

13 Tributyltin (TBT) is used on the hulls of ships. It is toxic to most marine life.

A biology student investigated the effects of different concentrations of TBT on the reproductive rate of dog whelks.

Dog whelks inhabit rocky seashores and feed on mussels, barnacles and limpets.

The research method is described below:

Five 50 litre glass aquariums containing sea water with different concentrations of TBT were set up next to a large window as shown in the table below:

	1	2	3	4	5
Concentration of TBT ngL^{-1}	0	3	6	9	12

10 male and 10 female whelks collected from a shore close to a busy port, were placed in each aquarium.

Each aquarium contained the same number of live mussels.

The water is collected from the same shore and is constantly filtered, aerated and maintained at 10°C.

The aquariums were inspected daily, and any hatchlings removed and counted.

The investigation ran from January 1st to December 31st in one year.

Evaluate the student's methodology to determine if this approach would produce reliable results.

Your response should demonstrate:

- reasoned judgements about the outlined methodology and/or conclusions about the effectiveness and reliability of this methodology.

[9 marks, plus 3 marks for QWC]

AO1 = 3 marks

AO2 = 3 marks

AO3 = 3 marks

QWC = 3 marks

AP Reference = A6.12.0.1, A6.12.0.2, A6.13.0.2, A.9.11.0.1, A.9.11.0.2, A.9.11.0.3, A.9.11.0.4 and A9.2.0.2.1, A9.2.0.2.2 and A9.2.0.2.3

This is a band marked question.

Band	Mark	Descriptor
3	7–9	AO3 Evaluation of the biology student's methodology in relation to the effects of TBT on the reproductive rate of dog whelks is comprehensive, effective, and relevant, showing detailed understanding and logical and coherent chains of reasoning throughout. Informed conclusions that are fully supported with rational and balanced judgements are evident. AO2 Applied all relevant knowledge of the techniques used in the methodology to the given context and shows a detailed functional understanding of the methods used with suggested amendments/improvements. AO1 There is a wide range of relevant knowledge and understanding of the relevant factors used in the methodology which is accurate and detailed. A wide range of appropriate technical terms are used. The answer demonstrates comprehensive breadth and/or depth of understanding.
2	4–6	AO3 Evaluation of the biology student's methodology in relation to the effects of TBT on the reproductive rate of dog whelks is in most parts effective and mostly relevant, showing mostly logical and coherent chains of reasoning. Conclusions supported by reasoned judgements that consider most of the relevant arguments are evident. AO2 Applied mostly relevant knowledge of the techniques used in the methodology to the context showing some functional understanding of the methods used and how these are applied in this specific situation. AO1 Knowledge and understanding of the relevant factors used in the methodology is in most parts clear and mostly accurate, although on occasion may lose focus. The answer demonstrates reasonable breadth and/or depth of understanding, with occasional inaccuracies and/or omissions.
1	1–3	AO3 Evaluation of the biology student's methodology in relation to the effects of TBT on the reproductive rate of dog whelks is in some parts effective and of some relevance, with some understanding and reasoning taking the form of generic statements with some development. Brief conclusions supported by judgements that consider only basic arguments and show little relevance to the question aims are evident. AO2 Applied limited knowledge of the techniques used in the methodology to the context and may show a lack of functional understanding of the diagnostic tools.

		AO1 Knowledge and understanding of the relevant factors used in the methodology show some but limited accuracy, focus and relevance. The answer is basic and shows limited breadth and/or depth of understanding, with inaccuracies and omissions.
	0	No creditworthy material.

Indicative content

AO1 and AO2 will be implicit through the level of evaluation and reasoned judgements/and or conclusions that the learner provides.

AO1 Relevant factors/reference in evaluation and/or reasoned judgements

Relevant factors may include:

- sample size is sufficient to enable statistical analysis
- sampling technique is appropriate
- control variables are identified and controlled
- the appropriate independent variable is identified
- the appropriate dependent variables are identified
- the use of known standards or literature reviews
- reflecting on experimental design
- the reliability of the methods.

AO2 Techniques used in methodology

- The student **did** collect the water in the aquarium from the same site as the whelks, mimicking their natural habitat.
- The student **did** provide a range of concentrations of TBT including an aquarium with no TBT.
- The student **did** provide the whelks with a food source that they would consume in their natural habitat.
- The student **did** expose the aquariums to natural light, thus creating the changing light conditions they would experience throughout the year in their natural habitat.
- The student **did** conduct the investigation over one year, which is likely to allow for any seasonality in reproduction.
- The student **did** inspect the aquariums daily for hatchlings which were removed and counted.
- The student **did** control the possible variables in each aquarium (for example, food source, temperature) and maintained them at the same level.
- The student **did not** attempt to agitate the water to mimic the wave action found in their natural habitat.
- The student **did not** provide the whelks with a range of food sources they would consume in their natural habitat, which may affect reproductive rate.
- The student **did not** adjust the temperature of the aquariums each month to create temperatures found in their natural habitat (seasonally changing factors are reproductive triggers for many organisms), this may affect reproductive rate.

- The student **did not** provide other natural materials from their natural habitat, eg weeds, rocks etc, these may be necessary as egg laying sites.
- The student **did not** take into account the effect of artificial light in the laboratory. Seasonally changing factors are reproductive triggers for many organisms, this may affect reproductive rate.
- The student **did not** explain how they would record their results which could affect reliability.

AO3 Evaluation/reasoned judgements/conclusions

- TBT was likely to have been in the water due to its proximity to the busy port; this would alter the TBT levels the student attempted to create and invalidate all results.
- The student attempted to create some of the conditions found in the natural habitat, (natural light, mussels as food source and water from the collection point). There were (five) more conditions that they did not create (seasonal temperature changes, range of food sources, weed, rocks, agitation to represent wave action). The significant differences between the investigation and the natural environment may invalidate all the results.
- The lack of any statistical analysis would mean that the significance of any observed differences (between the different levels of TBT) could not be judged, thus affecting the reliability of the results.
- The student **did not** select a large enough sample size to ensure reliability of the results.
- The student **did not** provide any data (from a literature search) to justify the concentrations of TBT they have selected, which may have all been above or below the threshold to affect reproduction. This may invalidate all results.
- The student **did not** provide any data (from a literature search) on the typical reproductive rate of the dog whelk (to enable comparison), thus the student would not know if any variations (in reproductive rates) were due to the TBT concentrations or to naturally occurring variation, thus affecting the reliability of the results.

Accept any other suitable response.

QWC mark scheme

Mark	Descriptor
3	The answer is clearly expressed and well-structured. The rules of grammar are used with effective control of meaning overall. A wide range of appropriate technical terms are used effectively.
2	The answer is generally clearly expressed and sufficiently structured. The rules of grammar are used with general control of meaning overall. A good range of appropriate technical terms are used effectively.
1	The answer lacks some clarity and is generally poorly structured. The rules of grammar are used with some control of meaning and any errors do not significantly hinder the overall meaning. A limited range of appropriate technical terms are used effectively.
0	There is no answer written or none of the material presented is creditworthy. OR The answer does not reach the threshold performance level. The answer is fragmented and unstructured, with inappropriate use of technical terms. The errors in grammar severely hinder the overall meaning.