National Certificate of Educational Achievement
TAUMATA MĀTAURANGA Ā-MOTU KUA TAEA

Exemplar for Internal Achievement Standard

Earth and Space Science Level 3

This exemplar supports assessment against:

Achievement Standard 91410

Carry out an independent practical Earth and Space Science investigation.

An annotated exemplar is an extract of student evidence, with a commentary, to explain key aspects of the standard. It assists teachers to make assessment judgements at the grade boundaries.

New Zealand Qualifications Authority

To support internal assessment

	Grade Boundary: Low Excellence
1.	For Excellence, the student needs to comprehensively carry out an independent practical Earth and Space Science investigation. This involves: • justifying how the investigation method supports the collection of valid and reliable data • evaluating the investigation with respect to relevant Earth and Space Science This student has carried out a comprehensive and independent investigation into the effects of carbon dioxide on water acidification. The student has justified their method (1) and explained how it gave the collection of valid and reliable data (2). The student has evaluated the investigation with respect to relevant Earth and Space Science knowledge. (3). For a more secure Excellence, the student could comprehensively explain the timings of their investigation. Why were the cockle shells left in the solution for 2 days?

Method Summary:

Too much carbon dioxide!

Purpose:

A/ To see how altering the amount of CO_2 dissolved in sea water alters the pH of the sea water solution.

B/ To see how this acidified sea water dissolves calcium carbonate rich mollusc shells using cockle shells (Austrovenus stutchburyi) from the Aromoana Estuary.

Method:

(Students followed a valid method that allowed for the production of valid data.)

Results:

Sea water plus Dry ice pH

250 mLs sea water + 0g Dry ice	8.06 +- 0.02
250 mLs sea water + 1g Dry ice	8.03 +- 0.02
250 mLs sea water + 2g Dry ice	7.99 +- 0.02
250 mLs sea water + 3g Dry ice	7.94 +- 0.02
250 mLs sea water + 4g Dry ice	7.79 +- 0.02

Average loss of mass in cockle shells in different solutions pH solutions

Sea water pH mass loss as a percentage (7 days)

8.06	1.01%
8.03	1.92%
7.99	2.13%
7.94	2.35%
7.79	2.51%

Conclusion:

The results show that the more carbon dioxide that ends up dissolved in sea water the lower the pH. This lower pH is the main cause of ocean acidification. Sea water is slightly basic and excess carbon dioxide dissolved in the sea water makes it more acidic. The change may be small but a change of 0.1 pH units is a 30 fold increase in the hydrogen ion (H^+).
Sea shells made of calcium carbonate lose mass faster in a lower pH. This is because the carbonate ion CO_3^{2-} is being converted to the hydrogen carbonate ion HCO_3^- and shellfish cannot use the hydrogen carbonate ion for building their shells. They need to have the carbonate ion.

Reasons why these results are reliable and valid.

My results are reliable and valid because I made sure the fair test was repeatable. Weighing the dry ice was a problem to start with as it was hard to get the required amount. I solved the problem by cutting excess dry-ice and sitting it on filter paper and letting it sublimate until the required mass was achieved. This mass was then dropped into the 250 mL flask into 100mLs sea water. As soon as the carbon dioxide sublimated the flask was corked and shaken by inversion three times. The flask was left for 30 minutes to stabilise and then the pH was taken using a pH meter that had been calibrated using known buffer solutions at pH 7, pH 7.5 and pH 8. This made the results valid. 1

The cockles were washed, cleaned and dried at 70^0C for 20 minutes and allowed to come to room temperature. The mass was accurately measured and shells placed into each flask at the measured pH. The shells were left in the solution for 2 days, dried, heated to 70^0C and allowed to come to room temperature. They were reweighed and the mass loss was calculated and recorded as a percentage. This allowed for an accurate comparison. 2

The significance of these results related to Earth and Space Science knowledge.

As more carbon dioxide dissolve in sea water the pH of the sea water lowers and the carbonate ion is converted to the hydrogen carbonate ion and this lowers the amount of carbonate ion available for plants and animals to be used for life processes and shell formation for bottom dwelling organisms.

Equation:

$$CO_2 + H_2O + CO_3^- \leftrightarrow 2HCO_3^-$$

This reaction is a buffer reaction and when more carbon dioxide is added more carbonate is converted to hydrogen carbonate. In today's oceans about 89 percent of the carbon dioxide dissolved in seawater takes the form of hydrogen carbonate ion, about 10 percent as carbonate ion, and 1 percent as dissolved gas. We have "disposed" of 530 billion tons of the gas in this way, and the rate worldwide is now one million tons per hour, faster than experienced on earth for tens of millions of years. Modern marine life has evolved to live in this ecosystem and a dramatic change in this chemistry could occur faster than species can evolve; hence large scale extinctions in our oceans could follow. At 4000m in the deep oceans it is possible to get all the carbon dioxide converted to hydrogen carbonate and there is no carbonate ion left for the few animals that live in this zone. This depth level will rise as more carbon dioxide is dissolved in sea water and the levels of the carbonate ion will also fall. A change in pH towards an acid environment is going to affect all life forms that depend on the carbonate ion for their existence. This is why corals are dying and being bleached. The results show us what has happened in the past will affect us in the future. The great unknown is the speed we are doing it this time. The only comparable event is the Permian extinction and that destroyed over 90% of life on this planet. We have been warned. 3

	Grade Boundary: High Merit
2.	For Merit, the student needs to carry out an in depth independent practical Earth and Space Science investigation. This involves: • carrying out a valid method to collect reliable and valid data • interpreting the processed data to draw a valid conclusion related to the purpose of the investigation • explaining in depth how the Earth and Space Science links to the investigation • explaining in depth how the investigation method allows for valid and reliable data to be collected. This student has carried out an in depth and independent investigation into the effects of carbon dioxide on water acidification. The conclusion reached is valid and linked to the data collected (1). The student has explained in depth how their method allowed the collection of valid and reliable data (2). The student has explained the significance of the investigation with respect to relevant Earth and Space Science knowledge (3). To reach Excellence, the student could comprehensively explain the effects of changing the carbon dioxide levels linked to the geological past.

Student 2: High Merit

NZQA Intended for teacher use only

Method Summary:

Too much carbon dioxide!

Purpose:

A/ To see how altering the amount of CO_2 dissolved in sea water alters the pH of the sea water solution.

B/ To see how this acidified sea water dissolves calcium carbonate rich mollusc shells using cockle shells (Austrovenus stutchburyi) from the Aromoana Estuary.

Method:

(Students followed a valid method that allowed for the production of valid data.)

Results:

Sea water plus Dry ice pH

250 mLs sea water + 0g Dry ice	8.06 +- 0.02
250 mLs sea water + 1g Dry ice	8.03 +- 0.02
250 mLs sea water + 2g Dry ice	7.99 +- 0.02
250 mLs sea water + 3g Dry ice	7.94 +- 0.02
250 mLs sea water + 4g Dry ice	7.79 +- 0.02

Average loss of mass in cockle shells in different solutions pH solutions

Sea water pH mass loss as a percentage (7 days)

8.06	1.01%
8.03	1.92%
7.99	2.13%
7.94	2.35%
7.79	2.51%

Conclusion:

The results show that the more carbon dioxide that ends up dissolved in sea water the lower the pH. This lower pH is the main cause of ocean acidification. Sea water is slightly basic and excess carbon dioxide dissolved in the sea water makes it more acidic. The change may be small but a change of 0.1 pH units is a 30 fold increase of the hydrogen ion.

Sea shells made of calcium carbonate lose mass faster in a lower pH. This is because the -carbonate ion CO_3^{2-} is being converted to the hydrogen carbonate ion HCO_3^- and shellfish cannot use the hydrogen carbonate ion for building their shells. They need to have the carbonate ion. (1)

Reasons why these results are reliable and valid.

My results are reliable and valid because I made sure the fair test was repeatable. Weighing the dry ice was a problem to start with as it was hard to get the required amount. I solved the problem by cutting excess dry-ice and sitting it on filter paper and letting it sublimate until the required mass was achieved. This mass was then dropped into the 250 mL flask into 100mLs sea water. As soon as the carbon dioxide sublimated the flask was corked and shaken by inversion three times. The pH was taken using a pH meter that had been calibrated using known buffer solutions at pH 7, pH 7.5 and pH 8. This made the results valid.

The cockles were washed, cleaned and dried at 70^0C for 20 minutes and allowed to come to room temperature. The mass was accurately measured and shells placed into each flask at the measured pH. The shells were left in the solution for 2 days, dried, heated to 70^0C and allowed to come to room temperature. 2

The significance of these results related to Earth and Space Science knowledge.

As more carbon dioxide dissolve in sea water the pH of the sea water lowers and the carbonate ion is converted to the hydrogen carbonate ion and this lowers the amount of carbonate ion available for plants and animals to be used for life processes and shell formation for bottom dwelling organisms.

Equation:

$$CO_2 + H_2O + CO_3^- \leftrightarrow 2HCO_3^-$$

This reaction is a buffer reaction and when more carbon dioxide is added more carbonate is converted to hydrogen carbonate. In today's oceans about 89 percent of the carbon dioxide dissolved in seawater takes the form of hydrogen carbonate ion, about 10 percent as carbonate ion, and 1 percent as dissolved gas. We have "disposed" of 530 billion tons of the gas in this way, and the rate worldwide is now one million tons per hour, faster than experienced on earth for tens of millions of years. Modern marine life has evolved to live in this ecosystem and a dramatic change in this chemistry could occur faster than species can evolve; hence large scale extinctions in our oceans could follow. At 4000m in the deep oceans it is possible to get all the carbon dioxide converted to hydrogen carbonate and there is no carbonate ion left for the few animals that live in this zone. This depth level will rise as more carbon dioxide is dissolved in sea water and the levels of the carbonate ion will also fall. A change in pH towards an acid environment is going to affect all life forms that depend on the carbonate ion for their existence. 3

3

	Grade Boundary: Low Merit
3.	For Merit, the student needs to carry out an in depth independent practical Earth and Space Science investigation. This involves: • carrying out a valid method to collect reliable and valid data • interpreting the processed data to draw a valid conclusion related to the purpose of the investigation • explaining in depth how the Earth and Space Science links to the investigation • explaining in depth how the investigation method allows for valid and reliable data to be collected. This student has carried out an in depth and independent investigation into the effects of carbon dioxide on water acidification. The conclusion reached is valid and linked to the data collected (1). The student has explained in depth how their method allowed the collection of valid and reliable data (2). The student has explained the significance of the investigation with respect to relevant Earth and Space Science knowledge (3). For a more secure Merit, the student could explain in depth how our knowledge of the past foretells the future. For example, the student could explain the relevance today of what happened in the Permian.

Student 3: Low Merit

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Method Summary:

Too much carbon dioxide!

Purpose:

A/ To see how altering the amount of CO_2 dissolved in sea water alters the pH of the sea water solution.

B/ To see how this acidified sea water dissolves calcium carbonate rich mollusc shells using cockle shells (Austrovenus stutchburyi) from the Aromoana Estuary.

Method:

(Students followed a valid method that allowed for the production of valid data.)

Results:

Sea water plus Dry ice pH

250 mLs sea water + 0g Dry ice	8.06 +- 0.02
250 mLs sea water + 1g Dry ice	8.03 +- 0.02
250 mLs sea water + 2g Dry ice	7.99 +- 0.02
250 mLs sea water + 3g Dry ice	7.94 +- 0.02
250 mLs sea water + 4g Dry ice	7.79 +- 0.02

Average loss of mass in cockle shells in different solutions pH solutions

Sea water pH mass loss as a percentage (7 days)

8.06	1.01%
8.03	1.92%
7.99	2.13%
7.94	2.35%
7.79	2.51%

Conclusion:

The results show that the more carbon dioxide that ends up dissolved in sea water the lower the pH. This lower pH is the main cause of ocean acidification. Sea water is slightly basic and excess carbon dioxide dissolved in the sea water makes it more acidic. The change may be small but a change of 0.1 pH units is a 30 fold increase of the hydrogen ion.

Sea shells made of calcium carbonate lose mass faster in a lower pH. This is because the -carbonate ion CO_3^{2-} is being converted to the hydrogen carbonate ion HCO_3^- and shellfish cannot use the hydrogen carbonate ion for building their shells. They need to have the carbonate ion. (1)

Reasons why these results are reliable and valid.

My results are reliable and valid because I made sure the fair test was repeatable. Weighing the dry ice was a problem to start with as it was hard to get the required amount. I solved the problem by cutting excess dry-ice and sitting it on filter paper and letting it sublimate until the required mass was achieved. This mass was then dropped into the 250 mL flask into 100mLs sea water and sealed.

The cockles were washed, cleaned and dried at 70^0C for 20 minutes and allowed to come to room temperature. The mass was accurately measured and shells placed into each flask at the measured pH. The shells were left in the solution for 2 days, dried, heated to 70^0C and allowed to come to room temperature. 2

The significance of these results related to Earth and Space Science knowledge.

As more carbon dioxide dissolve in sea water the pH of the sea water lowers and the carbonate ion is converted to the hydrogen carbonate ion and this lowers the amount of carbonate ion available for plants and animals to be used for life processes and shell formation for bottom dwelling organisms.

Equation:

$$CO_2 + H_2O + CO_3^- \leftrightarrow 2HCO_3^-$$

This reaction is a buffer reaction and when more carbon dioxide is added more carbonate is converted to hydrogen carbonate. In today's oceans about 89 percent of the carbon dioxide dissolved in seawater takes the form of hydrogen carbonate ion, about 10 percent as carbonate ion, and 1 percent as dissolved gas. At 4000m in the deep oceans it is possible to get all the carbon dioxide converted to hydrogen carbonate and there is no carbonate ion left for the few animals that live in this zone. This depth level will rise as more carbon dioxide is dissolved in sea water and the levels of the carbonate ion will also fall. A change in pH towards an acid environment is going to affect all life forms that depend on the carbonate ion for their existence. 3

	Grade Boundary: High Achieved
4.	For Achieved, the student needs to carry out an independent practical Earth and Space Science investigation. This involves: • carrying out a method to collect raw data • interpreting the processed data to draw a conclusion related to the purpose of the investigation • explaining how Earth and Space Science links to the investigation • explaining how the investigation method allowed for reliable data to be collected This student has carried out an independent investigation into the effects of carbon dioxide on water acidification. Raw data has been processed (1). The conclusion reached is linked to the data collected (2). The student has explained how their method allowed the collection of data (3). The student has explained the link between their investigation and the relevant Earth and Space Science knowledge (4). To reach Merit, the student could explain in depth why the actions taken during the investigation were taken. For example why was the dry-ice dropped into the sea-water.

Student 4: High Achieved

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Method Summary:

Too much carbon dioxide!

Purpose:

A/ To see how altering the amount of CO_2 dissolved in sea water alters the pH of the sea water solution.

B/ To see how this acidified sea water dissolves calcium carbonate rich mollusc shells using cockle shells (Austrovenus stutchburyi) from the Aromoana Estuary.

Method:

(Students followed a valid method that allowed for the production of valid data.)

Results:

Sea water plus Dry ice pH

250 mLs sea water + 0g Dry ice	8.06 +- 0.02
250 mLs sea water + 1g Dry ice	8.03 +- 0.02
250 mLs sea water + 2g Dry ice	7.99 +- 0.02
250 mLs sea water + 3g Dry ice	7.94 +- 0.02
250 mLs sea water + 4g Dry ice	7.79 +- 0.02

Average loss of mass in cockle shells in different solutions pH solutions

Sea water pH mass loss as a percentage (7 days)

8.06	1.01%
8.03	1.92%
7.99	2.13%
7.94	2.35%
7.79	2.51%

Conclusion:

The results show that the more carbon dioxide that ends up dissolved in sea water the lower the pH. This lower pH is the main cause of ocean acidification. Sea water is slightly basic and excess carbon dioxide dissolved in the sea water makes it more acidic. The change may be small but a change of 0.1 pH units is a 30 fold increase of the hydrogen ion.
Sea shells made of calcium carbonate lose mass faster in a lower pH.

1

Reasons why these results are reliable and valid.

My results are reliable and valid because I made sure the fair test was repeatable. Weighing the dry ice was a problem to start with as it was hard to get the required amount. I solved the problem by cutting excess dry-ice and sitting it on filter paper and letting it sublimate until the required mass was achieved. This mass was then dropped into the 250 mL flask into 100mLs sea water and sealed.

The cockles were washed, cleaned and dried at 70^0C for 20 minutes and allowed to come to room temperature. The mass was accurately measured and shells placed into each flask at the measured pH. The shells were left in the solution for 2 days, dried, heated to 70^0C and allowed to come to room temperature. 2

The significance of these results related to Earth and Space Science knowledge.

As more carbon dioxide dissolve in sea water the pH of the sea water lowers and the carbonate ion is converted to the hydrogen carbonate ion and this lowers the amount of carbonate ion available for plants and animals to be used for life processes and shell formation for bottom dwelling organisms.

Equation:

$$CO_2 + H_2O + CO_3^- \leftrightarrow 2HCO_3^-$$

This reaction is a buffer reaction and when more carbon dioxide is added more carbonate is converted to hydrogen carbonate. In today's oceans about 89 percent of the carbon dioxide dissolved in seawater takes the form of hydrogen carbonate ion, about 10 percent as carbonate ion, and 1 percent as dissolved gas. 3

	Grade Boundary: Low Achieved
5.	For Achieved, the student needs to carry out an independent practical Earth and Space Science investigation. This involves: • carrying out a method to collect raw data • interpreting the processed data to draw a conclusion related to the purpose of the investigation • explaining how Earth and Space Science links to the investigation • explaining how the investigation method allowed for reliable data to be collected This student has carried out an independent investigation on the effects of carbon dioxide on water acidification. Raw data is collected (1). The conclusion reached is linked to the data collected (2). The student has explained how their method allowed the collection of valid and reliable data (3). The student has explained the link between their investigation and the relevant Earth and Space Science (4). For a more secure Achieved, the student could fully explain the link between the ESS and the investigation. For example explain the significance of lowering the amount of carbonate ion in sea water.

Student 5: Low Achieved

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Method Summary:

Too much carbon dioxide!

Purpose:

A/ To see how altering the amount of CO_2 dissolved in sea water alters the pH of the sea water solution.

B/ To see how this acidified sea water dissolves calcium carbonate rich mollusc shells using cockle shells (Austrovenus stutchburyi) from the Aromoana Estuary.

Method:

(Students followed a valid method that allowed for the production of valid data.)

Results:

Sea water plus Dry ice pH

250 mLs sea water + 0g Dry ice	8.06 +- 0.02
250 mLs sea water + 1g Dry ice	8.03 +- 0.02
250 mLs sea water + 2g Dry ice	7.99 +- 0.02
250 mLs sea water + 3g Dry ice	7.94 +- 0.02
250 mLs sea water + 4g Dry ice	7.79 +- 0.02

Average loss of mass in cockle shells in different solutions pH solutions

Sea water pH mass loss as a percentage (7 days)

8.06	1.01%
8.03	1.92%
7.99	2.13%
7.94	2.35%
7.79	2.51%

(1)

Conclusion:

The results show that the more carbon dioxide that ends up dissolved in sea water the lower the pH. This lower pH is the main cause of ocean acidification. Sea water is slightly basic and excess carbon dioxide dissolved in the sea water makes it more acidic. (2)

Reasons why these results are reliable and valid.

My results are reliable and valid because I made sure the fair test was repeatable. Weighing the dry ice was a problem to start with as it was hard to get the required amount.

The cockles were washed, cleaned and dried at 70^0C for 20 minutes and allowed to come to room temperature. The mass was accurately measured and shells placed into each flask at the measured pH. The shells were left in the solution for 2 days. 3

The significance of these results related to Earth and Space Science knowledge.

As more carbon dioxide dissolve in sea water the pH of the sea water lowers and the carbonate ion is converted to the hydrogen carbonate ion and this lowers the amount of carbonate ion available for plants and animals to be used for life processes and shell formation for bottom dwelling organisms.

Equation:

$$CO_2 + H_2O + CO_3^- \leftrightarrow 2HCO_3^-$$

This reaction is a buffer reaction and when more carbon dioxide is added more carbonate is converted to hydrogen carbonate. 4

	Grade Boundary: High Not Achieved
6.	For Achieved, the student needs to carry out an independent practical Earth and Space Science investigation. This involves: • carrying out a method to collect raw data • interpreting the processed data to draw a conclusion related to the purpose of the investigation • explaining how Earth and Space Science links to the investigation • explaining how the investigation method allowed for reliable data to be collected. This student has demonstrated an investigation by carrying out a valid independent investigation on the effects of carbon dioxide on water acidification. The conclusion reached is linked to the data collected (1). The student has explained how their method allowed the collection of valid and reliable data (2). To reach Achieved, the student could explain the link between their investigation and the relevant Earth and Space Science knowledge. For example how do the collected results link to known data – what has happened in the past?

Method Summary:

Student 6: High Not Achieved
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Too much carbon dioxide!

Purpose:

A/ To see how altering the amount of CO_2 dissolved in sea water alters the pH of the sea water solution.

B/ To see how this acidified sea water dissolves calcium carbonate rich mollusc shells using cockle shells (Austrovenus stutchburyi) from the Aromoana Estuary.

Method:

(Students followed a valid method that allowed for the production of valid data.)

Results:

Sea water plus Dry ice pH

250 mLs sea water + 0g Dry ice	8.06 +- 0.02
250 mLs sea water + 1g Dry ice	8.03 +- 0.02
250 mLs sea water + 2g Dry ice	7.99 +- 0.02
250 mLs sea water + 3g Dry ice	7.94 +- 0.02
250 mLs sea water + 4g Dry ice	7.79 +- 0.02

Average loss of mass in cockle shells in different solutions pH solutions

Sea water pH mass loss as a percentage (7 days)

8.06	1.01%
8.03	1.92%
7.99	2.13%
7.94	2.35%
7.79	2.51%

Conclusion:

The results show that the more carbon dioxide that ends up dissolved in sea water the lower the pH. This lower pH is the main cause of ocean acidification. Sea water is slightly basic and excess carbon dioxide dissolved in the sea water makes it more acidic. (1)

Reasons why these results are reliable and valid.

My results are reliable and valid because I made sure the fair test was repeatable. Weighing the dry ice was a problem to start with as it was hard to get the required amount.

The cockles were washed, cleaned and dried at 70^0C for 20 minutes and allowed to come to room temperature. The mass was accurately measured and shells placed into each flask at the measured pH. The shells were left in the solution for 2 days. (2)