porpoises were detected (O)</b> | <b>expected number of days that porpoises were detected (E)</b> | <b>(O–E)</b> | <b>(O–E)<sup>2</sup></b> | <b>(O–E)<sup>2</sup> / E</b> | <b>1</b> |
|           | 2005 (before construction)                                                                                                                                                                                                                                                                                                                                                                                                    | 56                                                     | 49                                                              | 7            | 49                       | 1                            |          |
|           | 2006 (during construction)                                                                                                                                                                                                                                                                                                                                                                                                    | 54                                                     | 49                                                              | 5            | 25                       | 0.5                          |          |
|           | 2007 (after construction)                                                                                                                                                                                                                                                                                                                                                                                                     | 36                                                     | 49                                                              | <b>–13</b>   | <b>169</b>               | <b>3.4(5) ;</b>              |          |
| 3(c)(ii)  | 4.9(5) ;                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                        |                                                                 |              |                          |                              | <b>1</b> |
| 3(c)(iii) | <p><i>any 4 of:</i></p> <p>1 null hypothesis is, not rejected / accepted, / porpoises are not harmed by wind turbine construction ;</p> <p>2 calculated value is lower than critical value / <b>AW</b> ;</p> <p>3 identified critical value as 5.991 ;</p> <p>4 greater than 5% probability that the difference is due to chance ;</p> <p>5 no significant difference / porpoise movement is not significantly affected ;</p> |                                                        |                                                                 |              |                          |                              | <b>4</b> |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                           | Marks    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 3(d)     | <p><i>any 2 of:</i></p> <ol style="list-style-type: none"> <li>1 (reduced dependency on fossil fuels so) reduced greenhouse effect / less climate change / less global warming / less risk of sea level rises / <b>AW</b> ;</li> <li>2 will not run out / renewable / sustainable / <b>AW</b> ;</li> <li>3 low risk of acid rain ;</li> <li>4 low risk of oil spills ;</li> <li>5 no habitat damage from (oil) drilling / <b>AW</b> ;</li> </ol> | <b>2</b> |

| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                       | Marks    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 4(a)(i)  | <ol style="list-style-type: none"> <li>1 two linear y-axes and linear x-axis labelled with units ;</li> <li>2 both plotted lines taken up at least three large squares ;</li> <li>3 correct plots for percentage change in mass (+/– ½ square) ;</li> <li>4 correct plots for turgor pressure (+/– ½ square) ;</li> <li>5 plots joined with straight lines and lines have a key or are labelled ;</li> </ol> | <b>5</b> |

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| Question  | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Marks    |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 4(a)(ii)  | <p><i>any 3 of:</i></p> <ol style="list-style-type: none"> <li>1 at low concentrations / below 0.5, mass increases / water enters cells, / <b>AW</b> ;</li> <li>2 at high concentrations / above 0.75 / value from graph, decrease in mass / water leaves cells ;</li> <li>3 (water moves in / out) by osmosis ;</li> <li>4 (water moves) from a higher water potential to a lower water potential ;</li> <li>5 solute concentration of cells is equivalent to value from graph where line intersects x-axis ;</li> </ol>                                                  | <b>3</b> |
| 4(a)(iii) | <p><i>any 2 of:</i></p> <ol style="list-style-type: none"> <li>1 turgor pressure decreases up to concentration of 0.75 and then levels off (at zero) / <b>AW</b> ;</li> <li>2 because as concentration increases, water content of cells is less / <b>AW</b> ;</li> <li>3 below 0.75, membrane presses / touches cell wall / <b>AW</b> ;</li> <li>4 over 0.75, cell membrane peels away from cell wall / cells has become plasmolysed / <b>AW</b> ;</li> </ol>                                                                                                             | <b>2</b> |
| 4(b)(i)   | <p><i>any 2 of:</i></p> <ol style="list-style-type: none"> <li>1 water would (naturally) move into chamber A / from chamber B / from freshwater to sea water / <b>AW</b> ;</li> <li>2 as the water potential of B is higher than A / water would down the water potential gradient / water is being forced against the water potential gradient / <b>AW</b> ;</li> <li>3 so pressure needs to be greater than osmotic force / pressure / <b>AW</b> ;</li> <li>4 salts cannot pass through the membrane / only water can pass through the membrane / <b>AW</b> ;</li> </ol> | <b>2</b> |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Marks    |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 4(b)(ii) | <p><i>any 3 of:</i></p> <ol style="list-style-type: none"> <li>1 salinity of the sea increases / water potential decreases ;</li> <li>2 affects osmoconformer species / <b>AW</b> ;</li> <li>3 water would be lost (from organisms) / cause dehydration / <b>AW</b> ;</li> <li>4 alters density of water / salinity gradients / haloclines / <b>AW</b> ;</li> <li>5 (high salinity) would reduce oxygen content of water / <b>AW</b> ;</li> <li>6 causing organisms to suffocate / reduces respiration / <b>AW</b> ;</li> <li>7 (the salt solution) may also contain high concentrations of toxins / <b>AW</b> ;</li> <li>8 <b>AVP</b> ;</li> </ol> | <b>3</b> |

| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Marks    |
|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| 5(a)     | <p><i>any 3 of:</i></p> <ol style="list-style-type: none"> <li>1 in pumped ventilation mouth opens and closes / buccal cavity opens and closes / <b>ORA</b> ;</li> <li>2 in pumped ventilation operculum opens and closes / <b>ORA</b> ;</li> <li>3 pumped ventilation can be used when fish not moving / is not continuous / <b>ORA</b> ;</li> <li>4 pumped ventilation, requires more energy / is an active process / <b>ORA</b> ;</li> <li>5 pumped ventilation requires more muscle contractions / <b>ORA</b> ;</li> </ol> | <b>3</b> |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Marks     |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| 5(b)     | <p><i>hypothesis (h):</i></p> <ul style="list-style-type: none"> <li>changing concentration of carbon dioxide affects the rate of ventilation / carbon dioxide content affects rate of ventilation / <b>AW</b> ;</li> </ul> <p><i>and 11 from:</i></p> <p><i>independent variable (i):</i></p> <ul style="list-style-type: none"> <li>carbon dioxide concentration / different concentrations of sodium hydrogen carbonate / <b>AW</b> ;</li> <li>minimum of five concentrations / <b>AW</b> ;</li> </ul> <p><i>dependent variable (d):</i></p> <ul style="list-style-type: none"> <li>rate of ventilation / number of times fish opens mouth / operculum / <b>AW</b> ;</li> <li>count opening / closing, in stated time period ;</li> </ul> <p><i>standardised variables (c):</i><br/> <b>MAX 3 of:</b></p> <ul style="list-style-type: none"> <li>species of fish / sex of fish / age / mass of fish ;</li> <li>(frequency of) feeding ;</li> <li>temperature of water ;</li> <li>(starting) pH of water ;</li> <li>volume of water / tank ;</li> <li>salinity / stated salinity ;</li> <li>speed of current / water flow ;</li> <li>light intensity ;</li> <li>oxygen concentration (of water) ;</li> </ul> | <b>12</b> |

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| Question | Answer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Marks |
|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| 5(b)     | <p><i>experimental details (m):</i><br/> <b>MAX 3 of</b></p> <ul style="list-style-type: none"> <li>• method for maintaining temperature, e.g. thermostatically controlled water bath / heat lamp ;</li> <li>• use of, serial / proportional dilutions, e.g. use of pipettes ;</li> <li>• use of buffer solutions ;</li> <li>• use of oxygenator / bubbler / <b>AW</b> ;</li> <li>• use of sodium hydrogen carbonate / bubbling carbon dioxide gas into water / <b>AW</b> ;</li> <li>• allowing fish to equilibrate to different concentrations / <b>AW</b> ;</li> </ul> <p><i>safety / ethics (e):</i></p> <ul style="list-style-type: none"> <li>• relevant precaution and reason / <b>AW</b> ;</li> <li>• ethical statement / <b>AW</b> ;</li> </ul> <p><i>analysis (a):</i><br/> <b>MAX 3 of:</b></p> <ul style="list-style-type: none"> <li>• example of table for results ;</li> <li>• detail about graph to be plotted ;</li> <li>• repeat at least twice / replicates and calculating means / median ;</li> <li>• use of a correct statistical test and reason ;</li> </ul> |       |