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 91411

Investigate a socio-scientific issue in an Earth and Space Science context.

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 investigate comprehensively a socio-scientific issue in an Earth and Space Science context. This involves: • evaluating the issue and the impact on individuals and society • justifying a personal response to the issue • evaluating a societal response to the issue. This student has conducted a comprehensive investigation by evaluating the issue of the effects of global warming due to increases of carbon in the atmosphere (1), justifying a personal response to the effects of global warming (2) and evaluating a societal response to the effects of global warming (3). For a more secure Excellence, the student could evaluate further how society needs to act quickly to slow down the possible negative effects of global warming. This could involve the use of 'scrubbers' to help remove carbon dioxide from the atmosphere and store it long term.

Student 1: Low Excellence

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The past explains the future.

The issue:

Just how will the increases world wide of carbon dioxide in the atmosphere affect our weather, climate, and life in general? Rather than guess at or use models we need to look at the evidence for this in the geological record. Some of the best evidence comes from the PETM (Paleocene-Eocene Thermal maximum) 55.8ma when carbon dioxide levels rose quickly and there were major environmental effects. The warming lasted 100000-170000 years before the CO_2 levels stabilised. This carbon dioxide increase mirrors what is happening today. Geologists still don't know exactly where the carbon dioxide came from but come it did and we can read the rocks to show its effects. (1)

Evidence from the PETM (55.8ma)

During the PETM, around 5 billion tons of CO_2 was released into the atmosphere per year. The Earth warmed around 6°C over 20,000 years; although some estimates are that the warming was more like 9°C. Using the low end of that estimated range, the globe warmed around 0.025°C every 100 years. Today, the globe is warming at least ten times as fast, anywhere from 1 to 4°C every 100 years. In 2012, our fossil fuel burning released 35 billion tons of CO_2 into the atmosphere. How fast carbon enters the atmosphere translates to the how fast temperature increases, and the environmental and societal consequences of warming at such a break-neck speed could be devastating.

PETM Warming vs. Current Warming (final summary

Feature	**PEMT**	**Today**
Cause	Continental drift, volcanoes, methane hydrate melting, fires, permafrost melting	Anthropogenic burning of fossil fuels (oil, coal, natural gas, etc)
CO_2 emissions	Around 5 billion tons per year	At least 35 billion tons per year
Rate of warming	0.025°C per 100 years	1 to 4°C per 100 years
Environmental impact	Ocean circulation reversed, oceans acidified, oceans became toxic and oxygen poor, permafrost melted, peat and forests burned in wildfires	**Observed impacts**: significant sea ice decline, extreme drought, more wildfires, increase in glacier melt, more catastrophic floods, ocean acidification, ocean toxicity in deep oceans, sea level rise, shoreline erosion, degraded air and water quality global ocean circulation changes, more violent storms
Ecosystem & human impact	Migration of land mammals, extinction of some benthic foraminifera, coral bleaching	**Observed impacts**: Famine and malnutrition due to drought, coral bleaching, species endangerment (e.g. polar bears) **Potential impacts**: increased mortality

		from extreme weather and malnutrition, increase in disease vectors, decrease in agricultural yield, mass wildlife migration and extinction, total societal collapse.

1

My personal response:

We are told that increasing carbon in the atmosphere will have a detrimental effect on Earth. When we have a look in the past to the PETM we see this response is true. All the projections by scientists have happened in the past and are linked with large amounts of CO_2 going into the atmosphere. The effects in the Paleocene – Eocene boundary was dramatic and stressed the environment for over 100 000years. This was when only 5 billion tonnes was added to the atmosphere annually. Today we are adding 35 billion tonnes annually. The geological record says change the CO_2 in the atmosphere and the environments will become unstable.

My personal view is bad times are ahead of us. Now that we humans have introduced global warming, there are some useful lessons from the past we can show:

- The rapid pulse of PETM CO_2 followed by rapid warming indicates high climate sensitivity.
- CO_2 does indeed appear to have a long atmospheric lifetime.
- Ocean acidification (of the deep sea at least) can occur even under conditions of CO_2 release much slower than today.
- Present acidification of the ocean is far greater than the PETM, and is probably unprecedented in the last 65 million years.

2

A societal response:

Politicians need to take heed of the scientific evidence. Too often we hear “global warming is not happening” or that the “models are not correct” or “economics must come before environmentalism.” All of these are extremely dangerous stands made by burying our heads in the sand. The evidence is out there. The PETM shows us the long term effects of increased carbon dioxide and what we are doing to the atmosphere is about 15 times worse. We don’t have 200 000 years in which to stabilise the climate to about 300 parts per million of CO_2.

Society needs to realise we live in extremely dangerous times and global warming due to the burning of fossil fuels to release carbon dioxide into the atmosphere is happening now and very fast (geologically). The PETM event showed scientists that once a process is set in motion it can take a long time to right itself: right itself it will without any regard for us as a species. Could we become extinct? The answer is a definite yes. We need to respond now and maybe the United Nations is the way to go as an independent body that could unite the world. Is it too late? The evidence suggests that it may well be.

3

	Grade Boundary: High Merit
2.	For Merit, the student needs to investigate, in depth, a socio-scientific issue in an Earth and Space Science context. This involves: • explaining in detail the issue and impacts on individuals and society • explaining a personal response to the issue • explaining a societal response to the issue. This student has conducted an in-depth investigation by explaining the issue of the effects of global warming due to increases of carbon in the atmosphere (1), explaining a personal response to the effects of global warming (2) and explaining a societal response to the effects of global warming (3). To reach Excellence, the student could evaluate the issue and describe the significance of the graph included in the report and link that to what is happening today.

Student 2: High Merit
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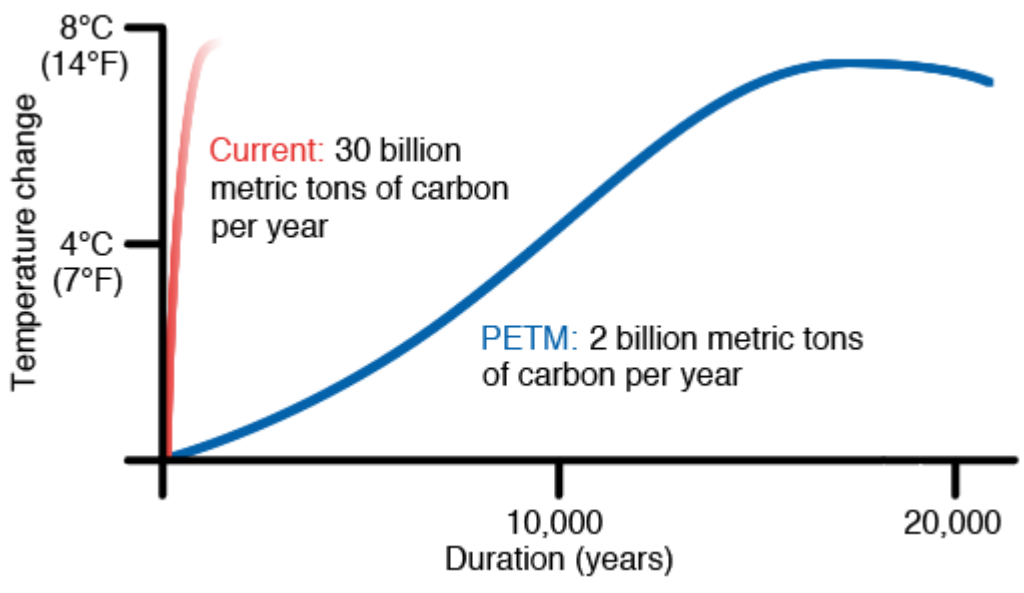
The past explains the future.

The issue:

Just how will the increases world wide of carbon dioxide in the atmosphere affect our weather, climate, and life in general? Rather than guess at or use models we need to look at the evidence for this in the geological record. Some of the best evidence comes from the PETM (Paleocene-Eocene Thermal maximum) 55.8ma when carbon dioxide levels rose quickly and there were major environmental effects. The warming lasted 100000-170000 years before the CO_2 levels stabilised. This carbon dioxide increase mirrors what is happening today. Geologists still don't know exactly where the carbon dioxide came from but come it did and we can read the rocks to show its effects. 1

Evidence from the PETM (55.8ma)

During the PETM, around 5 billion tons of CO_2 was released into the atmosphere per year. The Earth warmed around 6°C over 20,000 years; although some estimates are that the warming was more like 9°C. Using the low end of that estimated range, the globe warmed around 0.025°C every 100 years. Today, the globe is warming at least ten times as fast, anywhere from 1 to 4°C every 100 years. In 2012, our fossil fuel burning released 35 billion tons of CO_2 into the atmosphere. How fast carbon enters the atmosphere translates to the how fast temperature increases, and the environmental and societal consequences of warming at such a break-neck speed could be devastating.



Wikipedia 1

My personal response:

We are told that increasing carbon in the atmosphere will have a detrimental effect on Earth. When we have a look in the past to the PETM we see this response is true. All the projections by scientists have happened in the past and are linked with large amounts of CO_2 going into the atmosphere. The effects in the Paleocene – Eocene boundary was dramatic and stressed the environment for over 100,000 years. This was when only 5 billion tonnes was added to the atmosphere annually. Today we are adding 35 billion tonnes annually. The geological record says change the CO_2 in the atmosphere and the environments will become unstable.

My personal view is bad times are ahead of us. Now that we humans have introduced global warming we are set to suffer the consequences. 2

A societal response:

Politicians need to take heed of the scientific evidence. Too often we hear “global warming is not happening” or that the “models are not correct” or “economics must come before environmentalism.” All of these are extremely dangerous stands made by burying our heads in the sand. The evidence is out there.

Society needs to realise we live in extremely dangerous times and global warming due to the burning of fossil fuels to release carbon dioxide into the atmosphere is happening now and very fast (geologically). The PETM event showed scientists that once a process is set in motion it can take a long time to right itself: right itself it will without any regard for us as a species. Could we become extinct? The answer is a definite yes. We need to respond now and maybe the United Nations is the way to go as an independent body that could unite the world. Is it too late? The evidence suggests that it may well be. 3

	Grade Boundary: Low Merit
3.	For Merit, the student needs to investigate, in depth, a socio-scientific issue in an Earth and Space Science context. This involves: • explaining in detail the issue and impacts on individuals and society • explaining a personal response to the issue • explaining a societal response to the issue. This student has conducted an in-depth investigation by explaining the issue of the effects of global warming due to increases of carbon in the atmosphere (1), explaining a personal response to the effects of global warming (2) and explaining a societal response to the effects of global warming (3). For a more secure Merit the student could explain further a societal response to the issue. For example, rather than arguing whether global warming occurs or not, the student needs to look at the geological evidence for where it has occurred in the past and link that to what may happen in the future.

Student 3: Low Merit

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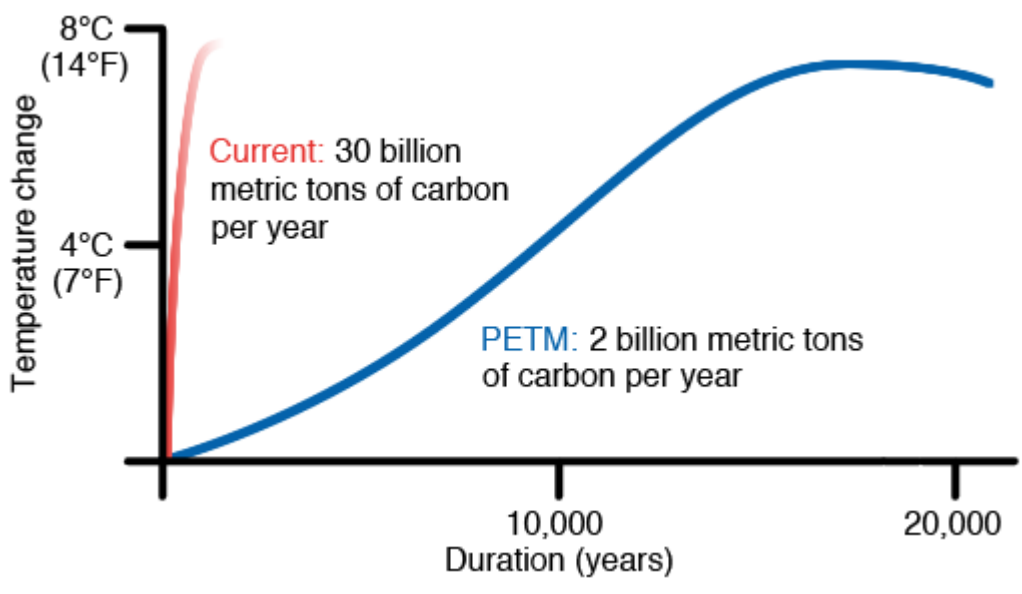
The past explains the future.

The issue:

Just how will the increases world wide of carbon dioxide in the atmosphere affect our weather, climate, and life in general? Rather than guess at or use models we need to look at the evidence for this in the geological record. Some of the best evidence comes from the PETM (Paleocene-Eocene Thermal maximum) 55.8ma when carbon dioxide levels rose quickly and there were major environmental effects. The warming lasted 100000-170000 years before the CO_2 levels stabilised. This carbon dioxide increase mirrors what is happening today. Geologists still don't know exactly where the carbon dioxide came from but come it did and we can read the rocks to show its effects. (1)

Evidence from the PETM (55.8ma)

During the PETM, around 5 billion tons of CO_2 was released into the atmosphere per year. The Earth warmed around 6°C over 20,000 years; although some estimates are that the warming was more like 9°C. Using the low end of that estimated range, the globe warmed around 0.025°C every 100 years. Today, the globe is warming at least ten times as fast, anywhere from 1 to 4°C every 100 years. In 2012, our fossil fuel burning released 35 billion tons of CO_2 into the atmosphere. How fast carbon enters the atmosphere translates to the how fast temperature increases, and the environmental and societal consequences of warming at such a break-neck speed could be devastating.



Wikipedia (1)

My personal response:

We are told that increasing carbon in the atmosphere will have a detrimental effect on Earth. When we have a look in the past to the PETM we see this response is true. All the projections by scientists have happened in the past and are linked with large amounts of CO_2 going into the atmosphere. The effects in the Paleocene – Eocene boundary was dramatic and stressed the environment for over 100 000years. This was when only 5 billion tonnes was added to the atmosphere annually. Today we are adding 35 billion tonnes annually. The geological record says change the CO_2 in the atmosphere and the environments will become unstable.

My personal view is bad times are ahead of us. 2

A societal response:

Politicians need to take heed of the scientific evidence. Too often we hear “global warming is not happening” or that the “models are not correct” or “economics must come before environmentalism.” All of these are extremely dangerous stands made by burying our heads in the sand. The evidence is out there. The PETM shows us the long term effects of increased carbon dioxide and what we are doing to the atmosphere is about 15 times worse. We don’t have 200 000 years in which to stabilise the climate to about 300 parts per million of CO_2. 3

	Grade Boundary: High Achieved
4.	For Achieved, the student needs to investigate a socio-scientific issue in an Earth and Space Science context. This involves: • explaining the issue and impacts on individuals and society • describing a personal response to the issue • describing a societal response to the issue • selecting and processing a valid range of scientific information on the issue. This student has conducted an investigation into a socio-scientific issue by explaining the effects of global warming due to increases of carbon in the atmosphere (1), describing a personal response to the effects of global warming (2), and describing a societal response to the effects of global warming (3). To reach Merit, the student could explain a personal and societal response to the issue. For example, the student could explain how society could overcome the increase in carbon dioxide levels using a body like the United Nations.

Student 4: High Achieved

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The past explains the future.

The issue:

Just how will the increases world wide of carbon dioxide in the atmosphere affect our weather, climate, and life in general? Rather than guess at or use models we need to look at the evidence for this in the geological record. Some of the best evidence comes from the PETM (Paleocene-Eocene Thermal maximum) 55.8ma when carbon dioxide levels rose quickly and there were major environmental effects. The warming lasted 100000-170000 years before the CO_2 levels stabilised. This carbon dioxide increase mirrors what is happening today. Geologists still don't know exactly where the carbon dioxide came from but come it did and we can read the rocks to show its effects. (1)

Evidence from the PETM (55.8ma)

During the PETM, around 5 billion tons of CO_2 was released into the atmosphere per year. The Earth warmed around 6°C over 20,000 years; although some estimates are that the warming was more like 9°C. Using the low end of that estimated range, the globe warmed around 0.025°C every 100 years. Today, the globe is warming at least ten times as fast, anywhere from 1 to 4°C every 100 years. In 2012, our fossil fuel burning released 35 billion tons of CO_2 into the atmosphere. How fast carbon enters the atmosphere translates to the how fast temperature increases, and the environmental and societal consequences of warming at such a break-neck speed could be devastating.

My personal response:

We are told that increasing carbon in the atmosphere will have a detrimental effect on Earth. When we have a look in the past to the PETM we see this response is true. All the projections by scientists have happened in the past and are linked with large amounts of CO_2 going into the atmosphere. The effects in the Paleocene – Eocene boundary was dramatic and stressed the environment for over 100 000years. (2)

A societal response:

Politicians need to take heed of the scientific evidence. Too often we hear "global warming is not happening" or that the "models are not correct" or "economics must come before environmentalism." All of these are extremely dangerous stands made by burying our heads in the sand. The evidence is out there. The PETM shows us the long term effects of increased carbon dioxide and what we are doing to the atmosphere is about 15 times worse. We don't have 200 000 years in which to stabilise the climate to about 300 parts per million of CO_2. (3)

	Grade Boundary: Low Achieved
5.	For Achieved, the student needs to investigate a socio-scientific issue in an Earth and Space Science context. This involves: • explaining the issue and impacts on individuals and society • describing a personal response to the issue • describing a societal response to the issue • selecting and processing a valid range of scientific information on the issue. This student has conducted an investigation into a socio-scientific issue by explaining the effects of global warming due to increases of carbon in the atmosphere (1), describing a personal response to the effects of global warming (2), and describing a societal response to the effects of global warming (3). For a more secure Achieved, the student could describe a societal response to the issue in more detail, for example how a knowledge of the past, when carbon dioxide levels rapidly increased, increased temperatures and extinctions followed.

Student 5: Low Achieved

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The past explains the future.

The issue:

Just how will the increases world wide of carbon dioxide in the atmosphere affect our weather, climate, and life in general? The best evidence comes from the PETM (Paleocene-Eocene Thermal maximum) 55.8ma when carbon dioxide levels rose quickly and there were major environmental effects. This carbon dioxide increase mirrors what is happening today.

Evidence from the PETM (55.8ma) 1

During the PETM, around 5 billion tons of CO_2 was released into the atmosphere per year. The Earth warmed around 6°C over 20,000 years; although some estimates are that the warming was more like 9°C. Using the low end of that estimated range, the globe warmed around 0.025°C every 100 years. Today, the globe is warming at least ten times as fast, anywhere from 1 to 4°C every 100 years. In 2012, our fossil fuel burning released 35 billion tons of CO_2 into the atmosphere. How fast carbon enters the atmosphere translates to the how fast temperature increases, and the environmental and societal consequences of warming at such a break-neck speed could be devastating.

My personal response:

We are told that increasing carbon in the atmosphere will have a detrimental effect on Earth. When we have a look in the past to the PETM we see this response is true. All the projections by scientists have happened in the past and are linked with large amounts of CO_2 going into the atmosphere. I think global warming is therefore a fact and we need to do something about it. 2

A societal response:

Politicians need to take heed of the scientific evidence. Too often we hear “global warming is not happening” or that the “models are not correct” or “economics must come before environmentalism.” All of these are extremely dangerous stands made by burying our heads in the sand. The evidence is out there.

Could we become extinct? The answer is a definite yes. We need to respond now and do something about it. Trust geologists. 3

	Grade Boundary: High Not Achieved
6.	For Achieved, the student needs to investigate a socio-scientific issue in an Earth and Space Science context. This involves: • explaining the issue and impacts on individuals and society • describing a personal response to the issue • describing a societal response to the issue • selecting and processing a valid range of scientific information on the issue. This student has demonstrated an investigation into a socio-scientific issue by explaining the effects of global warming due to increases of carbon in the atmosphere (1), and describing a personal response to the effects of global warming (2). To reach Achieved, the student could describe a societal response to the issue, for example how an increase of carbon dioxide in the past caused an increase in the temperature of our planet.

Student 6: High Not Achieved

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The issue:

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During the PETM, around 5 billion tons of CO_2 was released into the atmosphere per year. The Earth warmed around 6°C over 20,000 years; although some estimates are that the warming was more like 9°C. Using the low end of that estimated range, the globe warmed around 0.025°C every 100 years. Today, the globe is warming at least ten times as fast, anywhere from 1 to 4°C every 100 years. In 2012, our fossil fuel burning released 35 billion tons of CO_2 into the atmosphere. How fast carbon enters the atmosphere translates to the how fast temperature increases, and the environmental and societal consequences of warming at such a break-neck speed could be devastating.

My personal response:

We are told that increasing carbon in the atmosphere will have a detrimental effect on Earth. When we have a look in the past to the PETM we see this response is true. All the projections by scientists have happened in the past and are linked with large amounts of CO_2 going into the atmosphere. The effects in the Paleocene – Eocene boundary was dramatic and stressed the environment for over 100 000years. This was when only 5 billion tonnes was added to the atmosphere annually. Today we are adding 35 billion tonnes annually. The geological record says change the CO_2 in the atmosphere and the environments will become unstable.

My personal view is bad times are ahead of us. Now that we humans have introduced global warming, there are some useful lessons from the past we can show:

- The rapid pulse of PETM CO_2 followed by rapid warming indicates high climate sensitivity.
- CO_2 does indeed appear to have a long atmospheric lifetime.
- Ocean acidification (of the deep sea at least) can occur even under conditions of CO_2 release much slower than today.
- Present acidification of the ocean is far greater than the PETM, and is probably unprecedented in the last 65 million years. 2