



Cambridge International AS & A Level

MARINE SCIENCE

9693/41

Paper 4 A Level Data-handling and Investigative Skills

May/June 2026

MARK SCHEME

Maximum Mark: 75

Published

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

This document consists of **21** printed pages.

General marking principles

All examiners must apply these marking principles when marking candidate responses.

1	Examiners must award marks for each response in line with: - the specific content defined in the mark scheme - the specific skills defined in the mark scheme or in the level descriptions - the standard of response required as exemplified by the standardisation scripts.
2	Examiners must award whole marks (not half marks, or other fractions).
3	Examiners must award marks positively . This means that: - marks are not deducted for errors or omissions - marks are awarded for correct/valid answers as defined in the mark scheme and also for other valid answers which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate - the quality of spelling, punctuation and grammar are judged only when the mark scheme indicates that these features are specifically assessed in the question. However, the meaning of all responses must be unambiguous.
4	Examiners must consistently apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly.
5	Examiners must use the full range of marks defined in the mark scheme, unless limited by the quality of the candidate responses seen.
6	Examiners must award marks according to the mark scheme and must not award marks with grade thresholds or grade descriptions 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	<u>'List rule' guidance</u> For questions that require <i>n</i> responses (e.g. State two reasons ...): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked <i>ignore</i> in the mark scheme should not count towards <i>n</i>. • Incorrect responses should not be awarded credit but will still count towards <i>n</i>. • 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 <i>n</i> 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.

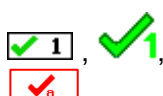
We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of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

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

Annotations

Annotation	Meaning
	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
	point already given

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Annotation	Meaning
	power of ten error
	incorrect point or mark not awarded
	rounding error
	point has been noted, but no credit has been given or 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
ruler	allows lengths to be measured
multi-line overlay	overlays graphs

Question	Answer	Marks	Guidance
1(a)(i)	outline: clear unbroken lines and no shading ; size: at least size of original ; proportion: projection and width in proportion and all in parallel ; detail: two sides for projection, clear cell wall, minimum of two flagella on either side of spike, between eight and 18 chloroplasts ;	4	MAX 3 if drawn in pen R if clearly drawn using a ruler R if touching text R if whole cell drawn
1(a)(ii)	(x) 200 ;;;	3	A range between 195–205 If working shown: - scale bar measured as 4 <u>cm</u> or 40 <u>mm</u> for 1 mark A 3.9 cm – 4.1 cm / 39 mm – 41 mm - correct conversion into same units for 1 mark - division by 0.2 mm OR 200 μm for 1 mark ECF for working out marking points 2 and 3

Question	Answer	Marks	Guidance
1(a)(iii)	any 3 from: 1 occurs in the stroma (of chloroplast) ; 2 correct ref to rubisco (catalysing reaction) ; 3 use of ATP (as a source of energy) ; 4 use of <u>reduced</u> NADP (as reducing agent) ; 5 manufacture of <u>glucose</u> ; 6 AVP ;	3	I uses carbon to form Rubisco A NADPH R NAD A correct chemical formula e.g. correct reference to GP, TP, RUBP
1(b)(i)	any 1 from: 1 temperature ; 2 <u>concentration</u> of carbon dioxide ; 3 pH ; 4 volume / mass, of water ; 5 salinity ; 6 light, intensity / colour / wavelength ; 7 AVP ;	1	I heat I amount e.g. depth / time of day
1(b)(ii)	78.95 OR 79 ;;	2	A 78.947..... (any number of dps) A 0.789... : for 1 mark 5.7 / 4.5 = 1.2 for 1 mark

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Question	Answer	Marks	Guidance
1(b)(iii)	<i>any 2 from:</i> wider range of data for photosynthesis / data is more variable for photosynthesis / ORA / AW ; difference is (likely to be) significant ; as there is no overlap (of error bars) ;	2	A values for photosynthesis extend further from mean

Question	Answer	Marks	Guidance
1(b)(iv)	any 5 from: MAX 3 from: 1 photosynthesis is higher (than chemosynthesis / than in open ocean) on the continental shelf / ORA / AW ; 2 chemosynthesis is higher (than photosynthesis / than on continental shelf) in open water / ORA / AW ; 3 higher <u>overall</u> carbon fixation on continental shelf / photosynthesis is higher <u>overall</u> than chemosynthesis / ORA ; 4 credit manipulation of data / correct comment about error bars, e.g. chemosynthesis bars overlap so no significant difference ; AND at least 1 from: 5 more, algae / phytoplankton, on continental shelf / more chemosynthetic bacteria in open ocean / ORA ; 6 (photosynthesis is higher on continental shelf as) more, run off / nutrients, (from land / river) / AW ; 7 (chemosynthesis is higher in open ocean) likely to be close to hydrothermal vents / more hydrogen sulfide / methane / iron / hydrogen / ammonia / AW ;	4	I data quotes A other correct producers e.g. cyanobacteria / diatoms / dinoflagellates A archaea for chemosynthetic bacteria I sulfur

Question	Answer	Marks	Guidance
1(b)(v)	any 2 from: 1 Q is closer to, hydrothermal vent / volcanic activity / ORA ; 2 so (Q has), hydrogen sulfide / hydrogen / methane / iron / ORA ; 3 which provide a source of energy/ ORA ; 4 temperature is optimal in location Q / AW ;	2	A Q is warmer so has faster rate of chemosynthesis

Question	Answer	Marks	Guidance
2(a)(i)	any 2 from: forms carbonic acid / H_2CO_3 ; (carbonic acid / H_2CO_3) dissociates into, hydrogencarbonate <u>ions</u> / HCO_3^- ; and hydrogen <u>ions</u> / H^+ ;	2	A correct chemical formulae A formation of carbonic acid Has to be ions for both R hydrogen atoms
2(a)(ii)	any 2 from: lack of carbonate ions / removes carbonate ions (CO_3^{2-}) / reacts with carbonate (in water) / AW ; less shell production / skeleton production / shells dissolve / weaker shells / AW ; more susceptible to predation ;	2	I less <u>calcium carbonate</u> in water A less depositing of calcium carbonate A softer shell / thinner shells / wear down A exoskeleton I less protected

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Question	Answer	Marks	Guidance
2(b)(i)	1 linear y axis for rate of tentacle movement and labelled ; 2 linear y axis for rate of growth and labelled ; 3 bars accurately plotted for tentacles ($\pm$ half square); 4 bars plotted for growth ($\pm$ half square) ; 5 bars drawn neatly with gaps and same width and key ;	5	Must be at least half grid tentacle movement / pulses min^{-1} coral growth / au A mp1,2,3,4 for line graph A mp1 / 2 and mp3 / 4 and mp5 if one data set
2(b)(ii)	300 ;; mm^2 ;	3	A 301 / 301.4 / 301.444... / 300.0 for 1 mark A 301.59..... for 1 mark A 3.0×10^2 for 1 mark $8 \times 2 \times 3.14 \times 1.5 \times 4 = 301.44$ for 1 mark A other correct units if number is correct

Question	Answer	Marks	Guidance
2(b)(iii)	<i>any 4 from:</i> (in acid) reduced tentacle movement / less movement / AW ; - less catching of prey / less food caught / AW ; <i>idea of</i> impact on diffusion gradient (for gases) ; - less oxygen (available) ; (less) respiration / energy release / less ATP ; - less carbon dioxide (available) for photosynthesis ; - zooxanthellae lost / kill zooxanthellae / AW ; - so less glucose production (so less growth) ;	4	Must be context of catching A relies on energy from zooxanthellae A decreases zooxanthellae I acid affects zooxanthellae

Question	Answer	Marks	Guidance
3(a)	<i>any 2 from:</i> close to (many) rivers / receives water from rivers / rivers release freshwater / glacial runoff / meltwater runoff / melting icebergs / high rainfall / snow / AW ; small inlet to open ocean reduces mixing with higher salinity water / the area is enclosed so little mixing of water with ocean / AW ; reduced evaporation as colder area / AW ;	2	A freshwater runoff from land A due to distance from equator there is little evaporation

Question	Answer	Marks	Guidance
3(b)(i)	25 OR 26 OR 27 ;;;	3	Correct answer with decimal places = 2 marks One mark only for difference in two osmolarities (e.g. 920–400 = 520) OR difference in appropriate salinity (e.g. 35–15 = 20)
3(b)(ii)	any 4 from: 1 as salinity of water increases, osmolarity increases / as salinity of water increases, salinity of mussel increases / AW ; 2 so blue mussels are <u>osmoconformers</u> ; 3 so <u>water potential</u> inside mussel is same as outside / match <u>water potential</u> inside and outside ; 4 (having same water potential / being an osmoconformer) reduces / prevents, water loss / water gain, (in changing salinities) ; 5 as salinity increases, water content decreases (and levels off) ; 6 (more) water is lost by <u>osmosis</u> / (some) salt is gained by <u>diffusion</u> / AW / ORA ; 7 mussels close shells (to reduce water loss / water gain) / mussels may control water movement ;	4	A water is gained by osmosis at low salinities / high water potential

Question	Answer	Marks	Guidance
3(c)	any 3 from: 1 salmon are osmoregulators ; 2 water potential will be lower outside the body / ORA ; 3 so water would be lost by <u>osmosis</u> ; 4 fish drink (more) water ; 5 ion pumps in gills remove salt / kidney removes, salt / magnesium / sulfate ; 6 by active transport ; 7 concentrated urine released ;	3	A excrete salt from gills / kidney excretes salt BUT ignore if salt water A sodium / chloride for ions / salt

Question	Answer	Marks	Guidance
4(a)(i)	any 2 from: restriction by: 1 season / AW ; 2 location / AW ; 3 quota / AW ; 4 licensing / permits / AW ; 5 fishing method / AW ; 6 on size of organism that can be kept ; 7 (of) fishing intensity / number of boats / AW ;	2	I size unqualified A set times for fishing A size <u>of catch</u> / number of fish A mass of catch I size of fish / mass of fish A net size / mesh size / fishing gear I mass of catch A mass of fish / size of fish A boat size / number of boat days / fishing times
4(a)(ii)	any 2 from: 1 unemployment / fewer jobs / less income / AW ; 2 higher food prices / less food / food security loss / AW ; 3 loss of services (as people move away) / AW ; 4 AVP ;	2	A poverty A malnutrition / lack of protein / other correct deficiencies e.g. fewer shops e.g. increased crime / loss of homes / riots / breakdown of social cohesion / may have to move I break restrictions
4(b)(i)	4.5 / $\sqrt{5} = 2.(01)....$;	1	A any number of dp

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Question	Answer	Marks	Guidance
4(b)(ii)	71.4(8) to 79.5(2) ;	1	A 71.5 to 79.5 A ecf from 4(b)(i)
4(b)(iii)	<i>any 2 from:</i> there is a <u>significant</u> difference (between the mean total number of fish) ; as there is no <u>overlap</u> (between the confidence intervals) ; there is a less than 0.05 probability that the difference is due to chance ;	2	A ecf from (b)(ii) A <u>significant</u> increase (for MPA) A confidence intervals were significantly higher as a bod for mp1

Question	Answer	Marks	Guidance
4(b)(iv)	<i>any 4 from:</i> <i>supported from (MAX 3):</i> 1 more fish in MPA / ORA / AW ; 2 larger fish / ORA / AW ; 3 (more) energy / (more) food sources must be present in MPA / AW ; <i>opposed by:</i> MAX 3 from 4 no direct evidence for trophic levels number / has not assessed trophic level number / AW ; 5 no idea what species are present / no idea of numbers of each species / AW ; 6 fish may just live longer / more older fish (rather than being different species) / AW ; 7 <i>idea of</i> lack of sample size / lack of repetition / only two areas / short period of time / only one week / AW ;	4	A more large fish = mp1 and mp2 A <u>biodiversity</u> has increased A did not count number of each trophic level A more fish mature / reach adulthood

Question	Answer	Marks	Guidance
5(a)	any 3 from: 1 <u>more</u> arsenic, absorbed / taken up / AW, by <u>phytoplankton</u> (than mercury) / AW / ORA ; 2 may be more arsenic present in water / less mercury in area / AW ; 3 <u>biomagnification</u> of mercury occurs (through all levels) / <u>biomagnification</u> of arsenic from phytoplankton to shrimp / AW ; 4 arsenic, does not increase / decreases, in <u>fish</u> (compared with shrimp) AW ; 5 (arsenic is reduced in fish) as parts of shrimp are not eaten / fish may excrete arsenic / passes out in faeces / AW ;	3	A phytoplankton (bio)accumulate more arsenic than mercury A fish have least arsenic A shrimp may filter feed (so have more arsenic than fish) A arsenic breaks down (more than mercury)

Question	Answer	Marks	Guidance
5(b)	1 increasing <u>concentration</u> of iron will increase <u>rate</u> of <u>photosynthesis</u> / AW ; PLUS any 10 from: independent variable (i) 2 concentration of iron ; 3 use of at least five stated concentrations ; dependent variable (d) 4 photosynthesis / oxygen production / AW ; standardised variables (s) (MAX 3) 5 light intensity / lamp at same distance ; 6 same light wavelength / colour of light ; 7 same species / age of plant / size of plant / mass of plant / AW ; 8 same concentration of carbon dioxide / bicarbonate / AW ; 9 temperature ; 10 pH ; 11 salinity ; 12 volume of solution / volume of water / AW ;	11	A null hypothesis A different volumes of iron sulfate A five concentrations in a range A percentages for concentrations Needs to have unit at least once A cm³

Question	Answer	Marks	Guidance
5(b)	methods (m) (MAX 3) 13 <u>grow</u> aquatic plant in concentrations of iron (before measuring photosynthesis) ; 14 method of measuring oxygen in stated time, e.g. counting bubbles / volume in syringe / volume in inverted measuring cylinder / use of oxygen meter ; 15 use of heat shield / water bath ; 16 placing cut end of shoot uppermost ; 17 method of making dilutions of iron, e.g. adding stock to water in flask ; 18 use of buffer solution to maintain pH ; safety and ethics (e) 19 suitable safety measure linked with the risk ; 20 suitable ethical measure ; analysis (a) (MAX 3) 21 example of results table ; 22 calculation of rate described as, change in / volume of oxygen / time ; 23 replications + calculation of means / median / standard deviations ; 24 use of appropriate statistical test (e.g. Spearman's rank) ; 25 description of appropriate graph ;		I amount e.g. use of eye protection as iron sulphate is <u>irritant</u> e.g. do not wash waste chemicals into water system, e.g. buy plant rather than taking from wild needs headings and units A bubbles divided by time A standard error concentration of iron on one axis and rate. bubbles on other