



# Earth and Environmental Science

Year 11 Annotated Tasks and  
Student Work

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## 1. Acknowledgements

The Board of Senior Secondary Studies (BSSS) in partnership with teachers of Earth and Environmental Science (EES), as well as in other subjects, have developed a suite of materials to support school based and system moderation. The materials featured in this publication include:

- Quality assessment tasks informed by BSSS Quality Assessment Guidelines (QAG)
- Annotated student work samples using the BSSS Achievement Standards.

The quality assessment tasks, and annotated student work samples included in this publication have been quality assured by expert teachers in the subject.

I thank teachers involved in this project for their significant contribution. The ACT senior secondary system is richer for the development of these important teaching and learning resources.

Martin Watson  
BSSS Executive Director

## 2. Rationale

Our primary task is to work collaboratively to uphold the integrity of the ACT Senior Secondary Certificate for all ACT students. Working in unison, we can continue to strengthen the integrity of the ACT Senior Secondary Certificate by ensuring:

- curriculum is delivered as accredited.
- comparability of unit and assessment grades within and across schools
- assessment aligns with Board endorsed Achievement Standards.

Quality assessment tasks and annotated student work samples make thinking and judgements explicit and visible for teachers. Quality assessment tasks and annotated student work samples provide a basis for teachers to develop a shared understanding of quality assessment and Achievement Standards in practice. Annotated student work samples ensure consistency in the allocation of grades across the system.

Quality assessment tasks and annotated student work samples support teachers to experience greater clarity about key aspects that will be taught. Providing opportunities for the collaborative development of shared understandings of Achievement Standards, through the use of annotations and dialogue will create consistency in judgements within standards-referenced assessment systems. Achievement Standards without exemplification can be open to different interpretations among teachers, parents, and the wider community.

Provision of quality assessment tasks is intended to support teachers by providing examples for reference. They are not intended to provide rigid guidelines to restrict the nature and variety of assessment tasks being developed in schools.

It is envisaged that the development of quality assessment tasks and annotated student work samples is expanded to encompass most learning areas.

*Australian Curriculum P-10* has exemplars online illustrating the levels of student work that is expected along with annotations showing why it is at the level. BSSS quality assessment tasks and annotated student work samples

complement *Australian Curriculum P-10* exemplars, in turn, creating a complete continuum of learning expectations in English, science and mathematics from P-12.

### 3. Significance

The benefits of provision of quality assessment tasks and annotated student work samples for students, teachers, principals, and the ACT senior secondary system are:

#### System

- supporting system-wide planning
- developing a consistent and shared language around assessment across the jurisdiction
- working collaboratively in course teams ensuring assessment strategy is aligned across the course and helping everyone with professional development, enhancing the integrity of the ACT Senior Secondary Certificate.

#### Students

- student work samples provide clarity of grade expectations and provide examples of higher order thinking skills.
- students gain confidence in their own skills and in their relationships with their teachers when the assessments they must complete are aligned to the work they've done in class.

#### Teachers

- building capacity to enhance or change assessment tasks and the program of learning.
- ensuring alignment between curriculum, pedagogy, and reporting
- maximising collaboration and sharing of knowledge to support the learning and development of all students.

#### Principals

- supporting school planning
- providing shared understanding between students and teaching staff as to what is required in assessment and reporting.
- developing greater consistency of language around assessment and Programs of Learning across the school
- promoting diverse pedagogical approaches
- developing more robust assessment strategies for future assessments
- providing an opportunity for professional growth and sharing amongst peers.

### 4. How to use the Document

This document is design for practical application in schools and at system moderation. There are many approaches to assessment that meet requirements outlined in the BSSS Quality Assessment Guidelines. Quality assessment tasks within this document may inspire you, however, they are not intended to be interpreted as the only BSSS endorsed approach.

Expectations about the quality of knowledge and skills that students should have attained are represented by Achievement Standards. Achievement Standards without exemplification can be open to different interpretations. Student work samples within this document make the standard visible. Student work samples graded A and C are Board endorsed. This means that they are the official standard used to inform judgements on grading student work at a school and system level.

All tasks and assessment rubrics delivered in schools must be tailored to allow students to meet the expectations and cognitive demands of the course. This means developing assessment that enables students within your context and cohort to meet the Standard as articulated in the Achievement Standards in the given course.

When developing a suite of assessment tasks for a unit consider the following:

- curriculum coverage and coverage of general capabilities and cross curriculum priorities
- diversity of task types
- opportunities for students to demonstrate all knowledge, understanding and skills outlined in the Achievement Standards

This document can be used to guide:

### **Teachers**

- task development, particularly the creation of tasks that enable higher order thinking and that elicit a spread of achievement from students.
- design of marking rubrics and criteria
- benchmarking to the standard of how assessors determine grades, and the types of thinking associated with particular grades.
- discussion with students/classes about what different quality responses look like

### **Head Teachers**

- quality assurance of the assessment tasks and processes within your own faculty
- calibration of internal moderation processes
- support of new educators and preservice teachers
- examples of feedback to educators about quality of work and thinking

### **Principals**

- professional conversations in your school about equity, quality assurance, and the quality assessment guidelines
- professional conversations about what it means to meet the Achievement Standards
- conversations with students and parents about what it means to meet the Achievement Standards
- supporting staff to undertake quality assurance and assessment processes.

### **The ACT Senior Secondary System**

- moderation discussion about quality assurance and the Achievement Standards
- discussion about the meeting of students' learning entitlement

## **Program of Learning: Earth and Environmental Science (T/A) Unit 2: Earth Processes**

### **Unit Description**

Earth system processes require energy. In this unit, students explore how the transfer and transformation of energy from the sun and Earth's interior enable and control processes within and between the geosphere, atmosphere, hydrosphere and biosphere. Students examine how the transfer and transformation of heat and gravitational energy in Earth's interior drive movements of Earth's tectonic plates. They analyse how the transfer of solar energy to Earth is influenced by the structure of the atmosphere; how air masses and ocean water move as a result of solar energy transfer and transformation to cause global weather patterns; and how changes in these atmospheric and oceanic processes can result in anomalous weather patterns.

Students use their knowledge of the photosynthetic process to understand the transformation of sunlight into other energy forms that are useful for living things. They study how energy transfer and transformation in ecosystems are modelled and they review how biogeochemical cycling of matter in environmental systems involves energy use and energy storage.

Through the investigation of appropriate contexts, students explore how international collaboration, evidence from multiple disciplines and individuals and the development of ICT and other technologies have contributed to developing understanding of the energy transfers and transformations within and between Earth systems. They investigate how scientific knowledge is used to offer valid explanations and reliable predictions, and the ways in which it interacts with social, economic, and cultural factors, including the design of action for sustainability.

Students use inquiry skills to collect, analyse and interpret data relating to energy transfers and transformations and cycling of matter and make inferences about the factors causing changes to movements of energy and matter in Earth systems.

### **Specific Unit Goals (T)**

By the end of this unit, students:

- understand how energy is transferred and transformed in Earth systems, the factors that influence these processes, and the dynamics of energy loss and gain.
- understand how energy transfers and transformations influence oceanic, atmospheric and biogeochemical cycling.
- understand how theories and models have developed based on evidence from multiple disciplines, and the uses and limitations of Earth and environmental science knowledge in a range of contexts.
- use science inquiry skills to collect, analyse and communicate primary and secondary data on energy transfers and transformations between and within Earth systems.
- evaluate, with reference to empirical evidence, claims about energy transfers and transformations between and within Earth systems.
- communicate Earth and environmental understanding using qualitative and quantitative representations in appropriate modes and genres.

### **Key Questions (Enduring Understandings)**

- What drives processes on Earth?
- Where does the energy required from Earth's processes come from?
- Why is this energy important?

<p><b>General Capabilities</b></p> <ul style="list-style-type: none"> <li>• literacy</li> <li>• numeracy</li> <li>• information and communication technology (ICT)</li> <li>• critical and creative thinking</li> <li>• personal and social</li> <li>• ethical understanding</li> <li>• intercultural understanding</li> </ul> <p><b>Cross Curriculum Priorities</b></p> <ul style="list-style-type: none"> <li>• Aboriginal and Torres Strait Islander histories and cultures</li> <li>• Asia and Australia’s engagement with Asia</li> <li>• Sustainability</li> </ul>		
<p><b>Assessment Tasks</b></p> <p>1: Investigation</p> <p>2: Exam</p>		
Content Descriptions	Content Elaborations	Teaching and Learning Activities, Points of Progress Assessment
<ul style="list-style-type: none"> <li>• Energy is neither created nor destroyed but can be transformed from one form to another (for example, kinetic, gravitational, thermal, light) and transferred between objects.</li> <li>• Identify, research and construct questions for investigation; propose hypotheses; and predict possible outcomes.</li> </ul>	<ul style="list-style-type: none"> <li>• Define energy.</li> <li>• Recall different types of energy.</li> <li>• State the first law of thermodynamics.</li> <li>• Describe a range of simple energy transformations - conduction, convection, and radiation.</li> <li>• Evaluate the importance of energy transfers and transformations.</li> </ul>	<p><b>Week 1- 2</b></p> <ul style="list-style-type: none"> <li>• Practical observing energy transfers and transformations</li> <li>• Direct Instruction with definitions and PowerPoint</li> </ul>
<ul style="list-style-type: none"> <li>• Processes within and between earth systems require energy that originates either from the sun or the interior of earth.</li> <li>• Transfers and transformations of heat and gravitational energy in earth's interior drives the movement of tectonic plates through processes including mantle convection, plume formation and slab sinking.</li> <li>• Science is a global enterprise that relies on clear communication, international conventions, peer review and reproducibility.</li> <li>• Development of complex models and/or theories often requires a wide range of evidence from multiple individuals and across disciplines.</li> <li>• Advances in science understanding in one field can influence other areas of science, technology and engineering.</li> <li>• Interpret a range of scientific and media texts and evaluate processes, claims and conclusions by considering the quality of available</li> </ul>	<ul style="list-style-type: none"> <li>• Identify that the energy for earth processes comes from the sun, or inside the earth.</li> <li>• Describe the electromagnetic spectrum.</li> <li>• Account for the range of processes that require solar energy.</li> <li>• Recall that the earth’s interior is driven by radioactive decay and geothermal energy.</li> <li>• Describe the 3 types of radioactive decay.</li> <li>• Explain the evidence for geothermal energy.</li> <li>• State the theory of continental drift.</li> <li>• Explain the evidence for continental drift.</li> <li>• Evaluate tectonic processes – including convections cells, heat plumes and slab motion.</li> <li>• Calculate plate speed.</li> <li>• Describe plate interactions- 3 types of boundaries Convergent, Divergent and Transform.</li> <li>• Account for the motion of the continents in terms of density</li> </ul>	<p><b>Week 3-6</b></p> <ul style="list-style-type: none"> <li>• Direct instruction with PowerPoint</li> <li>• Calculate Plate speed.</li> <li>• Scootle activity on Plate tectonics</li> <li>• Explore Wegner’s theory of continental drift and look at the evidence for continental drift.</li> <li>• Slab pull method with data correlation.</li> </ul> <p><b>Investigation</b></p>

<p>evidence; use reasoning to construct scientific arguments.</p> <ul style="list-style-type: none"> <li>• Select, construct and use appropriate representations, including maps and other spatial representations, diagrams and flow charts, to communicate conceptual understanding, solve problems and make predictions.</li> <li>• Communicate to specific audiences and for specific purposes using appropriate language, genres and modes, including compilations of field data and research reports</li> </ul>		
<ul style="list-style-type: none"> <li>• Thermal and light energy from the sun drives important earth processes including evaporation and photosynthesis.</li> <li>• The net transfer of solar energy to Earth's surface is influenced by its passage through the atmosphere, including impeded transfer of ultraviolet radiation to Earth's surface due to its interaction with atmospheric ozone, and by the physical characteristics of Earth's surface, including albedo.</li> <li>• Most of the thermal radiation emitted from earth's surface passes back out into space but some is reflected or scattered by greenhouse gases back toward earth; this additional surface warming produces a phenomenon known as the greenhouse effect.</li> <li>• Design investigations including the procedure/s to be followed, the information required and the type and amount of primary and/or secondary data to be collected; conduct risk assessments; and consider research ethics.</li> <li>• Conduct investigations, including using map and field location techniques and environmental sampling procedures, safely, competently and methodically for the collection of valid and reliable data.</li> <li>• Represent data in meaningful and useful ways; organise and analyse data to identify trends, patterns and relationships; qualitatively describe sources of measurement error, and uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions.</li> </ul>	<ul style="list-style-type: none"> <li>• Describe photosynthesis, evaporation weather patterns and transpiration</li> <li>• Explain the role of solar energy in evaporation.</li> <li>• Define Earth's energy budget.</li> <li>• Describe the factors involved in the Earth's energy budget.</li> <li>• Recall the structure of the atmosphere.</li> <li>• Explain the importance of Albedo.</li> <li>• Explain the role of the ozone layer.</li> <li>• Identify the greenhouse gases.</li> <li>• Explain the significance of the greenhouse effect.</li> <li>• Define buoyancy</li> </ul>	<p><b>Week 7-9</b></p> <ul style="list-style-type: none"> <li>• Albedo Practical</li> <li>• Direct instruction with PowerPoint notes</li> <li>• Greenhouse effect practical</li> <li>• Buoyancy practical</li> </ul>

<ul style="list-style-type: none"> <li>The use of scientific knowledge may have beneficial and/or harmful and/or unintended consequences.</li> <li>Scientific knowledge can enable scientists to offer valid explanations and make reliable predictions</li> </ul>		
<ul style="list-style-type: none"> <li>The movement of atmospheric air masses due to heating and cooling, and earth's rotation and revolution, cause systematic atmospheric circulation; this is the dominant mechanism for the transfer of thermal energy around earth's surface</li> </ul>	<ul style="list-style-type: none"> <li>Explain the Coriolis effect.</li> <li>Account for global atmospheric circulation, global wind belts and 3 cell model.</li> <li>Describe major mass air movements (jet stream, trade winds)</li> <li>Define sea and land breezes</li> </ul>	<p><b>Week 10-11</b></p> <ul style="list-style-type: none"> <li>Direct instruction with PowerPoint notes</li> <li>Worksheet on air circulation</li> <li>Ocean air interaction</li> <li>Specific heat capacity of water practical</li> </ul>
<ul style="list-style-type: none"> <li>The behaviour of the global oceans as a heat sink, and earth's rotation and revolution, cause systematic ocean currents; these are described by the global ocean conveyor model.</li> <li>The interaction between earth's atmosphere and oceans changes over time and can result in anomalous global weather patterns, including El Nino and La Nina</li> </ul>	<ul style="list-style-type: none"> <li>Define thermohaline circulation and gyre.</li> <li>Map the major global ocean currents.</li> <li>Account for ocean circulation in terms of temperature, density, depth and salinity.</li> <li>Explain the significance of thermohaline circulation.</li> <li>Compare weather and climate.</li> <li>Describe tropical storm systems.</li> <li>Outline the major ocean currents that influence Australia.</li> <li>Evaluate the significance of ENSO and IOD on Australia</li> </ul>	<p><b>Week 12-14</b></p> <ul style="list-style-type: none"> <li>Direct instruction with PowerPoint notes</li> <li>Mapping activity</li> <li>Video on ocean currents BOM</li> <li>ENSO activity from NOAA</li> </ul>
<ul style="list-style-type: none"> <li>Photosynthesis is the principal mechanism for the transformation of energy from the sun into energy forms that are useful for living things; net primary production is a description of the rate at which new biomass is generated, mainly through photosynthesis</li> <li>The availability of energy and matter are one of the main determinants of ecosystem carrying capacity; that is, the number of organisms that can be supported in an ecosystem.</li> <li>Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability</li> </ul>	<ul style="list-style-type: none"> <li>State word and chemical equation for photosynthesis.</li> <li>Define the term biomass, biosphere.</li> <li>Account for changes in photosynthetic rate due to geographical location</li> <li>Define ecosystem, carrying capacity, sustainability.</li> <li>Describe simple ecosystems.</li> <li>Construct food chains and webs.</li> <li>Construct and analyse Ecological pyramids.</li> </ul>	<p><b>Week 15-17</b></p> <ul style="list-style-type: none"> <li>Direct instruction with PowerPoint notes</li> <li>Practical on photosynthesis</li> <li>Power point on ecosystems and populations</li> <li>Food web game</li> </ul>
<ul style="list-style-type: none"> <li>Biogeochemical cycling of matter, including nitrogen and phosphorus, involves the transfer and transformation of energy between the biosphere, geosphere, atmosphere and hydrosphere.</li> <li>Energy is stored, transferred and transformed in the carbon cycle; biological elements, including living and dead organisms, store energy over relatively short timescales, and geological elements (for example,</li> </ul>	<ul style="list-style-type: none"> <li>Define biogeochemical, nutrient cycling.</li> <li>Draw carbon, phosphorus, and nitrogen cycles.</li> <li>Describe the main processes in carbon, phosphorus and nitrogen cycle.</li> <li>Define hydrocarbon, kerogen.</li> <li>Identify the main fossil fuels.</li> <li>Explain how fossil fuels are formed.</li> </ul>	<p><b>Week 18</b></p> <ul style="list-style-type: none"> <li>Direct instruction with PowerPoint notes</li> <li>Carbon cycle interactive</li> <li>Research how fossil fuels are formed.</li> </ul> <p><b>Semester Exam</b></p>

hydrocarbons, coal and kerogens) store energy for extended periods		
<b>Resources Required</b>	<p>Audio visual Material</p> <p>Earth – Power of the Planet (DVD), 2009, BBC</p> <p>Orbit: Earth’s Extraordinary Journey (DVD), 2013, BBC</p> <p>Catalyst – The Hole Truth <a href="http://www.abc.net.au/catalyst/stories/2974750.htm">http://www.abc.net.au/catalyst/stories/2974750.htm</a></p> <p>Web sites</p> <p>This Dynamic Planet: A teaching companion (online) <a href="http://volcanoes.usgs.gov/about/edu/dynamicplanet/">http://volcanoes.usgs.gov/about/edu/dynamicplanet/</a></p> <p>Geoscience Australia Education resources (online) <a href="http://www.ga.gov.au/education/classroom-resources.html">http://www.ga.gov.au/education/classroom-resources.html</a></p> <p>GPS Timeseries (real time tectonic plate motion) (online) <a href="http://sideshow.jpl.nasa.gov/post/series.html">http://sideshow.jpl.nasa.gov/post/series.html</a></p> <p>Climate Education (online) <a href="http://www.bom.gov.au/lam/climate/index.htm">http://www.bom.gov.au/lam/climate/index.htm</a></p> <p>Weather and Climate (online) <a href="http://www.science.org.au/scied/basics.html">http://www.science.org.au/scied/basics.html</a></p> <p>Simple Climate Models (online) <a href="http://www.easterbrook.ca/steve/2013/01/simple-climate-models-to-play-with-in-the-classroom/">http://www.easterbrook.ca/steve/2013/01/simple-climate-models-to-play-with-in-the-classroom/</a></p> <p>Introduction to the Atmosphere (online) <a href="http://www.physicalgeography.net/fundamentals/chapter7.html">http://www.physicalgeography.net/fundamentals/chapter7.html</a></p> <p>Global Maps (online) <a href="http://earthobservatory.nasa.gov/GlobalMaps/">http://earthobservatory.nasa.gov/GlobalMaps/</a></p>	



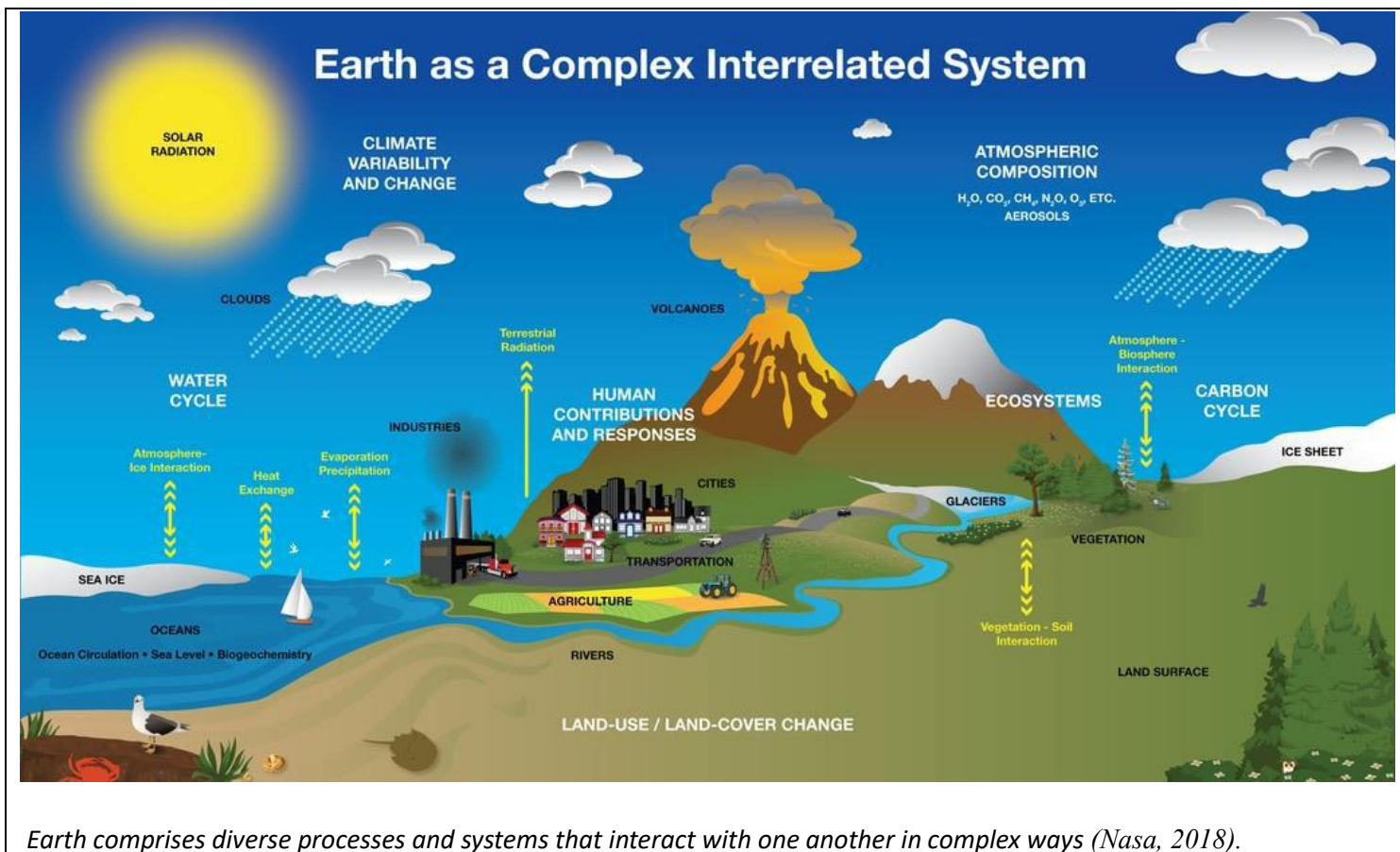
# Earth and Environmental Science

Assessment Task One: Investigation

Year 11 Annotated Tasks and  
Student Work

## BACKGROUND INFORMATION

Earth system processes require energy and most of this energy comes from just a few sources, solar energy, gravity, radioactive decay, and the rotation of the Earth.



*Earth comprises diverse processes and systems that interact with one another in complex ways (Nasa, 2018).*

You will use your inquiry skills to design, conduct, collect and represent data related to energy transfer and transformation and cycling of matter, that enables and controls processes within and between Earth's spheres.

## THE TASK

You are to conduct a practical investigation exploring how the transfer and transformation of energy from the sun and or Earth's interior, enable and control processes on Earth.

Working in a group (max 3) you will decide on a topic and plan and collect data for your investigation. You may choose to adapt an experiment or create a new one. After you conduct your investigation, you will individually analyse the data and write a scientific report, summarising your findings using the rubric to guide you.

Some possible research areas/topics to explore:

Conduction	Photosynthesis	Solar energy	Weather patterns	Volcanoes
Radiation	Solar energy	Global conveyor belt	Biogeochemical cycling	Humidity
Convection	Greenhouse Effect	Buoyancy	Nitrogen cycle	Wind
Energy transfer	Phosphorus cycle	Air pressure	Hot air balloon	Food chains/webs
Thermal energy	Density	Cartesian diver	Plate boundaries	Isostasy
Light	Carbon cycle	Ocean currents	Coriolis Effect	Magnetic fields
Water flow	Pressure	Water cycle		

# INVESTIGATION REPORT GUIDELINES

## **Presentation**

Correct and appropriate scientific language, correct format of the report, with headings (bold black as below). Correct in-text referencing from multiple and reputable sources, labelling of diagrams and reference of each diagram in the text. Ensure the text is legible.

### **Title Page**

Your report should include an appropriate title page with the following: title of the investigation, your name, and your teacher's name.

### **Introduction**

Sometimes the introduction section is called 'Background'. This section introduces the scientific concepts related to the investigation. It is your researched and referenced theory behind your investigation. Refer to all images/figures that are presented here.

#### **Aim/focused research question**

A clear statement of what your investigation is trying to find out.

#### **Identification of Variables**

Independent, dependent, and control

#### **Hypothesis**

The hypothesis is a prediction about the outcome of the investigation (refer to dependent and independent variables)

### **Materials**

All equipment used is listed (including quantities, volumes, dimensions).

#### **Method**

Highly detailed method, written step by step and in scientific report language, past tense, sequential, is supported by labelled diagrams/photos/illustrations and allows for sufficient data collection. It should be clear enough to be reproducible.

#### **Risk assessment and Ethical Considerations**

Analyse all the risks that you have identified and state how you could overcome the risk during the practical. This information is often presented in a table. Discuss any issues relating to the ethics of your experiments i.e., treatment and disposal of live organisms. Refer to your Risk Assessment (put in Appendix).

### **Results**

This should include numerical data obtained from the procedure and should be presented in a table and graphical form. You should also identify specific trends or patterns in the data that you think are important. All images, graphs and tables labelled and titled. Also referred to in the text.

No inferences or conclusion statements.

### **Discussion**

Start with a quick written statement of your results. You then go on to explain the results of your study and explore the significance of your findings.

Interpret and evaluate your results; examine whether and how the hypothesis raised in the introduction section has been answered; show how your results relate to the literature, referencing all your research.

Discuss any errors in the experimental design or procedure and describe how the investigation might be improved or further developed. Identify sources of error and uncertainty inherent to the study and analyse/evaluate and quantify error and uncertainty in measurement

Reflect and evaluate on the planning and time management of the investigation with reference to their impact on the task. Propose solutions to resolve any issues in a future investigation of the same nature.

## Conclusion

The conclusion is a single paragraph that sums up what has happened in the experiment. It is a response to the aim.

## References

Plagiarism is the copying, paraphrasing or summarising of work, in any form, without acknowledgement of sources, and presenting this as your own work. Any work that is found to be plagiarised will incur a penalty. All written work must be submitted through “[plagiarism checker name redacted]”. Using the Harvard referencing system is required of all students and will assist in meeting obligations for academic honesty. Refer to guides on “Bibliographies” for additional information. Refer to the ACT BSSS Policy and Procedures Manual for further details, available at <http://www.bsss.act.edu.au/>

## Use of AI

Students are allowed to use College-approved A.I. tools for planning and drafting assessment work, following specific guidelines in the Assessment Policy Agreement and any special A.I. Directions in the Task Description. Using A.I. tools outside these guidelines risks academic integrity. Students must retain and share evidence of their progress on assessment tasks with their teacher from the start. Failure to do so will not be an acceptable defence in cases of academic misconduct or plagiarism. Submitted work must not include A.I.-generated content.

A transcript of all dialogue with AI chatbots must be attached as an appendix to the assessment task. Your appendix will follow your reference list as a separate page.

## Appendix

A link to the risk assessment is attached which is completed, signed, and approved online through Risk Assess: <https://www.riskassess.com.au/>

## Reflection

Write a short reflection on how you found the task once you have finished it. Be honest with yourself.

This reflection is not included in the word count and is to be a maximum of 300 words.

This reflection forms part of your assessment task (see rubric).

Consider the following prompts in your response:

**What happened?** Describe what you did during this assignment. What process did you undertake? What planning, time management and work strategies did you use to approach the task?

**How did you overcome challenges?** How did you respond to challenges?

**Evaluation:** Was the knowledge generated valid? What were the limits of the reliability of knowledge produced?

**Analysis:** How effective was your approach to the task? What else can you make of the situation? What does this tell you about yourself as a learner? What were your strengths and weaknesses?

**Conclusion/Action plan:** What conclusions can you make from this reflection? What could you do to improve next time? What are your next steps?

Year 11 Earth and Environmental Science (T) Investigation Report Name: _____ Total: _____/40 Criteria						
	Indicator	A - 5	B - 4	C -3	D - 2	E -1
Concepts, Models and Applications	Properties and Functions <i>Introduction</i>	Evaluates analyses the fundamental properties and functions of their chosen topic on Earth systems.	Analyses the fundamental properties and functions of their chosen topic on Earth systems.	Explains the fundamental properties and functions of their chosen topic on Earth systems.	Describes the fundamental properties and functions of their chosen topic on Earth systems.	Identifies the fundamental properties and functions of their chosen topic on Earth systems.
	Evidence and Conclusions <i>Discussion &amp; Conclusion</i>	Evaluates research to develop evidence-based conclusions and evaluates the limitations of their research.	Analyses research to develop evidence-based conclusions and discusses the limitations of their research.	Explains research to develop evidence-based conclusions and identifies the limitations of their research.	Describes research and develops conclusions about their research.	Identifies research and states conclusions.
Contexts	Use and Influence of Science <i>Introduction</i>	Evaluates the impact of their chosen topic on social, economic, ethical, and cultural factors.	Analyses the impact of their chosen topic on social, economic, ethical, and cultural factors.	Explains the impact of their chosen topic on social, economic, ethical, and cultural factors.	Describes the impact of their chosen topic on social, economic, ethical, and cultural factors.	Identifies the impact of their chosen topic on social, economic, ethical, and cultural factors.
Inquiry Skills	Designs and Conducts <i>Aim Hypothesis Materials Method Risk Assessment</i>	Designs, conducts, and improves a safe and ethical investigation to collect valid, reliable data on energy transfer and transformation in Earth systems. Investigation explores a complex research question and clearly justifies their design choices.	Designs, conducts, and improves a safe, ethical investigation that collects valid, reliable data on energy transfer and transformation in Earth systems. Investigation explores a clear question and explains their design choices.	Plans and conducts a safe, ethical investigation that collects valid data on energy transfer and transformation in Earth systems. Investigation explores a familiar question and describes their design choices.	Follows a procedure to conduct a safe, ethical investigation to collect data on energy transfer and transformation in Earth systems. Investigation explores a simple question with varying success.	Follows a procedure to conduct a safe, ethical investigation to collect data energy transfer and transformation in Earth systems. Little to no connection to a research question.
	Analysis <i>Results Discussion</i>	Analyses causal and correlational relationships, anomalies, reliability, and validity of their data. Analyses links between hypotheses and results.	Analyses causal and correlational relationships, anomalies, reliability, and validity of their data. Discusses links between hypotheses and results.	Explains causal and correlational relationships, anomalies, reliability, and validity of their data. Explains links between hypotheses and results.	Describes trends, relationships, and anomalies in their data. Identifies some possible sources of error.	Identifies trends and relationships in data with little or no reference to sources of error.
	Evaluation <i>Discussion</i>	Analyses method, results, uncertainty and error to propose appropriate and justified improvements to enhance the validity and reliability of the investigation.	Assesses method, results, and some uncertainty and discusses error, to propose improvements to enhance the validity and reliability of the investigation.	Explains method, results, and some uncertainty and error, to suggest improvements to the investigation.	Describes the method and results to identify areas for improvement and mentions uncertainty/error.	Identifies the method and the need for some improvements.
	Communication	Consistently uses concise, effective, and accurate language to communicate ideas and construct justified, evidence-based arguments in the form of a science report. Cites a diverse range of credible sources accurately.	Uses clear and accurate language to communicate science ideas and construct evidence-based arguments in the form of a science report. Cites a range of credible sources accurately.	Uses appropriate language accurately to communicate science ideas and construct arguments in the form of a science report. Cites sources with mostly consistent referencing.	Uses everyday language to communicate science ideas and construct arguments in the form of a science report. Inconsistently cites sources.	Uses everyday language to communicate science ideas demonstrating limited scientific literacy in the form of a science report. Inconsistent and inaccurate referencing.
	Reflection	Reflects with insight on their own thinking throughout the task and that of others, and evaluates their planning, time management, and use of appropriate work strategies to complete the task.	Reflects on their own thinking and analyses their planning, time management, and use of appropriate work strategies to complete the task.	Reflects on their own thinking and explains their planning, time management and use of appropriate work strategies to complete the task.	Reflects on their own thinking, with reference to planning and the use of appropriate work strategies.	Reflects on their own thinking with little or no reference to planning, time management, and use of work strategies.

## Year Eleven Earth and Environment Science Investigation: Evaluating the task with the BSSS Quality Assessment Guidelines

Outstanding	Coverage of BSSS Accredited Courses	High	Reliability
Outstanding	Bias Awareness	Outstanding	Levels of Thinking
Outstanding	Student Engagement	Outstanding	Academic Integrity

### 1. Coverage of BSSS Accredited Courses

Outstanding Coverage of BSSS Accredited Courses – Assessment tasks are strategically planned for alignment with Achievement Standards, unit goals and content descriptors. Assessments are not too big: assessing irrelevant content or criteria; nor too small: missing important content or criteria

**Comments:** The student engages in key disciplinary skills such as investigation design, collecting and interpreting data and effectively communicating results. The task assesses a significant component of course content, i.e. energy transfers and transformations and cycling of matter in Earth systems.

### 2. Reliability

High Reliability – The task is strategically designed to focus on prescribed concepts and content. The rubric is clear and unambiguous and draws clearly from achievement standards. The Instructions and possible options are clear for students.

**Comments:** The task is well-structured and includes scaffolding that guides students to concentrate on the specific knowledge and skills required for the task. Student errors offer insight into their competency rather than reflecting misunderstandings. The marking rubric provides clear distinctions between levels of achievement and uses achievement standard verbs to good effect.

### 3. Bias Awareness

High Bias Awareness - The suite of assessment tasks is designed that promote the diverse needs of gender, socio-economic status, disabilities and/or cultures, and that do not marginalise or favour a student or group of students, or advantage or disadvantage certain background knowledge or ways of thinking.

**Comments:** There are no identifiable sources of bias in the task. The task is accessible to students from a wide range of backgrounds and has no special requirements that would favour one group of students over another. The task is clearly focussed on the key ideas of the unit, in particular the inquiry skills from the achievement standards in the context of the content of this unit.

### 4. Levels of Thinking

High Levels of Thinking – Clear assessment tasks are designed that allow students to engage at progressively higher cognitive demands. The suite of assessments demonstrates that there are expectations for all learners at all levels of learning and

opportunities for extending all learners are planned for. Assessment tasks are flexible and varied, covering a range of assessment modes

**Comments:** The student engages in higher order thinking and on key disciplinary skills. The focus on data analysis and representation pushes students towards high order thinking. The structured nature of the task into stages with coherent expectations and outcomes leads students to the level of thinking required. There is sufficient scaffolding to allow students at the D/E level to demonstrate what they are capable of, while presenting opportunities for A level students to extend themselves.

## 5. Student Engagement

High Student Engagement – Assessment tasks are thoughtfully planned to engage students. Assessment tasks are explicitly connected to contemporary issues or student lived experiences, interests, or prior knowledge. The suite of assessment tasks supports student ownership

**Comments:** Task and expectations are clear and unambiguous, not requiring any unexpected background knowledge or presenting any entry barriers to students. There is an option for some autonomy in allowing the students to design their method and investigations. Connections are made to relevant applications of the scientific principals being investigated.

## 6. Academic Integrity

High Academic Integrity - Academic integrity is discussed with students with expectations with respect to academic integrity and the consequences of cheating or plagiarising made clear. Assessment is designed to encourage original thinking from students and require individualised responses that will be different.

**Comments:** BSSS policies on penalties are referred to and it can be assumed that academic integrity and plagiarism have been discussed with students prior to assessment. The in-class nature of the practical task allows the teacher to have oversight of the collection and first parts of the analysis of results.



# Earth and Environmental Science

**Assessment Task One: Investigation**

**Student Work: C Grade Script**

Year 11 Annotated Tasks and  
Student Work

## OCEAN ACIDIFICATION ON CALCIUM CARBONATE STRUCTURES

### INTRODUCTION

Since 1981, combined global ocean and surface temperatures have risen at a rate of 0.18°C per year, with average global surface temperatures rising by 0.9°C (NOAA, 2021). On average, Australia's climate has warmed by 1.44°C, and its sea surface temperatures by 1°C (GBRMPA, 2022). According to NASA, 2019, global warming is defined as the long-term heating of the Earth's surface and the rapid rise in surface temperature. This is hypothesised to be due to the emission of greenhouse gases into the atmosphere. The primary atmospheric greenhouse gases are water vapour (H<sub>2</sub>O), methane (CH<sub>4</sub>), ozone (O<sub>3</sub>), nitrous oxide (N<sub>2</sub>O), and carbon dioxide (CO<sub>2</sub>), with CO<sub>2</sub> being the largest greenhouse gas emitted by human activities (EPA, 2022). CO<sub>2</sub> is emitted into the atmosphere through the combustion of fossil fuels, such as coal, oil, natural gas, and biological materials. Fossil fuels are composed primarily of hydrocarbons, which when burnt, produce energy, CO<sub>2</sub>, and water vapour (SERC, 2017). *Figure 1* illustrates how absorbed solar energy is radiated from the Earth's surface into the atmosphere as low infrared energy (heat). The infrared energy either enters space directly or is absorbed by greenhouse gas molecules. Due to their complex vibration modes, greenhouse gases are more likely to absorb and interact with infrared waves (UCAR, 2019). As seen in *Figure 1*, the absorbed energy is then re-radiated elsewhere, creating a chain reaction and preventing heat from exiting the troposphere (UCAR, 2019).

CMA1 – C  
Correct and well researched information about greenhouse gases and global warming, however, does not evaluate the fundamental properties in relation to this investigation. Global warming and ocean acidification, while linked to carbon dioxide concentration increase, are separate issues. The student should analyse these in the subsequent method.

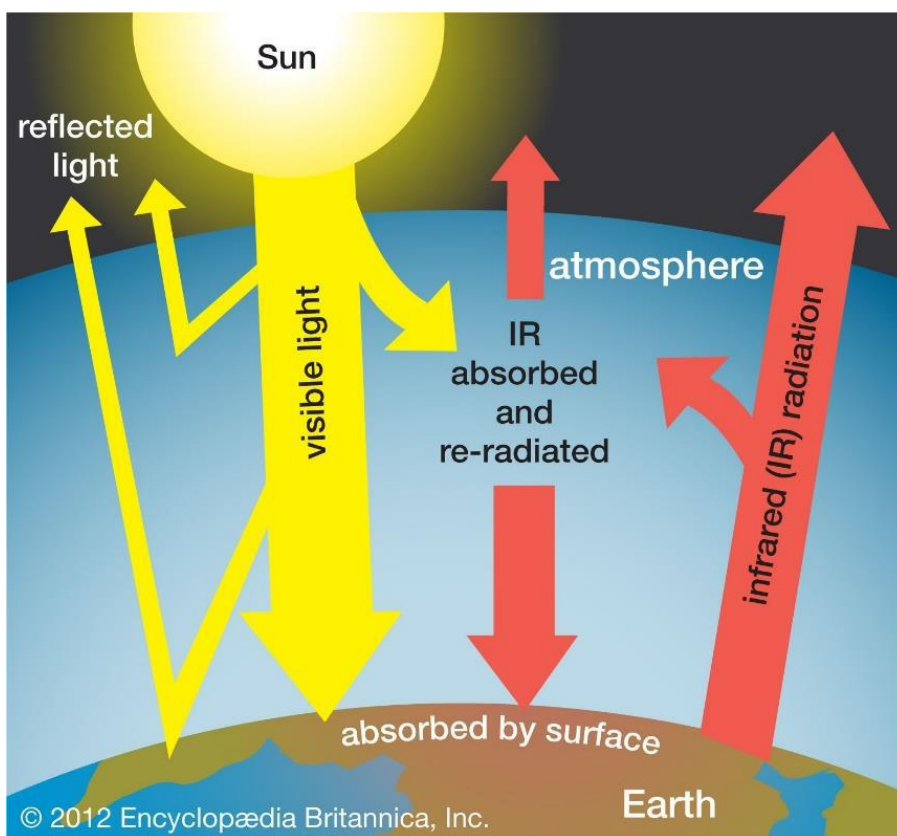


Figure 1. Diagram of the pathways of solar light entering and exiting the atmosphere (Encyclopedia Britannica, 2022).

Figure 2 illustrates the current, and future trends of global mean temperature and atmospheric CO<sub>2</sub> concentration. The current atmospheric CO<sub>2</sub> concentration is approximately 412 parts per million (ppm), an 11% increase since 2000, and a 47% increase since the Industrial Age (NASA, 2019). As atmospheric CO<sub>2</sub> concentration rises so will global temperatures.

CMA1 – B  
Analysis of researched information, including data to support understanding of global warming due to carbon dioxide concentration increase.

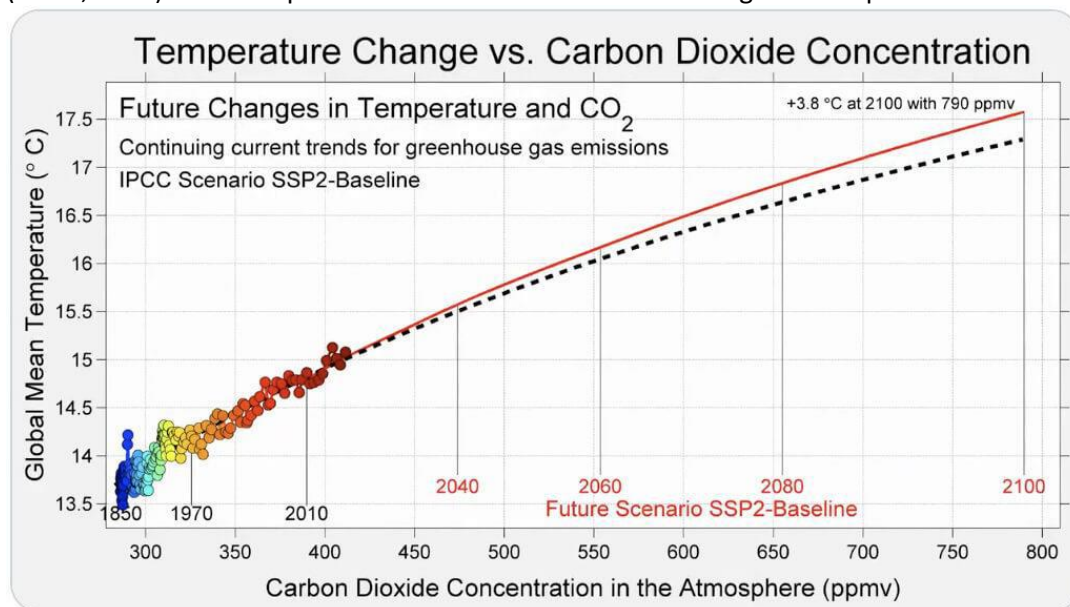


Figure 2. Graph of current and future global mean temperatures and atmospheric CO<sub>2</sub> concentration (Berkley Earth, 2020).

The carbon cycle is the circulation of CO<sub>2</sub> through the Earth's spheres; however, it is being altered due to anthropogenic intervention. Particularly, the ability of carbon sinks to store CO<sub>2</sub>, (EPA, 2022). The ocean is one of the largest carbon sinks, storing 38,000 gigatonnes (Gt) of carbon (STILE, n.d). The ocean absorbs approximately 30% of CO<sub>2</sub> emissions through assimilation and chemical reactions. As a result of increasing atmospheric CO<sub>2</sub> concentration, more CO<sub>2</sub> is being dissolved, altering the ocean's chemistry (NOAA, 2020). As CO<sub>2</sub> enters the ocean, it reacts with H<sub>2</sub>O to form carbonic acid (H<sub>2</sub>CO<sub>3</sub>). The carbonic acid then disassociates into hydrogen ions (H<sup>+</sup>) and bicarbonate ions (HCO<sub>3</sub><sup>-</sup>) (UCAR, 2020).



The scale used to measure the quantity of H<sup>+</sup> ions is the pH scale. The pH scale ranges from 0 – 14 and is a measure of how acidic or basic an object is. It is an inverse measurement of hydrogen ion concentration. 7 is a neutral pH, below 7 becomes increasingly acidic and above increasingly alkaline, or basic (Britannica, 2021). Figure 3 illustrates increasing acidity as a result of the increasing presence of hydrogen ions (NOAA, 2020). The current pH of ocean surface waters is 8.1, having dropped by 0.1 units since the Industrial Revolution, representing a 30% increase in acidity (Parker, 2018). A 0.3 – 0.4 unit decline is expected to occur by 2100, with pH level dropping to 7.8 units (Parker, 2018). As seen in Figure 3, certain marine organisms experience shell deterioration in acidic waters. This is hypothesised to be due to the bonding of carbonate ions (CO<sub>3</sub><sup>2-</sup>) with H<sup>+</sup> ions, lowering the amount of available CO<sub>3</sub><sup>2-</sup> ions. As a result,

calcifying organisms, organisms that combine calcium and carbonate to build hard, calcium carbonate ( $\text{CaCO}_3$ ) shells, are unable to maintain and build their shells (NOAA, 2020). Furthermore, if an organism is in its early stages of development, or if the pH is too low, the shell will dissolve (PMEL, 2019). This is hypothesised to be due to the ability of hydrogen ions to break down carbonate bonds.

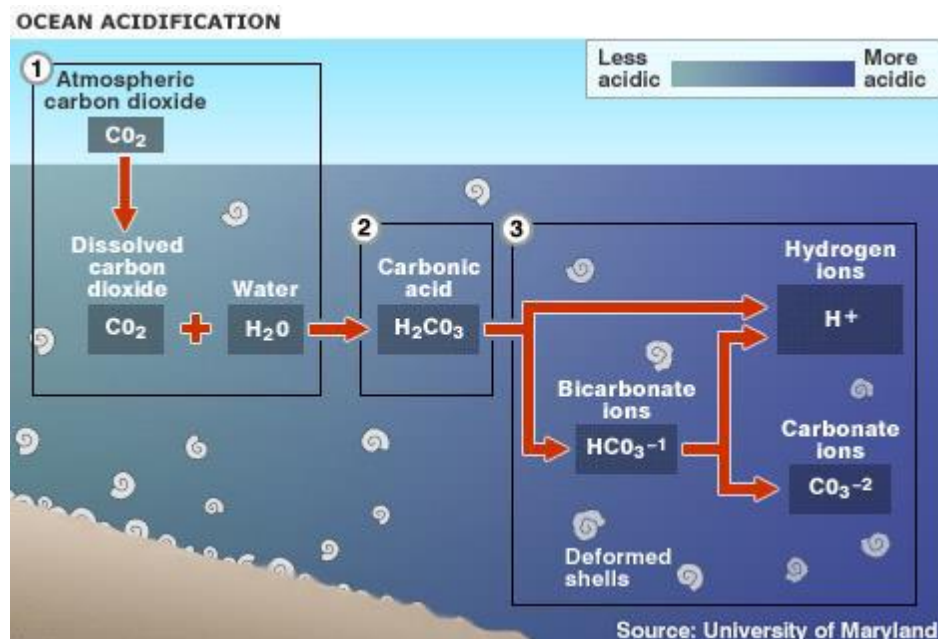


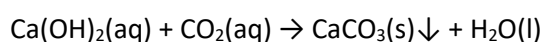
Figure 3. The process of ocean acidification and the resulting impacts on certain shell species (University of Maryland, n.d).

CMA1 - C  
Explains effect of ocean acidification of sea life citing evidence to support claims. To improve, the student could include and evaluation of information and the scale of the impact of ocean acidification.

The impacts of ocean acidification on calcifying organisms such as molluscs, benthic corals, oysters, and shellfish will result in severe, flow-on effects in marine ecosystems, food webs, and multiple industries (EPA, 2019). The Australian oyster industry was valued at 59 million dollars between 2018 – 2019, and the U.S shellfish market at 50.4 billion dollars in 2020 (NSW DPI, 2020). A loss of \$480 million per year would be expected to occur due to a falling supply of shellfish in the USA (EPA, 2019). Furthermore, traditional fishing communities will experience great reductions in socioeconomic status.

C – C  
Explains effect of economic and social factors on the science of ocean acidification and the need to find solutions.

The reaction rate of  $\text{CaCO}_3$  dissolving in hydrochloric acid (HCl), the proxy for carbonic acid, is calculated by dividing the change in weight post HCl treatment (mL) by the time exposed to the HCl solution (min). The reaction between limewater ( $\text{Ca}(\text{OH})_2$ ) and  $\text{CO}_2$  results in the formation of a weak carbonic acid in aqueous form. The carbonic acid then disassociates into hydrogen ions ( $\text{H}^+$ ), hydro carbonate ions ( $\text{HCO}_3^-$ ), and produces a white  $\text{CaCO}_3$  precipitate. Thus, verifying that  $\text{CO}_2$  is absorbed and that  $\text{H}^+$  ions are produced.



IS4 – B  
Good communication using appropriate terminology and conventions. Student should write more concisely to achieve at an A level. Mostly consistent referencing of information.

## AIM

To determine the effects of global warming induced ocean acidification on calcium carbonate structures. In particular, the inability of calcifying organisms to produce insoluble calcium carbonate shells and the deterioration of  $\text{CaCO}_3$  chips in low pH conditions (Parker, 2013).

IS1 - D  
Aim is not specific to the investigation and includes some irrelevant information. Experiment is looking at the effect of pH on carbonate structures of shellfish.

## VARIABLES

Independent variable –hydrochloric acid of different pH (pH 2,4,6,8,10 and 12)

Dependent variable – change in mass of the calcium carbonate chips after 5 minutes.

Controlled variable – length of time the calcium carbonate chips are dissolved in the acid, quantity of hydrochloric acid, starting mass of the calcium carbonate chips, length of time the calcium carbonate chips were left to dry

## HYPOTHESIS

Decreasing pH level will decrease the final weight of the calcium carbonate chips, the proxy for calcium carbonate ( $\text{CaCO}_3$ ) shells. At pH levels 6, 4 and 2, the largest decreases in weight will occur. This is hypothesised to be due to the higher acidity resulting in an increased presence of hydrogen ions. The National Oceanic and Atmospheric Association states that high concentrations of hydrogen ions result in the deterioration of  $\text{CaCO}_3$  shells due to the ability of hydrogen ions to break down  $\text{CaCO}_3$  to bond only with carbonate ions ( $\text{CO}_3^{2-}$ ) (NOAA, 2021)

IS1 - B  
Designs and conducts an investigation with a clear question to collect reliable data.

## MATERIALS

200g x marble chips  
6 x scallop seashells  
6 x medium borosilicate glass test tubes (150mm x 15mm)  
2 x 100mL glass beakers  
1 x 3M HCl bottle with pH 2 (200mL)  
1 x 2M HCl bottle with pH 4 (200mL)  
1 x 1.5M HCl bottle with pH 6 (200mL)  
1 x 1M NaOH bottle with pH 8 (200mL)  
1 x 1M NaOH bottle with pH 10 (200mL)  
1 x 1M NaOH bottle with 12 (200mL)  
1 x 50mL  $\text{Ca}(\text{OH})_2$  bottle  
1 x 25mL measuring cylinder  
1 x electronic balance (1kg+) accurate to 1 decimal place  
1 x electronic stopwatch  
1 x black marker  
1 x paper drinking straw  
1 x pH electrode  
1 x plastic container  
1 x scalpel  
1 x test tube holder  
1 x paper towel  
1 x plastic sieve

## METHOD

1. Appropriate PPE acquired and put on, gloves, safety glasses.
2. 6 x 250mL test tubes were labelled 2, 4, 6, 8, 10, and 12 with a permanent marker and placed into a test tube holder.
3. pH level was tested with a pH probe, see *Figure 4*.
4. 100mL of pH 2 solution, hydrochloric acid (HCl), was added to the test tube labelled 2.
5. Step 3 was repeated with pH solutions 4, 6, 8, 10, 12 and placed into respective labelled test tubes, see *Figure 5*.
6. 5g of calcium carbonate chips was measured using the electronic balance and placed into each test tube.
7. A timer was set for 5 minutes, and 6 squares of paper towel were placed onto the bench top.
8. After 5 minutes test tube 2 was poured through a sieve, separating the hydrochloric acid solution and calcium carbonate chips, see *Figure 6*.
9. The treated calcium carbonate chips were placed on a square of paper towel for 10 minutes to dry.
10. Steps 7-8 were repeated for the remaining treatment groups.
11. The weight of each treatment group was recorded
12. The test tubes and 25mL measuring cylinder were cleaned and calcium carbonate chips disposed of.
13. Steps 3 – 12 were repeated twice more for a total of three trials per pH level.
14. Average weight (g) post treatment for each pH level was calculated.
15. Change in weight for each pH level was calculated by subtracting the weight post treatment (g) from the weight pre-treatment (g).
16. The reaction rate was calculated by dividing the weight post treatment (g) by exposure time (min).
17. 2g of seashells were measured and steps 4, 5, 7, 8, 9, 11, 14, 15 repeated with the seashells.

IS1 - B  
Method should collect valid and reliable data. Several inconsistencies in equipment and method description.

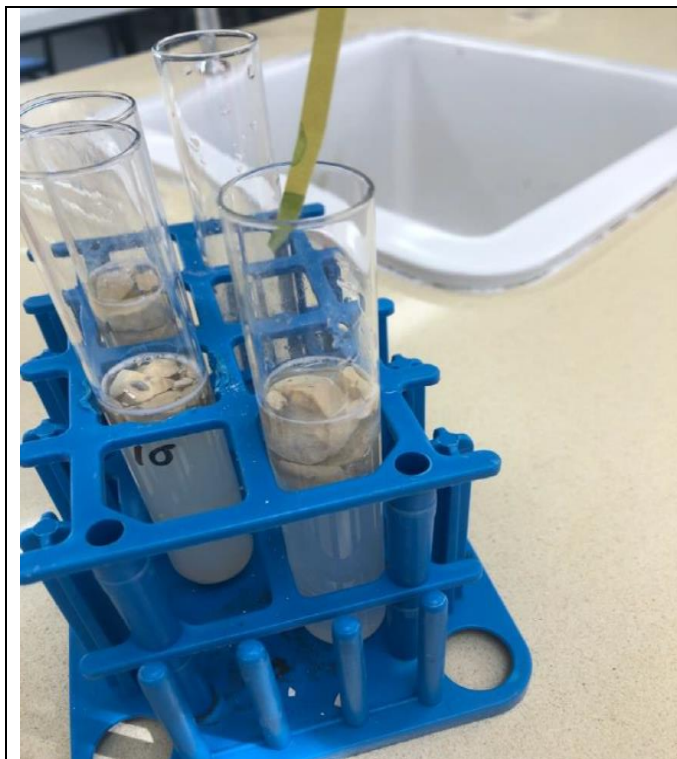


Figure 5. CaCO<sub>3</sub> chips undergoing treatment in HCl solutions. The test tube in the foreground is pH 6 as indicated by the pH testing strip.



Figure 6. Separating the HCl solution from the CaCO<sub>3</sub> strips.

## SAFETY AND ETHICS

### Equipment

Scalpel

Glass beaker 200mL

50mL

Medium borosilicate test tubes 150mm x 15mm

Calcium hydroxide, solution (limewater)

Hydrochloric acid <3M (<10% wt/wt)

Sodium hydroxide 0.51 – 1.3M (2-5% wt/wt)

Calcium chloride, hydrate

Seashells

### Potential Hazards & Handling Procedure

May cause severe injury when used inappropriately. Caution should be taken when handling, students should be vigilant in ensuring they know the scalpel's location.

Breakage of beaker, cuts from chipped rims. Inspect and discard chipped or cracked beakers, sweep up with dustpan and broom and handle with caution.

Glass cylinder may break, causing cuts. Discard cracked or broken measuring cylinders, do not heat cylinder.

Breakage resulting in cuts. Small test tubes likely to eject material in exothermic reactions. Inspect and discard broken test tubes and handle with caution.

Low toxicity, standard handling procedures. Avoid contact with eyes and mouth.

High concentrations may cause irritations to eyes, skin, and lungs. Avoid inhalation of vapour, wear safety glasses and gloves. Dispose of as advised by Risk Assess.

Corrosive to eyes and skin, wear safety glasses. Disposed of as advised by Risk Assess.

Harmful if swallowed, causes serious eye irritation. Wear safety glasses and gloves.

May contain live organisms, inspect shells before handling and wear gloves. Handle with caution as edges may be sharp

## ETHICS

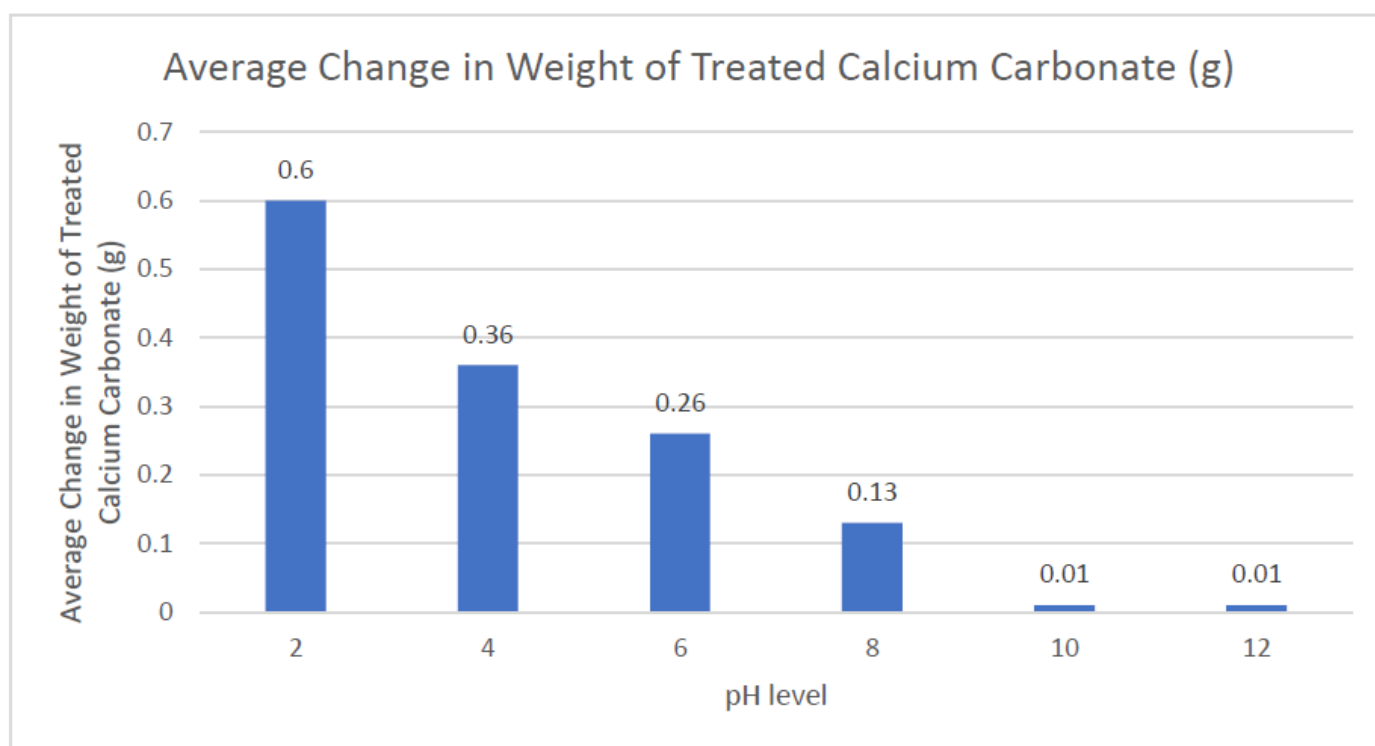
See Appendix for further potential hazards and standard handling procedures. Seashells used during the experiment were obtained from a sustainable source, and not removed from their immediate marine environment. Before the experiment, the seashells were checked for any visible signs of living organisms. Treated seashells were disposed of as advised by RiskAssess, and not placed back into a marine environment. No further ethical considerations had to be made for this practical.

IS1 - A  
Safety risks and precautions analysed.  
Ethical consideration of use of seashells collected.

## RESULTS

Table 1. The average change in weight of treated  $\text{CaCO}_3$  chips.

pH level	Average change in weight of treated $\text{CaCO}_3$ (g)
2	0.6
4	0.36
6	0.26
8	0.13
10	0.01
12	0.01



Graph 1. Graph of the average change in weight of calcium carbonate treated at pH levels 2, 4, 6, 8, 10, and 12.

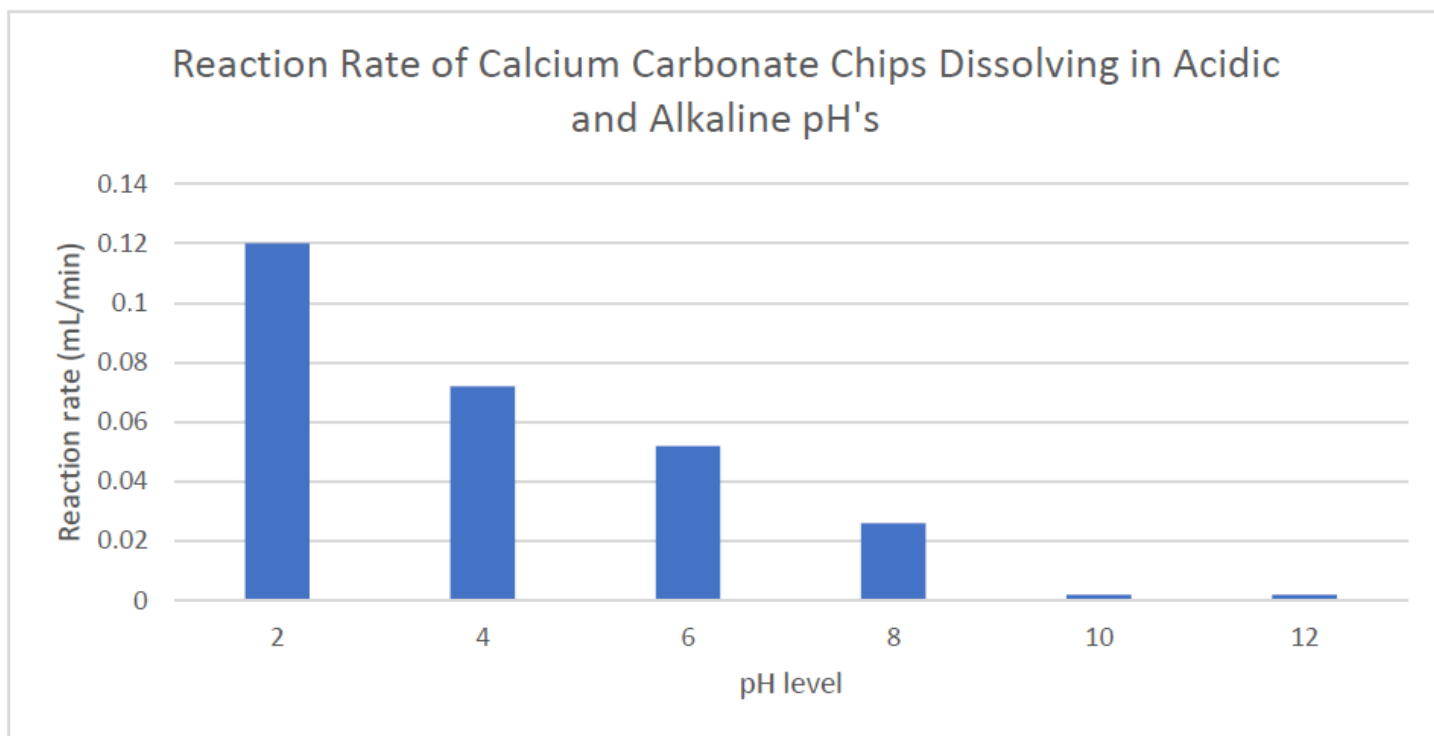
Graph 1 illustrates that the greatest change in weight occurred at pH 2, with the average change across the 3 trials being 0.6g. This is twice as great as the change in weight at pH 4, 0.36g. The initial weight of the  $\text{CaCO}_3$  chips treated at pH 2 was 4.99g, and post treatment 4.39g. At pH 6, a change of 0.26g occurred. As pH increased and the solution became alkaline

rather than acidic, the average change in weight decreased. As seen in *Table 1*, the change in weight was 0.13g at pH 8, and 0.01g at pH 10 and 12. Refer to Appendix for raw data and the average weight of treatment groups post treatment. Lowering pH by increasing the acidity, increases the average change in weight.

Table 2. The reaction rate of the calcium carbonate chips dissolving in the hydrochloric acid solution.

pH level	Reaction rate (mL/min)
2	0.12
4	0.072
6	0.052
8	0.026
10	0.002
12	0.002

IS1 - C  
Collection and manipulation of data to show trends. Minor errors in reaction rate units (g/min)

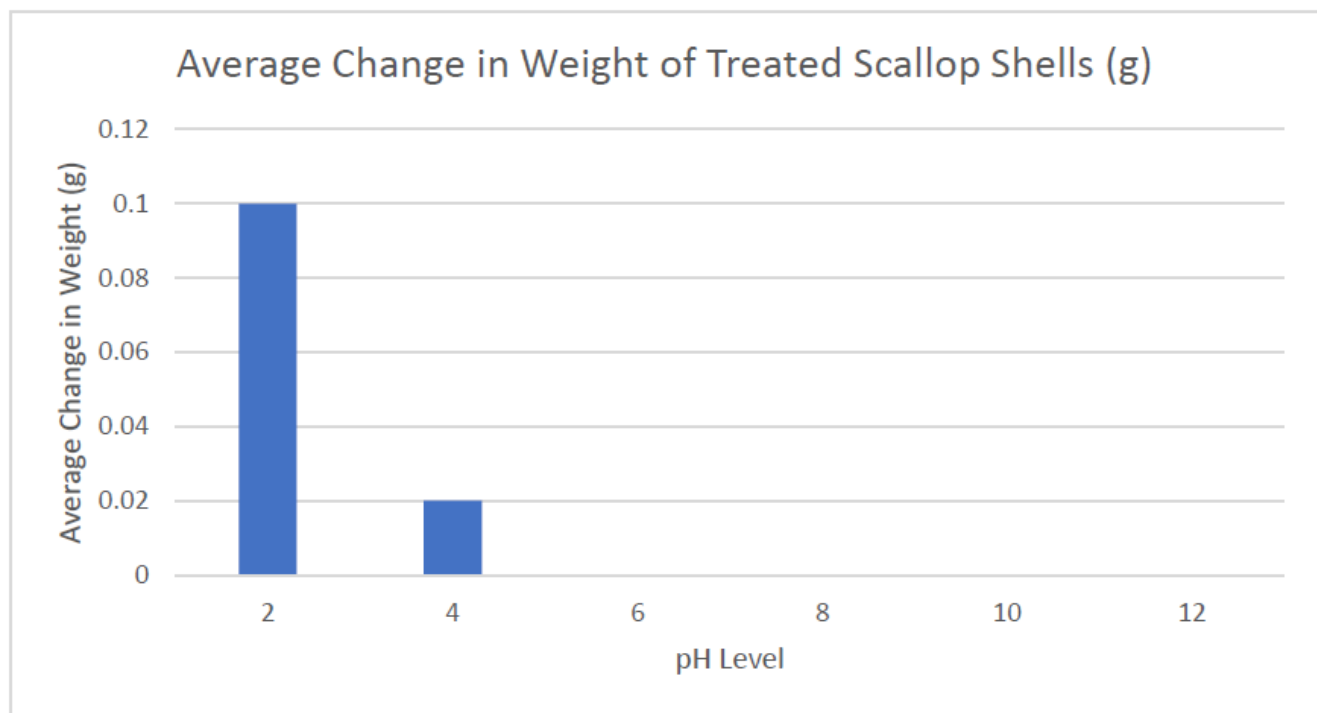


Graph 2. Graph of the reaction rate of calcium carbonate chips dissolving in hydrochloric acid solutions at pH 2, 4, 6, 8, 10, and 12.

As seen in *Table 2* the reaction rate of  $\text{CaCO}_3$  chips dissolving in HCl solution at pH 10 and 12 was lower than the other samples, at 0.002mL/min. The reaction rate at pH 8 was 0.026mL/min and 0.052mL/min at pH 6. As illustrated in *Graph 2*, as pH decreased, the reaction rate increased. The reaction rate at pH 4, 0.072mL/min, is more than two times greater than the reaction time at pH levels 8, 10, and 12, see *Table 2*. At pH 2 the reaction rate is 0.12g, a rate much higher than the other samples.

pH level	Average Change in Weight of Treated Seashells (g)
2	0.1
4	0.02
6	0
8	0
10	0
12	0

Table 3. Average change in weight of treated scallop shells.



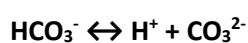
Graph 3. Graph of the average change in weight of treated scallop shells.

As seen in *Graph 3*, the greatest change in weight, 0.1g, occurred at pH 2. A change in weight of 0.02g occurred at pH 4. No change in weight occurred at pH 4, 6, 8, 10 and 12, see *Table 3*. Further investigation should be done to determine the effects of acidic and alkaline pH on scallop shells.

IS2 - B  
 Relationships clearly shown in tables and graphs. Summary of relationships given for calcium carbonate chips and shell used.

## DISCUSSION

The reaction rate of CaCO<sub>3</sub> chips dissolving in HCl solutions is greater at lower pH levels. The reaction rate increased as the pH level decreased, and the solution became more acidic rather than alkaline. CaCO<sub>3</sub> chips treated in pH 2 had an average reaction rate of 0.12mL/min. CaCO<sub>3</sub> chips treated at pH 10 and 12 had a reaction rate of 0.002mL/min. The greatest change in average weight, 0.6g, occurred at pH 2. The average change in weight increased as pH decreased, and acidity increased. This is hypothesised to be due to the increased presence of hydrogen ions (NOAA, 2020). Dissolved CO<sub>2</sub> reacts with water (H<sub>2</sub>O) to form carbonic acid (H<sub>2</sub>CO<sub>3</sub>). The carbonic acid dissociates into hydrogen ions (H<sup>+</sup>) and bicarbonate ions (HCO<sub>3</sub><sup>-</sup>). The bicarbonate further dissolves into carbonate ions (CO<sub>3</sub><sup>2-</sup>) and additional hydrogen ions, see *Figure 8* (Sea Grant Consortium, 2018).



Hydrogen ions are more likely to bond with carbonate ions, than calcium ions (Ca<sup>2+</sup>), resulting in the formation of bicarbonate, see *Figure 8* (HCO<sub>3</sub><sup>-</sup>). As pH decreases, the concentration of hydrogen ions increases. If the presence of hydrogen ions is greater than that of other molecules, the hydrogen ions will break apart CaCO<sub>3</sub> molecules to bond with CO<sub>3</sub> (Smithsonian Ocean, 2021). This is the process by which calcium carbonate shells dissolve in solutions with low pH. The rate of shell deterioration increases as the presence of hydrogen and bicarbonate ions increases and available calcium carbonate ions decrease. According to PMEL, 2019, increased death rates were observed in mollusc populations as a result of shell thinning and deterioration. A study conducted in 2017 at a COSEE-West workshop found that in tropical waters with an approximately 1,800ppm CO<sub>2</sub> concentration aragonite, a form of CaCO<sub>3</sub>, rapidly dissolves because of the decreasing supply of carbonate ions.

IS2 - C Level  
Explains the change in weight of calcium carbonate using equations. Incorrect use of reaction rate units (mL/min).

CMA2 – C  
Explains process of calcium carbonate dissolving and attempts to link to research into Molluscs.

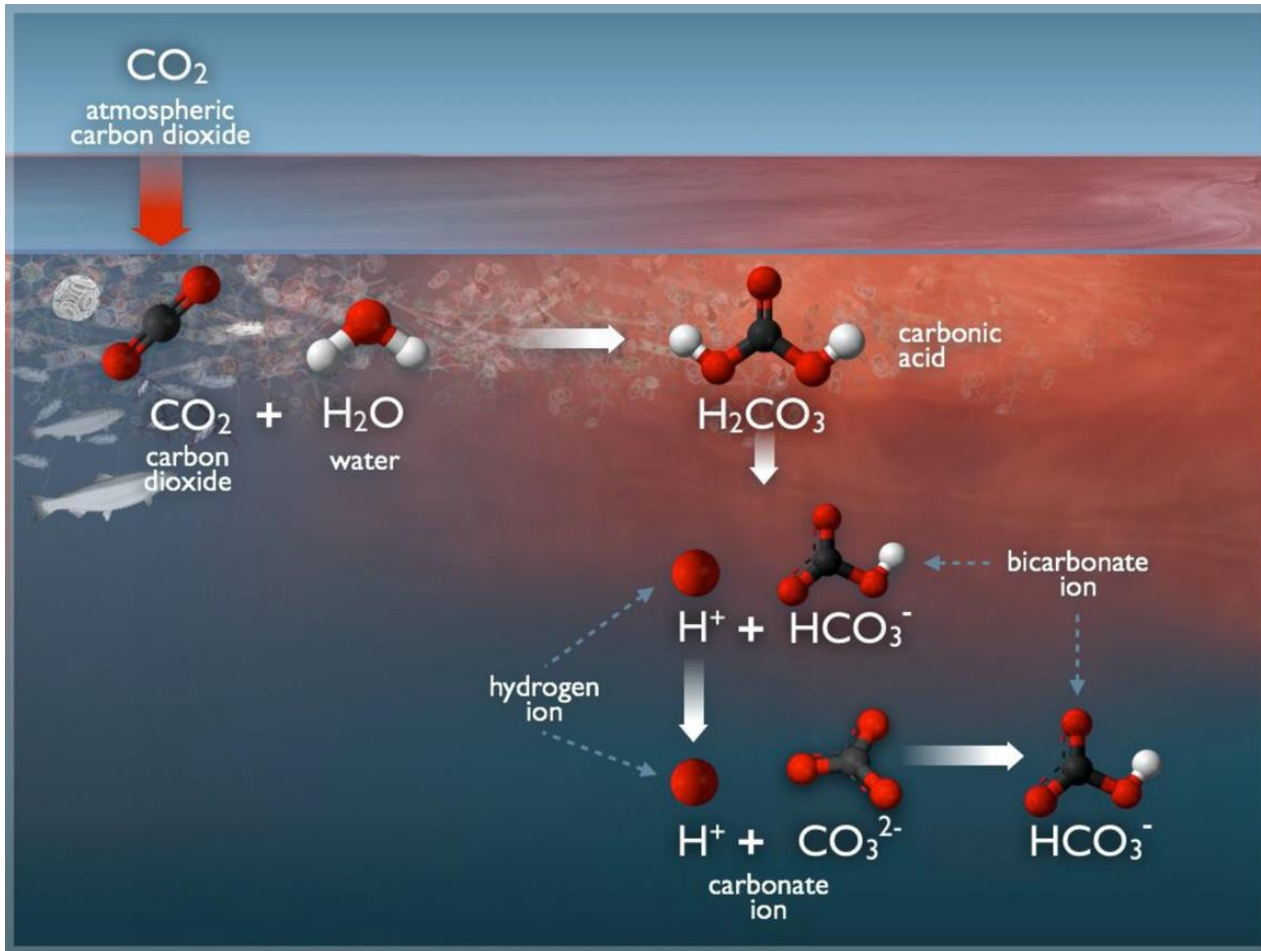


Figure 8. Diagram depicting the chemistry of ocean acidification (Pacific Marine Environmental Laboratory, 2015).

The hypothesis of the experiment was accurate, the greatest change in weight occurred in  $\text{CaCO}_3$  chips treated at pH 2, 4, and 6. However, a weight change, although far less, also occurred at alkaline pH; pH 8, 10 and 12. Seashells were treated at pH 2, 4, 6, 8, 10, and 12 in the experiment. However, no visible or physical reduction in weight occurred. This is due to the more complex composition of the seashells and the comparatively weak concentration of the HCl solutions. The limited timeframe of the experiment and the fact that the seashells were not being built by living hosts are also relevant since the deposition of  $\text{CaCO}_3$  by living organisms may be impacted by pH, as discussed below. The seashells used were scallop shells, which are composed of  $\text{CaCO}_3$  and organic materials (NOAA, 2021).  $\text{CaCO}_3$  in pure form is more reactive with hydrogen and calcium, and more soluble than scallop shells. In a study conducted by postdoctoral scholar at the Woods Hole Oceanographic Institution, Justin Ries, and 2 others raised 18 species of marine organisms with  $\text{CaCO}_3$  shells or skeletons. The species were kept at  $\text{CO}_2$  concentrations 400ppm, 600ppm, 900ppm, and 2,850ppm in temperate and tropical temperatures (Madin, 2018). Ries observed clear differences in shell growth rate and shell deterioration amongst the species, particularly in conch shells, tropical pencil urchins, oysters, and clams. Conch shells visibly deteriorated as seen in *Figure 9*. The

IS2 – C  
Reference to hypothesis included, however, should state whether hypothesis was un/supported or inconclusive.

IS2 – C  
Explains links between hypothesis and results. Explains unexpected results and possible reasons. Should consider lab versus real world acidification rates.

IS3 – B  
Analyses results and explains using reference to literature.

IS4 – C  
Cites sources with mostly consistent referencing. Some in-text referencing contains errors.

treated shell (right) protuberance's dissolved significantly compared to the untreated shell (left). Additionally, the tropical and temperature pencil urchins experienced severe shell deterioration. As CO<sub>2</sub> concentration increased, the shell growth rate decreased in the oysters, clams, and scallops. Furthermore, in high CO<sub>2</sub> concentrations, a total net loss occurred due to the dissolving of large portions of shell.



Figure 9. Untreated (left) and treated (right) conch shells. The left shell was exposed to current CO<sub>2</sub> concentrations (400ppm), and the right shell 2,850ppm. (Photo by Tom Kleindinst, Woods Hole Oceanographic Institution)

A study conducted by the National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory in 2017 found that oyster larvae died within 2 days of exposure to low pH. According to PMEL, 2019, young marine organisms are at a greater risk of ocean acidification. This is hypothesised to be due to easily soluble CaCO<sub>3</sub> being utilised to build structures as a result of the decreasing supply of available CO<sub>3</sub> ions (PMEL, 2019). Furthermore, more CO<sub>2</sub> can be held in hotter oceans, thus as global temperatures rise due to global warming, the ocean's acidity will increase (WHOI, 2021).

### INCONSISTENCIES AND IMPROVEMENTS

Data inconsistencies may have stemmed from systematic uncertainty in the electronic balance, parallax error, and the experimental procedure. The electronic balance utilised had an uncertainty of 0.05g systematic. Parallax errors may have occurred when measuring out the 100mL of each HCl solution, and reaction time errors may have occurred when the timer was stopped and started. Furthermore, the initial weight of the treatment groups was often dissimilar by 0.1 – 0.2g. This impacted the calculations of the final average weight, average change in weight, and the reaction rate.

IS3 - C  
Explains errors but does not evaluate the impact of these errors on the results - higher or lower than expected.

Improvements in the experiment 'Ocean Acidification on Calcium Carbonate Structures' include developing a method to measure the volume of the  $\text{CaCO}_3$  treated or to measure the weight with higher accuracy. The electronic balance was accurate to 2 decimal places, however, the initial weight across all treatment groups was not consistent. Furthermore, a method to completely dry treated samples should be developed. The samples may not have dried completely, resulting in additional weight. Due to the experimental procedure, some treatment groups were left in solution longer than others whilst waiting to be poured through the sieve. However, this period was unlikely to be long enough for additional dissolving to occur. pH levels were replicated with decent accuracy, however, the concentration of  $\text{CO}_2$  in solution could not be replicated. Further improvements include controlling the  $\text{pCO}_2$  concentration to further replicate current and future ocean acidification reactions. Improvements to testing seashells include increasing surface area by crushing the shells and drying the resulting chips in an oven before testing.

IS3 - B  
Explains how experiment could be improved, however, needs to analyse the impact on the results.

## CONCLUSION

As pH decreased and acidity increased, the average change in weight increased. The change in weight at pH 2 was 0.6g, and 0.01g at pH 10 and 12. The reaction rate of dissolving  $\text{CaCO}_3$  in HCl solutions increases at lower pH and decreases at higher pH. At pH 2, the reaction rate was 0.12mL/min and 0.002mL/min at pH 10 and 12. The  $\text{CaCO}_3$  chips, proxy for  $\text{CaCO}_3$  shells, experienced greater weight reduction in low pH solutions, replicating the deterioration of  $\text{CaCO}_3$  shells in acidic waters with high hydrogen ion and low carbonate ion concentration.

CM1 C: CM3 D: Conclusion reflects the experiment results but does not address how this would generalise to oceans and shellfish in the natural environment.

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IS4 – B  
Uses a wide range of credible sources with a few errors in citations

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## FIGURES

Figure 1

*The greenhouse effect* 2012, Diagram, Encyclopedia Britannica, viewed 14 October 2022, <<https://www.britannica.com/science/greenhouse-effect>>

Figure 2

*Temperature change vs carbon dioxide concentration* 2020, Graph, Berkley Earth, viewed 14 October 2022, <<http://berkeleyearth.org/dv/temperature-change-vs-carbon-dioxide-concentration/>>

Figure 3

*Chemical reactions in ocean acidification* n.d., Diagram, University of Maryland, viewed 14 October 2022, <<https://theotherco2problem.wordpress.com/what-happens-chemically/>>

Figure 8

*Ocean acidification chemistry* 2015, Diagram, Pacific Marine Environmental Laboratory, viewed 14 October 2022, <[http://www.cev.washington.edu/file/Ocean\\_Acidification\\_Chemistry.html](http://www.cev.washington.edu/file/Ocean_Acidification_Chemistry.html)>

Figure 9

Kleindinst, TK 2017, *Shell deterioration*, Photograph, Woods Hole Oceanographic Institution, viewed 14 October 2022, <<https://www.whoi.edu/oceanus/feature/ocean-acidification-a-risky-shell-game/>>

## APPENDIX One

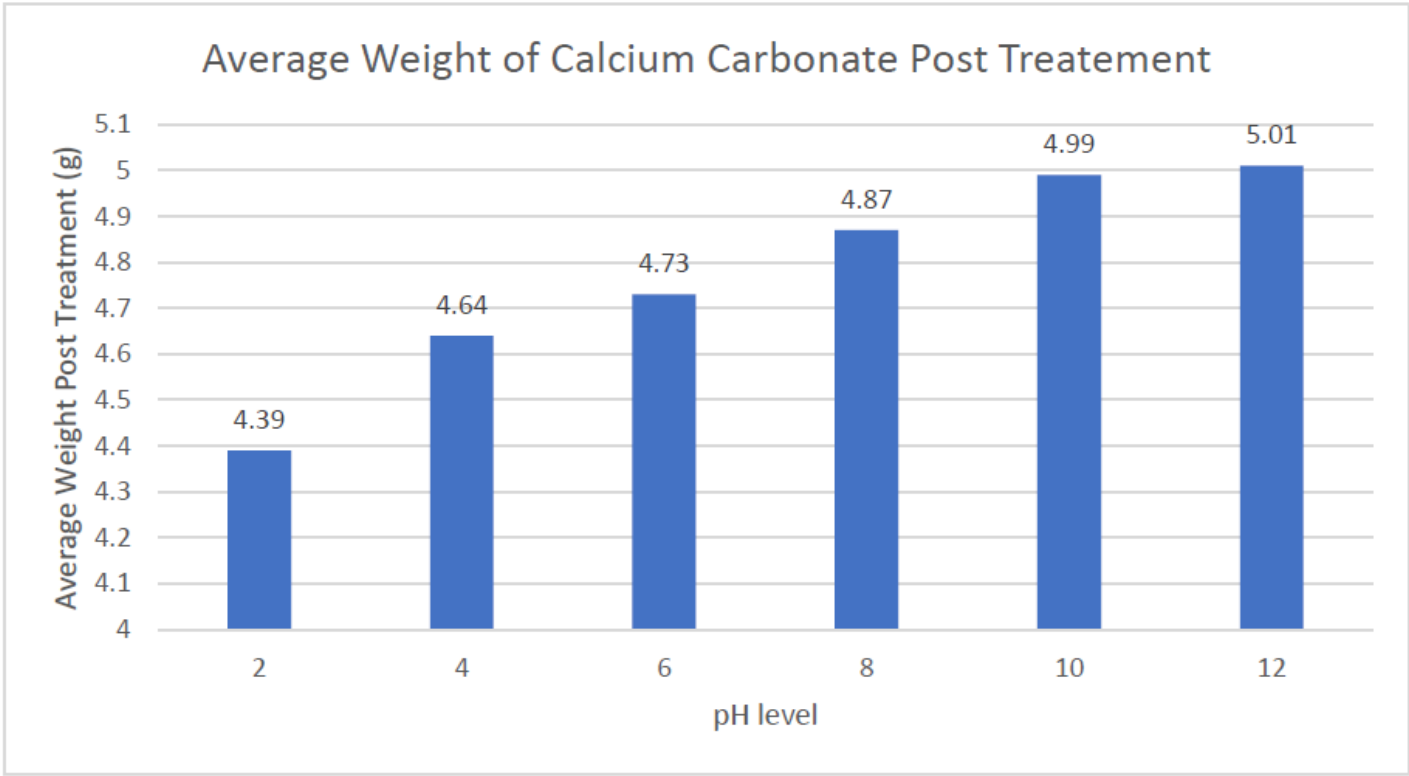
Risk Assessment – student linked to an external website (RiskAssess.com.au)

## APPENDIX Two

Trial 1 pH level	Initial weight (g)	Weight post treatment (g)
2	5.00	4.35
4	5.02	4.65
6	4.98	4.74
8	5.01	4.85
10	5.00	5.00
12	5.02	5.01
Trial 2 pH level	Initial weight (g)	Weight post treatment (g)
2	4.97	4.38
4	4.99	4.60
6	5.02	4.71
8	5.00	4.80
10	4.99	4.98
12	5.03	5.01
Trial 3 pH level	Initial weight (g)	Weight post treatment (g)
2	5.02	4.45
4	5.01	4.67
6	4.98	4.74
8	5.00	4.75
10	5.00	4.98
12	5.01	5.01

Table 1. The average initial weight and weight post treatment of calcium carbonate chips.

pH level	Average initial weight (g)	Average weight post treatment (g)
2	4.99	4.39
4	5.00	4.64
6	4.99	4.73
8	5.00	4.87
10	4.99	4.98
12	5.02	5.01



Graph 1. Graph of the average weight post treatment at pH levels 2, 4, 6, 8, 10, and 12.

## Reflection

In the Practical Investigation report, I designed and conducted an experiment with my partner on energy transfer in Earth. I researched the implications of ocean acidification on  $\text{CaCO}_3$  structures and marine ecosystems and designed an experiment that enabled me to understand the chemistry of ocean acidification. Before planning and conducting the experiment, I researched the impacts of  $\text{CO}_2$  on the ocean's chemistry to build a base knowledge. I was unable to work on the report for 10 days. To compensate, I utilised work strategies such as splitting the task into achievable sections and prioritising this assessment.

Initially, I was excited to conduct the experiment and research it due to my interest in this area. The experiment was mostly successful, furthering my positive outlook. However, the enormity of the task overwhelmed me, leading to procrastination. This was worsened by my absence. I responded to this by communicating and comparing my work with my partner and employing work strategies. However, I feel unsatisfied with my report. I feel I should have pushed myself to complete it earlier and polish it. The tasks were a good learning experience and how to push through procrastination and plan effectively. Overall, the task was enjoyable as I enjoyed conducting the experiment and researching.

My initial researching and planning were effective, however, I strayed from this approach quickly. This resulted in procrastination and stress. As a learner, I should strive to make clear plans. The report is over the word limits due to poor time management. In the future, I should make consistent additions to assessment tasks, completing planned out sections, reducing procrastination. My strengths in this task were researching, and weaknesses being concise and adhering to the word limit.

I can conclude that I am pleased with the report's content, but not satisfied with my approach to the task, time management, and word count. I should be vigilant in ensuring I work on assessment tasks consistently, so they aren't left to the last minute. I will apply feedback that I receive to improve my next assessments.

IS4 – C - Reflects on own thinking, explains planning and time management, and draws out the implications. Little reference to practical work strategies

IS5 – C  
Communicates accurately demonstrating scientific literacy. However, a couple of vocabulary errors and some repetition of points made.

<b>Year 11 Earth and Environmental Science (T) Investigation Report Name: _____ Total: _____/40 Criteria</b>						
Indicator	A - 5	B - 4	C -3	D - 2	E -1	
Concepts, Models and Applications	Properties and Functions Introduction	Evaluates analyses the fundamental properties and functions of their chosen topic on Earth systems.	Analyses the fundamental properties and functions of their chosen topic on Earth systems.	Explains the fundamental properties and functions of their chosen topic on Earth systems.	Describes the fundamental properties and functions of their chosen topic on Earth systems.	Identifies the fundamental properties and functions of their chosen topic on Earth systems.
	Evidence and Conclusions Discussion & Conclusion	Evaluates research to develop evidence-based conclusions and evaluates the limitations of their research.	Analyses research to develop evidence-based conclusions and discusses the limitations of their research.	Explains research to develop evidence-based conclusions and identifies the limitations of their research.	Describes research and develops conclusions about their research.	Identifies research and states conclusions.
Contexts	Use and Influence of Science Introduction	Evaluates the impact of their chosen topic on social, economic, ethical, and cultural factors.	Analyses the impact of their chosen topic on social, economic, ethical, and cultural factors.	Explains the impact of their chosen topic on social, economic, ethical, and cultural factors.	Describes the impact of their chosen topic on social, economic, ethical, and cultural factors.	Identifies the impact of their chosen topic on social, economic, ethical, and cultural factors.
Inquiry Skills	Designs and Conducts Aim Hypothesis Materials Method Risk Assessment	Designs, conducts, and improves a safe and ethical investigation to collect valid, reliable data on energy transfer and transformation in Earth systems. Investigation explores a complex research question and clearly justifies their design choices.	Designs, conducts, and improves a safe, ethical investigation that collects valid, reliable data on energy transfer and transformation in Earth systems. Investigation explores a clear question and explains their design choices.	Plans and conducts a safe, ethical investigation that collects valid data on energy transfer and transformation in Earth systems. Investigation explores a familiar question and describes their design choices.	Follows a procedure to conduct a safe, ethical investigation to collect data on energy transfer and transformation in Earth systems. Investigation explores a simple question with varying success.	Follows a procedure to conduct a safe, ethical investigation to collect data energy transfer and transformation in Earth systems. Little to no connection to a research question.
	Analysis Results Discussion	Analyses causal and correlational relationships, anomalies, reliability, and validity of their data. Analyses links between hypotheses and results.	Analyses causal and correlational relationships, anomalies, reliability, and validity of their data. Discusses links between hypotheses and results.	Explains causal and correlational relationships, anomalies, reliability, and validity of their data. Explains links between hypotheses and results.	Describes trends, relationships, and anomalies in their data. Identifies some possible sources of error.	Identifies trends and relationships in data with little or no reference to sources of error.
	Evaluation Discussion	Analyses method, results, uncertainty and error to propose appropriate and justified improvements to enhance the validity and reliability of the investigation.	Assesses method, results, and some uncertainty and discusses error, to propose improvements to enhance the validity and reliability of the investigation.	Explains method, results, and some uncertainty and error, to suggest improvements to the investigation.	Describes the method and results to identify areas for improvement and mentions uncertainty/error.	Identifies the method and the need for some improvements.
	Communication	Consistently uses concise, effective, and accurate language to communicate ideas and construct justified, evidence-based arguments in the form of a science report. Cites a diverse range of credible sources accurately.	Uses clear and accurate language to communicate science ideas and construct evidence-based arguments in the form of a science report. Cites a range of credible sources accurately.	Uses appropriate language accurately to communicate science ideas and construct arguments in the form of a science report. Cites sources with mostly consistent referencing.	Uses everyday language to communicate science ideas and construct arguments in the form of a science report. Inconsistently cites sources.	Uses everyday language to communicate science ideas demonstrating limited scientific literacy in the form of a science report. Inconsistent and inaccurate referencing.
	Reflection	Reflects with insight on their own thinking throughout the task and that of others, and evaluates their planning, time management, and use of appropriate work strategies to complete the task.	Reflects on their own thinking and analyses their planning, time management, and use of appropriate work strategies to complete the task.	Reflects on their own thinking and explains their planning, time management and use of appropriate work strategies to complete the task.	Reflects on their own thinking, with reference to planning and the use of appropriate work strategies.	Reflects on their own thinking with little or no reference to planning, time management, and use of work strategies.



# Earth and Environmental Science

**Assessment Task One: Investigation**

**Student Work: D Grade Script**

Year 11 Annotated Tasks and  
Student Work

## Earth and Environment investigation into the Great Conveyor System

### Introduction

The Great Conveyor System is one of the most important systems that is found within the ocean. (ABC, 2011) The way that the Great Conveyor System is the system within the ocean that transports the moving of different temperatures of water as well as nutrients. (NOAA, 2023) The hot water sits on the top of the surface, carrying carbon dioxide and no nutrient, it moves towards the colder water which in turn fill in the space the hot water left behind, this water loses the carbon dioxide and instead carries nutrient rich water. It then moves towards the surface, allowing for creatures to feed. This system is critical in keeping the balance of the ocean and allowing for life to exist in the sea. (National Geographic, 2023)

CMA1 – D  
Describes the Earth System chosen, however needs to be more specific with cause and effect to move to explaining the fundamental properties of the great conveyor system. Very little detail about system included.

### Aim

The aim of this investigation is to find out how cold and warm water will move inside the water tank to represent the Great Conveyor System.

S1 – E  
Aim needs to outline a testable hypothesis for investigation.

### Variables

Independent variable – water temperature

Dependent variable – how the water moves

Controlled variable – same tank

### Hypothesis

The hypothesis for this investigation is that the test with cold water at one end and boiling water at the other will mirror the Great Conveyor System of Earth, meaning that the cold water will sink to the bottom and then will spread towards the warm edge of water. While this is happening, the warm water will spread to the cold edge on the top of the water. However, with the experiment where there is hot water at both ends of the tank, it will not mirror the great conveyor and instead the water will just sit at the other ends of the water and not mix.

### Materials

2x Large Buckets  
2x Meter long rulers  
1x Red food colouring  
1x Blue food colouring  
1x 1L Kettle  
1x 30 L Water tank  
6x 1.5 L of tap water

## Method

1. Filled the kettle up with water and then it was left to boil while other steps were done.
2. Place a ruler along the bottom of the tank
3. Fill the buckets up with water from the taps, then pour it into the tank until it reaches 15cm height.
4. Quickly add 6 drops of blue food colouring at one end.
5. Pour the boiling water into the other end. Then add red food colouring where the boiling water was poured.
6. Record the water movement. Wait until the blue water reaches the other end of the tub.  
Then stop recording
7. Repeat steps 1 to 6 two more times.
8. Repeat steps 1 to 3. Pour hot water into both ends of the tubs.
9. Then put red food colouring at both ends.
10. Record the data.
11. Repeat steps 8 to 10 two more times.

IS1 - E  
Plans an investigation, including equipment with limited success. Reliable, quantitative data is not able to be collected using this equipment and method.

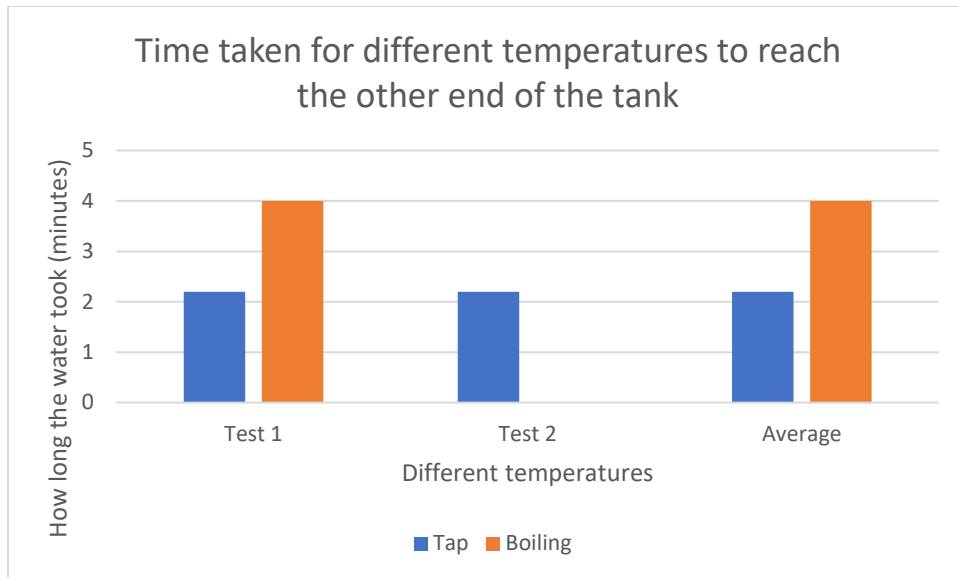
## Risk assessment and ethical considerations

Risk	What dangers it presents	How to negate the impact	Likely hood of happening
Boiling water	Can burn a person if it is spilt on them person	Make sure the water is carefully poured into the tub	Very low
Kettle	Can burn a person if they touch it by accident when not looking	Make sure to be careful around it.	Low

Not many ethical considerations had to be considered during this investigation due to how no animals or people were tested on during this experiment. However, consideration had to be used to make sure that no one was hurt accidentally hurt, this involves being careful around others.

S1 - D  
Considers some safety risks and ethical considerations in conducting investigation.

## Results



Graph 1. The relationship between time taken for water to reach the other end of the tank. With hot water it took 4 minutes on average and for cold water it took 2.25 minutes to reach the other end and simulate the Great Conveyor System.

## Discussion

In the graph 1 it is shown that the cold water at one end and one boiling at the other end has an average rate of 2.25 minutes for simulation of the Great Conveyor System. With Boiling water at both ends the average was 4 minutes. The hypothesis that was raised was indeed correct about how different temperatures of water would simulate the Great Conveyor System. The Great Conveyor System needs two very different temperatures for it to spread nutrients and the carbon dioxide in the water and if two hot sources exist it is unable to move the water around (NOAA, 2023)

As seen in the cold and hot water experiments in graph one, it is shown that the hotter water, which also simulates the carbon dioxide rich and low nutrient water moving across the top. While the colder water, which is low carbon dioxide but high nutrient sinks to the bottom and then moves to the hot water. The water in the tank is simulating the Great conveyor, thus "allowing" for animals and plants to be able to exist.

However, it is very clear from the tests with only hot water, the system is unable to work. This is seen by how the hot water at both ends just move towards each other and just merge into each other. This is caused by how there is no cold water to sink down. This means that the water only had carbon dioxide in it and little to no nutrients will reach the

IS1 – D  
Collects and displays data with limited success. Data should be presented in a table in addition to the graph.

IS2 – C  
Describes patterns in data.

IS3 – C  
Describes process of Earth system demonstrated in investigation. Tries to link basic observations to real life example with limited success.

CMA3 - D  
Describes how data collected in investigation supports model of great conveyor system. Response would be strengthened by linking cause and effect of system to explain the model.

C2 - D  
Describes environmental impact of system with little evidence. Student should consider the impact of other factors on the Science studied.

CMA3 - D  
Makes claims about model from data with minimal supporting evidence from literature.

surface, causing catastrophic for life in the sea. This is showing the importance of global ocean temperatures and its impact on the great conveyor system. (National Geographic, 2023)

IS2 - D  
Describes some issues with experiment in an attempt to evaluate data. Student should explain the impact of these errors or compare data with other sources.

A way that this experiment could be improved is that more tests with different temperatures water would be more useful as it allows for a great range of data that increase the validity of the results and this experiment. Having cold water at both ends could have been a good experiment. Some time was wasted during one of the experiments lessons due to the fact that for some strange reason the experiment it did not work at all. A solution to some of the issues would be to get another person to maybe help out with the task, so that one person isn't trying to multi-task everything all at once. This would significantly lower the risk of human error within the experiment results, meaning the validity would increase.

IS3 - D  
Describes issues with experimental method and suggests improvements for future research. Minimal reference to evidence.

## Conclusion

It was found that due to the changes in temperature of the water it took longer for the water to properly simulate the Great Conveyor System. Boiling hot water was unable to properly simulate the Great Conveyor System while tap water could.

IS2 - D  
Provides a generalised summation of findings but needs to link this to the hypothesis or aim of the experiment, as it applies to the great conveyor system.

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<https://mirjamglessmer.com/2018/08/10/experiment-oceanic-overturning-circulation-the-easiest-version/>

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National Oceanic and Atmospheric Administration, "what is the global ocean conveyor belt?", <https://oceanservice.noaa.gov/facts/conveyor.html#:~:text=The%20great%20ocean%20conveyor%20moves%20water%20around%20the,deep%20ocean%20and%20wind-driven%20currents%20on%20the%20surface.>

National Geographic (2023) *Ocean Conveyor Belt*, National Geographic, accessed 10 October 2023. <https://education.nationalgeographic.org/resource/ocean-conveyor-belt/>

IS4 - D  
Some referencing conventions followed. Some very low-level resources dominated reporting, with some references in the bibliography not mentioned at all in the text, indicating a lack of understanding of higher order reference material.

Science buddies (20 November 2020) *Ocean Currents: Modeling the 'Global Conveyor Belt' in Your Kitchen*, Science buddies, accessed 18 October 2023. [https://www.sciencebuddies.org/science-fair-projects/projectideas/OceanSci\\_p012/ocean-sciences/ocean-currents-modeling-global-conveyor-belt](https://www.sciencebuddies.org/science-fair-projects/projectideas/OceanSci_p012/ocean-sciences/ocean-currents-modeling-global-conveyor-belt)

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## Appendix

<file:///C:/Users/harry/Downloads/11ees-practical-investigation-great-conveyor-2023.pdf>

## Reflection

A strategy that I undertook was that I filled out anything I could, even if it wasn't in order, and then I could come back and fill out other parts of this investigations. This way I was taking advantage of all of my time availability. Throughout this investigation I was thinking and feeling many different things. Before my experiment I felt like it went very well. I felt a bit worried during the experiments due to how on the second lesson my experiment wasn't working at all. I responded to challenges by trying to find away in which I could find a solution. Overall, it was a good experience because I learnt a lot about my chosen topic. My effectiveness of my approach was strong, but it wasn't a hundred percent. My strengths in this assessment was that I used everything at my disposals to make this to the best of my ability. My weakness was that I didn't find to many sources to compare my investigation against. From this reflection I can see that I did okay but I can still improve. How I can improve next time is that I can try and base my assignment of with something I can compare it against.

IS5 – D  
Explains the process of completing the investigation including planning and work strategies. Lacks the detail in reflection and the links to improve for future tasks that is needed for analysis.

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Concepts, Models and Applications	Properties and Functions Introduction	Evaluates analyses the fundamental properties and functions of their chosen topic on Earth systems.	Analyses the fundamental properties and functions of their chosen topic on Earth systems.	Explains the fundamental properties and functions of their chosen topic on Earth systems.	Describes the fundamental properties and functions of their chosen topic on Earth systems.	Identifies the fundamental properties and functions of their chosen topic on Earth systems.
	Evidence and Conclusions Discussion & Conclusion	Evaluates research to develop evidence-based conclusions and evaluates the limitations of their research.	Analyses research to develop evidence-based conclusions and discusses the limitations of their research.	Explains research to develop evidence-based conclusions and identifies the limitations of their research.	Describes research and develops conclusions about their research.	Identifies research and states conclusions.
Contexts	Use and Influence of Science Introduction	Evaluates the impact of their chosen topic on social, economic, ethical, and cultural factors.	Analyses the impact of their chosen topic on social, economic, ethical, and cultural factors.	Explains the impact of their chosen topic on social, economic, ethical, and cultural factors.	Describes the impact of their chosen topic on social, economic, ethical, and cultural factors.	Identifies the impact of their chosen topic on social, economic, ethical, and cultural factors.
Inquiry Skills	Designs and Conducts Aim Hypothesis Materials Method Risk Assessment	Designs, conducts, and improves a safe and ethical investigation to collect valid, reliable data on energy transfer and transformation in Earth systems. Investigation explores a complex research question and clearly justifies their design choices.	Designs, conducts, and improves a safe, ethical investigation that collects valid, reliable data on energy transfer and transformation in Earth systems. Investigation explores a clear question and explains their design choices.	Plans and conducts a safe, ethical investigation that collects valid data on energy transfer and transformation in Earth systems. Investigation explores a familiar question and describes their design choices.	Follows a procedure to conduct a safe, ethical investigation to collect data on energy transfer and transformation in Earth systems. Investigation explores a simple question with varying success.	Follows a procedure to conduct a safe, ethical investigation to collect data energy transfer and transformation in Earth systems. Little to no connection to a research question.
	Analysis Results Discussion	Analyses causal and correlational relationships, anomalies, reliability, and validity of their data. Analyses links between hypotheses and results.	Analyses causal and correlational relationships, anomalies, reliability, and validity of their data. Discusses links between hypotheses and results.	Explains causal and correlational relationships, anomalies, reliability, and validity of their data. Explains links between hypotheses and results.	Describes trends, relationships, and anomalies in their data. Identifies some possible sources of error.	Identifies trends and relationships in data with little or no reference to sources of error.
	Evaluation Discussion	Analyses method, results, uncertainty and error to propose appropriate and justified improvements to enhance the validity and reliability of the investigation.	Assesses method, results, and some uncertainty and discusses error, to propose improvements to enhance the validity and reliability of the investigation.	Explains method, results, and some uncertainty and error, to suggest improvements to the investigation.	Describes the method and results to identify areas for improvement and mentions uncertainty/error.	Identifies the method and the need for some improvements.
	Communication	Consistently uses concise, effective, and accurate language to communicate ideas and construct justified, evidence-based arguments in the form of a science report. Cites a diverse range of credible sources accurately.	Uses clear and accurate language to communicate science ideas and construct evidence-based arguments in the form of a science report. Cites a range of credible sources accurately.	Uses appropriate language accurately to communicate science ideas and construct arguments in the form of a science report. Cites sources with mostly consistent referencing.	Uses everyday language to communicate science ideas and construct arguments in the form of a science report. Inconsistently cites sources.	Uses everyday language to communicate science ideas demonstrating limited scientific literacy in the form of a science report. Inconsistent and inaccurate referencing.
	Reflection	Reflects with insight on their own thinking throughout the task and that of others, and evaluates their planning, time management, and use of appropriate work strategies to complete the task.	Reflects on their own thinking and analyses their planning, time management, and use of appropriate work strategies to complete the task.	Reflects on their own thinking and explains their planning, time management and use of appropriate work strategies to complete the task.	Reflects on their own thinking, with reference to planning and the use of appropriate work strategies.	Reflects on their own thinking with little or no reference to planning, time management, and use of work strategies.



# Earth and Environmental Science

Assessment Task Two: Exam

Year 11 Annotated Tasks and  
Student Work

# Assessment Instrument #2 **ANSWERS**

## Year 11 Earth and Environmental Science T

Department	Science	Year Group	11	Semester	1	Year	
Course Title	Earth and Environmental Science T 2354				Unit Code		
Unit Title	Earth Processes			Value		1.0	
Teacher							
Assessment Instrument # and type	Task 3. Exam		Length – words/time		90 Minutes		
Weighting	30%		Date Due				
<b>Learning Goals</b>		<b>This task will allow students to:</b>					
<ul style="list-style-type: none"> <li>• understand how energy is transferred and transformed in Earth systems, the factors that influence these processes, and the dynamics of energy loss and gain</li> <li>• understand how energy transfers and transformations influence oceanic, atmospheric and biogeochemical cycling</li> <li>• understand how theories and models have developed based on evidence from multiple disciplines; and the uses and limitations of Earth and environmental science knowledge in a range of contexts</li> <li>• communicate Earth and environmental understanding using qualitative and quantitative representations in appropriate modes and genres.</li> </ul>							
<b>The Task</b>							
<p>This is a closed book written test which incorporates:</p> <ul style="list-style-type: none"> <li>• <b>Part A: Multiple Choice Section (1 mark each)</b> _____/20</li> <li>• <b>Part B: Short Answer Section (marks as indicated)</b> _____/56</li> <li>• <b>Part C: Long answer Section (marks as indicated)</b> _____/11</li> <li>• <b>Total marks :</b> _____/87 _____ %</li> </ul> <p>Name : _____</p>							
<b>Assessment Criteria</b>							
<ul style="list-style-type: none"> <li>• concepts, models and application</li> <li>• contexts</li> <li>• Inquiry skills</li> </ul>							
<b>Task Instructions</b>		<p>Material permitted are pen, pencil, calculator, and ruler            Test to be conducted under exam conditions. You must remain seated in silence for the duration of the test. Papers to be handed into class teacher</p>					
<p><b>BSSS policies on the application of penalties</b></p> <p>Penalties will be applied in accordance with ACTBSSS policies for cheating, plagiarism and the late and non-submission of assessment tasks. Information about assessment policies can be accessed in the College <i>Years 11 &amp; 12 Handbook</i> or on the ACTBSSS website.</p>							

## Part A – Multiple Choice Section

20 marks

1 mark per question

Circle the most correct answer

1. Which is **not** one of Earth's major systems?

- a. Atmosphere
- b. Biosphere
- c. Geosphere
- d. **Genosphere**

CMA1 E  
Identifies system component.

2. New oceanic crust is being made along:

- a. Convergent plate boundaries
- b. Destructive plate boundaries
- c. **Divergent plate boundaries**
- d. All of the above

CMA1 D  
Makes a decision about  
system components.

3. Which of the following group of islands has been formed over a mantle plume or hotspot?

- a. Indonesian volcanic islands
- b. Japanese volcanic islands
- c. Caribbean volcanic islands
- d. **Hawaiian volcanic islands**

CMA1 E  
Identifies interactions

4. Compressional forces in the Earth's crust can result in:

- a. Folding
- b. Reverse faulting
- c. Thrust faulting
- d. **All of the above**

CMA1 D  
Decision on effect of factors

## Magnetic Polarity

Questions 5 and 6 relate to Figure 1. below.

5. During geological history, the Earth's magnetic field has undergone numerous reversals of polarity. In the last 10 million years, there have been, on average 3 or 4 reversals per million years.

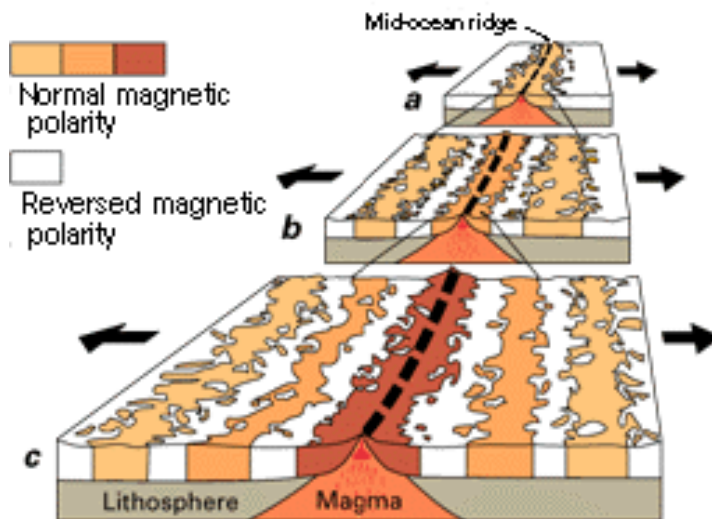


Image source:  
USGS.gov

**Figure 1.** The darker stripes on Figure 1 represent new oceanic crust formed when magnetic polarity was:

- a. Same as present
- b. Opposite to present
- c. In the process of changing
- d. Insufficient information to know which polarity

CMA3 C  
Develops evidence based conclusions.

6. Magnetic polarity striping, as represented by Figure 1, provides evidence of:

- a. Isostasy
- b. Subduction
- c. Sea-floor spreading
- d. All of the above

CMA3  
Explains evidence with reference to models and theories.

7. Two tectonic plates have the following characteristics.

Tectonic plate	% of boundary subducting	% of boundary divergent	Plate speed (cm/year)
1	35.1	32.5	7.5
2	2.4	34.9	1.5

This data is empirical evidence that the main cause of plate motion is:

- a. Mantle convection
- b. Slab pull**
- c. Ridge push
- d. Trench suction

CMA2 C  
Explains application of models using evidence in familiar contexts.

8. Energy from the sun is formed through which process?

- a. Nuclear fission
- b. Nuclear fusion**
- c. Electrical fusion
- d. Electrical synthesis

CMA1 E  
Identifies process.

9. The land warms up faster in the sun and cools faster at night compared with the sea. This is because rock and soil, compared with water, has a:

- a. Higher specific heat value
- b. Lower specific heat value**
- c. Different latent heat of fusion
- d. Different latent heat of vaporisation

CMA1 D  
Describes fundamental properties.

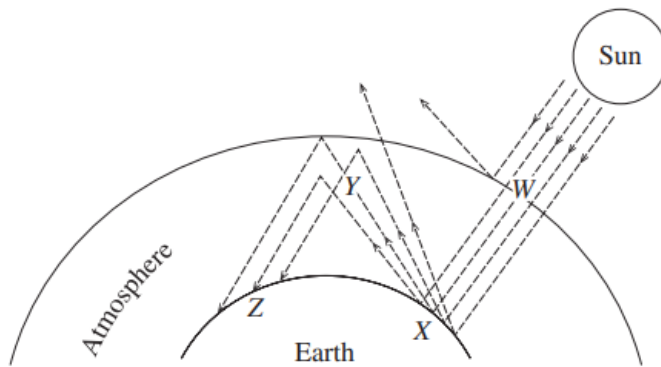
10. Due to the Coriolis Effect, which direction are ocean currents deflected in the Southern Hemisphere?

- a. The right
- b. Straight
- c. **The left**
- d. All of the above

CMA1 D  
Describes fundamental Properties.

11. The diagram shows as model of solar energy transformations occurring in the atmosphere, producing the greenhouse effect.

CMA2 C  
Explains functions of system components, with reference to models using evidence.



KEY

W	X	Y	Z
Solar radiation enters the atmosphere	Majority of solar radiation is absorbed by Earth's surface and then re-emitted as infrared radiation	Some infrared radiation escapes but most is trapped by the atmosphere	Reabsorption of trapped infrared radiation by Earth's surface

Image source:  
Researchgate.

Which statement correctly explains the 'enhanced' greenhouse effect?

- a. Increased melting of ice caps increased the reflection of solar radiation from the surface at X
- b. Increased ozone levels led to greater absorbance of solar radiation by Earth's surface at X
- c. A hole in the ozone layer decreased the solar radiation being reflected by the atmosphere at W
- d. **Increased carbon dioxide levels have increased the trapping of infrared radiation in the atmosphere at Y**

12. Which processes are driven by energy from the sun?

- a. Volcanic eruptions, earthquakes, photosynthesis
- b. Photosynthesis, ocean currents, water cycle
- c. Wind currents, photosynthesis, tectonic plate movement
- d. Ocean currents, Coriolis effect, volcanic eruptions

CMA3 D

Describes evidence and develops conclusions with reference to models and/or theories.

13. If an object has a greater mass than the fluid it can displace, that object is said to have:

- a. Buoyancy
- b. Neutral buoyancy
- c. Negative buoyancy
- d. All of the above

CMA3 D

Develops conclusions with some reference to models and/or theories.

14. The image below shows a weather chart of Australia (for tomorrow).

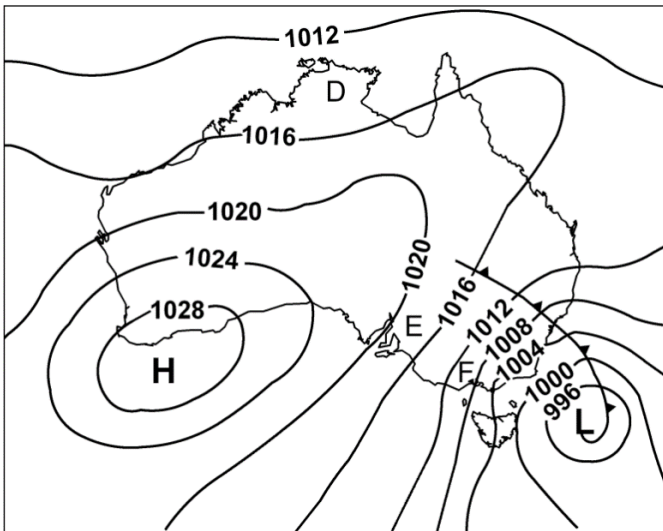


Image source  
Weebly.com

CMA1 C

Explains the functions of a system process and the effect of factors.

What is the weather likely to be tomorrow in Canberra?

- a. Windy and rain likely
- b. No wind, very clear skies
- c. Very hot and windy
- d. No wind and rain likely

15. Which is **not** one of the three primary gases responsible for most of the atmospheric absorption of energy?

- a. Nitrogen (N<sub>2</sub>)
- b. Ozone (O<sub>3</sub>)
- c. Carbon dioxide (CO<sub>2</sub>)
- d. Water vapor (H<sub>2</sub>O)

CMA1 D  
Describes the fundamental properties with some description of system components.

16. Which is **not** a cause of ocean currents:

- a. Winds
- b. Temperature differences
- c. Salinity variations
- d. Polarity of water

CMA1 D  
Describe the fundamental properties, with some description of system components.

17. Each hemisphere contains three cells in which air circulates through the entire depth of the atmosphere. The three cells are:

- a. Hadley, Ferrel, Polar
- b. Hadley, Ferrel, Glacial
- c. Hadley, Glacial, Polar
- d. Ferrel, Glacial, Polar

CMA2 D  
Describes applications of models.

18. Which is not a source for major processes on Earth?

- a. The Sun and sunlight
- b. Geothermal Energy
- c. Radio waves
- d. Rotational Energy

CMA3 D  
Asserts conclusion with some reference to models.

19. What is this image showing?

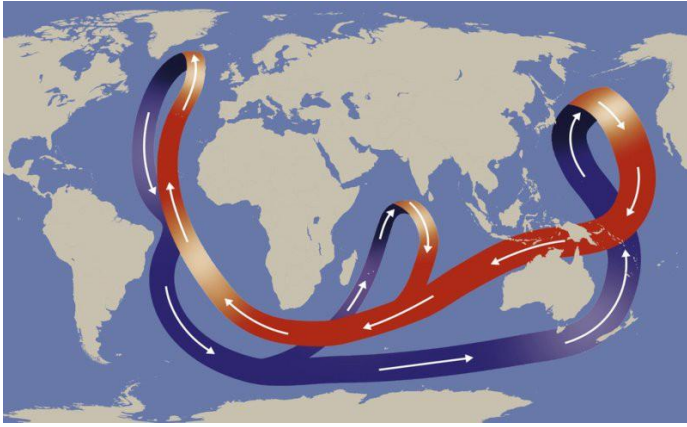


Image source

American  
Oceans.org

CMA2 D  
Develops conclusion with  
some reference to models.

- a. Surface currents of the ocean
- b. Global air movement
- c. Deep ocean currents (thermohaline circulation)
- d. Coriolis force (prevailing westerlies)

20. How are clouds formed?

- a. Warm buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form around condensation nuclei
- b. Cold buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form around condensation nuclei
- c. Warm buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form from condensing water droplets
- d. Cold buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form from evaporation of water droplets

CMA3 C  
Explains evidence with  
reference to models.

## DEVELOPING THE THEORY OF PLATE TECTONICS

21. New scientific theories are often proposed before there is a convincing driving mechanism or before there is strong evidence to show that the theory is correct. **Describe** three pieces of evidence used by Alfred Wegener to support his theory of continental drift. (3 marks)

- Jigsaw fit of continents e.g., Africa and South America (1 mark)
- Fossil and or rock matching between continents (1 mark)
- Glacial deposits and matching climate (e.g., Coal) (1 mark)

CMA3 D  
Describes evidence, and develops conclusions, with some reference to models and/or theories.

22. **Describe** a serious weakness in Alfred Wegener's theory when he proposed it in 1912. (2 marks)

- No convincing mechanism to move continents
- All evidence relates to ancient movement, not current
- No age dating to support other evidence

CMA3 B  
Assess evidence with reference to models and/or theories and develops evidence-based conclusions and discusses limitations.

(1 mark for weakness stated, 1 mark for description of weakness)

23. **Explain** how measuring the paleomagnetism in basalt provided evidence that the seafloors were spreading either side of mid-ocean ridges. (3 marks)

Reasoned answer:

**Magnetite crystals align** with the Earth's magnetic field. Magnetite in sea floor basalt produced magnetic striping as the **Earth's magnetic field switched** from normal to reverse and this striping is **symmetrical** either side of the mid ocean ridges. This can only be explained by new crust being formed at mid-ocean ridges and the sea floor spreading.

CMA3 C  
Explains evidence with reference to models and/or theories, and develops evidence based conclusions

## AUSTRALIA

CMA1 B  
Analyses the fundamental properties and functions of system processes.

24. Eastern Australia has been travelling over a series of hot spots that have left basaltic volcanic rocks scattered along the Great Dividing Range.

Mt Kaputar in northern NSW is a basaltic shield volcano that erupted about 18 million years ago and Mt Canobolas in NSW is a basaltic shield volcano that erupted about 12 million years ago. The two mountains are 380 km apart.

**Analyse** this data to:

**Calculate the speed** (in centimetres per year or cm/year) and **state the movement direction** of the Australian continent. (3 marks)



Speed = distance/ time

Speed = 380km/6 million

=63.3km/my (1 mark)

=6,333,333cm/1000000 yr

=6.3cm/yr (1 mark)

Direction: NE (1 mark) or North (½ mark)

## WHAT DRIVES PLATE TECTONICS?

Cross-section of a subduction zone with rock densities in  $\text{g/cm}^3$ .

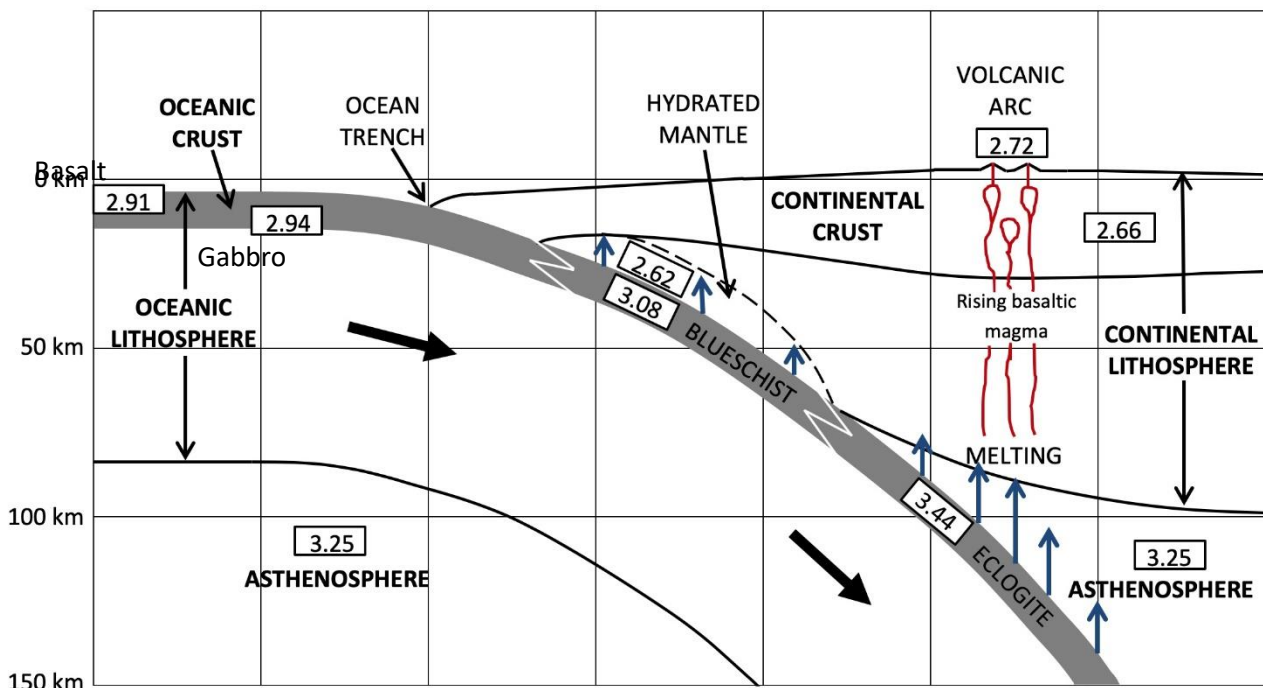


Image source:  
Australian Science  
Teachers  
Association.edu.au

**25. Justify** why the metamorphism of basalt and gabbro in oceanic crust to blueschist and then eclogite is a probable cause for subducted plates descending into the mantle (a mechanism called slab pull). (3 marks)

Can include:

The metamorphism of basalt and gabbro to blueschist and eclogite increases its density from  $2.9\text{g/cm}^3$  to  $3.1\text{g/cm}^3$  and then to  $3.4\text{g/cm}^3$ . **(1 mark).**

This then causes the descending plate to be denser than the asthenosphere ( $3.2\text{g/cm}^3$ ) so that it has **negative buoyancy (1 mark).**

So, the subducted plate sinks into the asthenosphere pulling the rest of the plate along with it. **(1 mark).**

CMA3 B  
Assesses evidence with  
reference to models and  
develops evidence based  
conclusions.

## PLATE MOVEMENT AND TYPES OF PLATE BOUNDARIES

26. The symbols opposite represent different types of plate boundaries. The diagram below represents several crustal plates moving in the direction indicated by the arrows.

Add these symbols to the diagram to indicate the type of plate boundaries that exists between the plates for **four** plate boundaries. (2 marks)

CMA3 B  
Assesses evidence with reference to models and develops evidence based conclusions.

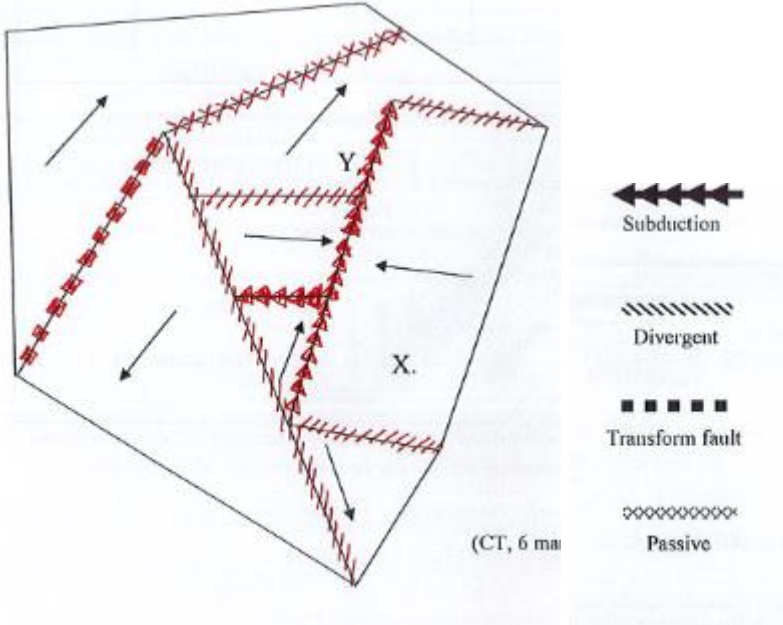


Image source unknown

### Volcanoes X and Y

27. Identify the type of volcano that forms in location X and location Y (2 marks)

Explain what would cause the volcanoes to form in each location? (2 marks)

CMA3 C  
Explains evidence with reference to models and/or theories, and develops evidence based conclusions.

Volcano X.

A hot spot volcano (1 mark).

The plate travels over a mantle plume or an area under the crust where magma is hotter than surrounding magma, forming a volcano. (1 mark)

Volcano Y.

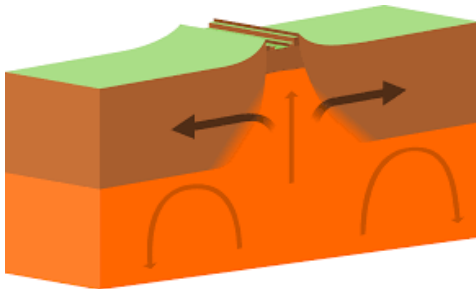
A convergent margin, subduction zone volcano (1 mark)

This type of volcano occurs in a subduction zone due to water released due to metamorphism of the descending plate (1 mark).

**28. Draw** a cross section of **two** tectonic plate boundary types (2 marks)  
**State** the geological features that occur at these boundaries (2 marks)  
**Identify** a location where each boundary is found (2 marks)

CMA1 D  
 Describes fundamental properties and functions of system components, processes and interactions.

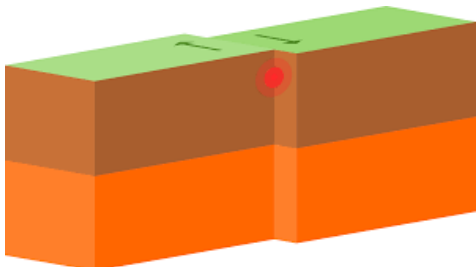
**Divergent Boundary diagram: (1 mark)**



Features present: **mid ocean ridges and rift valleys (1 mark)**

Location where boundary is found **e.g. East African Rift Valley (1 mark)**

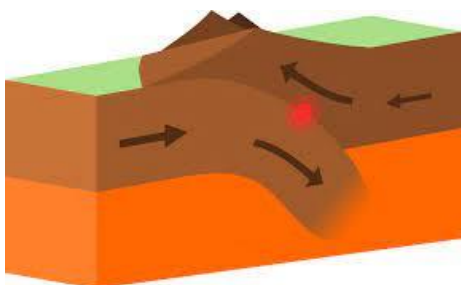
**Transform Boundary diagram:**



Features present: **earthquakes**

Location where boundary is found **e.g. San Andres Fault Zone**

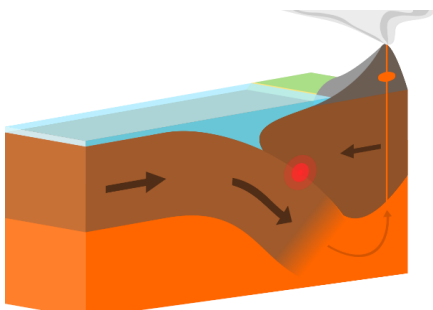
**Convergent Boundary (continent/continent):**



Features present: **some earthquakes, no volcanoes, mountains**

Location where boundary is found **India Plate with the Eurasian Plate, creating the Himalaya Mountains**

**Convergent Boundary (oceanic & continental):**



Features present: **volcanoes, earthquakes**

Location where boundary is found **e.g. Andes Mountain Range of Western South Aeric**

Image source  
 Wikipedia.org

29. The Wilson Cycle describes a cycle of supercontinents breaking up (1), moving further apart as oceans widen (2), the development of subduction zones (3), the ocean narrowing (4), collision (5) and reforming the supercontinent (6). Australia separated from Antarctica about 45 million years ago.

CMA1 D (Part a)  
Describes fundamental properties.

(a) What stage in the Wilson Cycle best describes the current state of Australia and Antarctica? (1 mark)

Stage 2 (1 mark)

(b) State locations in the modern world where the following stages are occurring. (2 marks)

Stage 3:

e.g. Pacific coast and S. America or Atlantic/Caribbean or Mid-Atlantic ridge (N. America and Africa) or Iceland (1 mark)

Stage 5:

Himalayas or S.Europe, or PNG (1 mark)

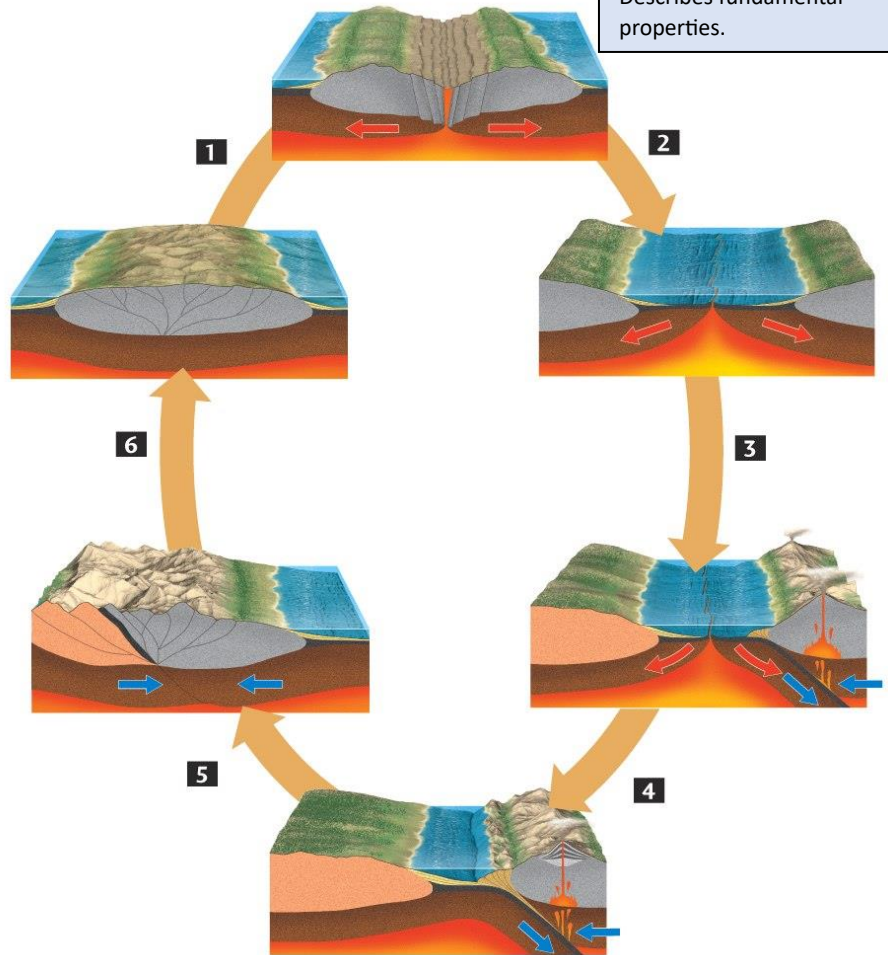


Image source  
Quizlet.com

CMA3 C (Part b)  
Explains evidence with reference to models, and develops evidence based conclusions.

## WEATHER AND CLIMATE

CMA1 D  
Describes fundamental properties, functions and interactions.

**30. List 4 factors that affect the average temperature of a location. (2 marks)**

Latitude/insolation; distance from the sea; prevailing winds, altitude, ocean currents, aspect (slope of ground), Earth's orbit and tilted Earth's axis with more direct light at equator and less at poles. **(1/2 mark each to max of 2 marks)**

CMA1 C  
Explains the fundamental properties and functions of system components.

**31. Explain the **difference** between weather and climate? Include an example of weather data and climate data in your answer. (2 marks)**

Weather- fluctuating short-term state of the atmosphere, short term (up to a few days), small area e.g. Today's temperature, humidity or rainfall

Climate- the average weather over a long time span (30 years) for a region. E.g. Canberra's average temperature or rainfall

**½ mark** for explaining what weather is

**½ mark** for providing an example of weather

**½ mark** for explaining what climate is

**½ mark** for providing an example of climate

## GLOBAL CLIMATE

The Intertropical Convergence Zone (ITCZ) is located where the Sun is directly overhead at midday. In spring and autumn, the ITCZ is close to the Equator. The ITCZ migrates north of the Equator during the Southern Hemisphere winter and south of the Equator during the Southern Hemisphere summer.

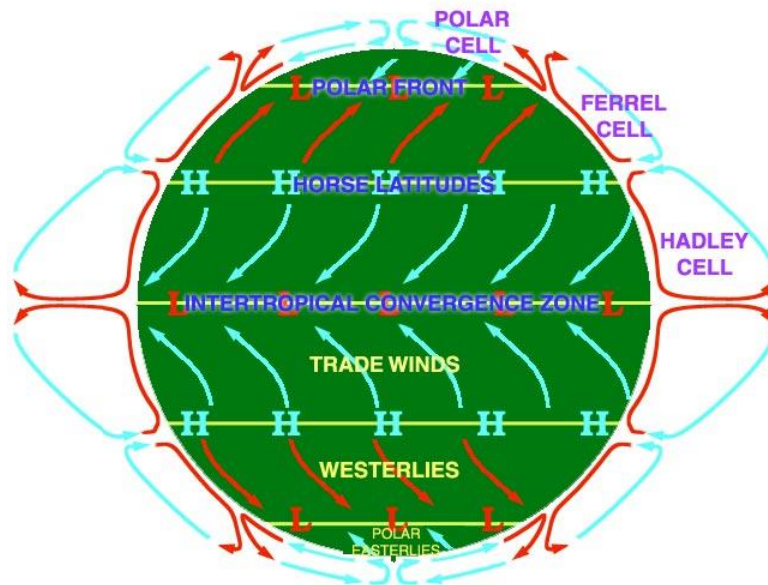


Image source  
Wikipedia.org

**32. Explain** why a low-pressure zone develops at the ITCZ? (3 Marks)

CMA1 C  
Explains the fundamental properties and functions of system components.

The ITCZ usually has the sun's light hits more directly, so it receives maximum solar energy per unit of area, which heats the air above by conduction (1 mark). Hot air is less dense and positively buoyant (1 mark), so it rises causing low pressure (1 mark).

**33. Analyse** how tropical heat is redistributed towards the poles and evaluate why this is important for life on Earth. (4 marks)

CMA1 B  
Analyses the fundamental properties and functions of system components, processes and interactions, and the effects of factors.

**2 marks:**

-air currents in Hadley, Ferrel and Polar cells

-surface ocean currents e.g. Eastern Australian Current (EAC), Gulf stream, Kuroshio

-Global ocean conveyor

**2 marks:**

Makes temperatures less extreme, tropics cooler and liveable, polar regions warmer and liveable. Also, ocean conveyor takes nutrients and moves them from one area to another which make nutrients available for living things.

## Southern Oscillation Index (SOI) & El Niño and La Niña

CMA1 B  
Analyses the fundamental properties and functions of system components, processes and interactions, and the effects of factors.

### 34. Compare and Contrast El Niño and La Niña (4 marks)

El Niño associated with warming of central and eastern tropical Pacific, while La Niña events are the reverse, with sustained cooling in the same areas.

Both are changes in the Pacific Ocean and are known as El Niño-Southern Oscillation (ENSO)

Occurs in the Pacific Ocean between South America and Australia

Both driven by trade winds

La Niña occurs when trade winds are stronger, pushing warm water towards Australia, there is more rainfall and lower temperatures in Australia as a result

El Niño occurs when trade winds weaken or are reversed- warm water is pushed towards South America causing higher rainfalls in South America while in Australia there is low rainfall, drought, and increased bushfires.

**1 mark for each similarity and difference (need to have both similarities and differences)**

## CLIMATES, BIOMES AND ECOSYSTEMS

A, B and C are three locations in Australia: A is in the Northern Territory, B is in South Australia and C is in Western Australia. Their average annual temperature and average annual rainfall are given below.

CMA3 B

Assess evidence with reference to models and/or theories, and develops evidence based conclusions.

- A. NT, 27°C 106cm
- B. SA 19°C 22cm
- C. WA 15°C 54cm

35. Plot A, B and C on the graph and then state the Australian biome in which each belongs. (3 marks)

Biomes:

A: Tropical seasonal forest/ savannah (1)

B: Temperate grassland/cold desert (1)

C: Woodland/shrubland (1)

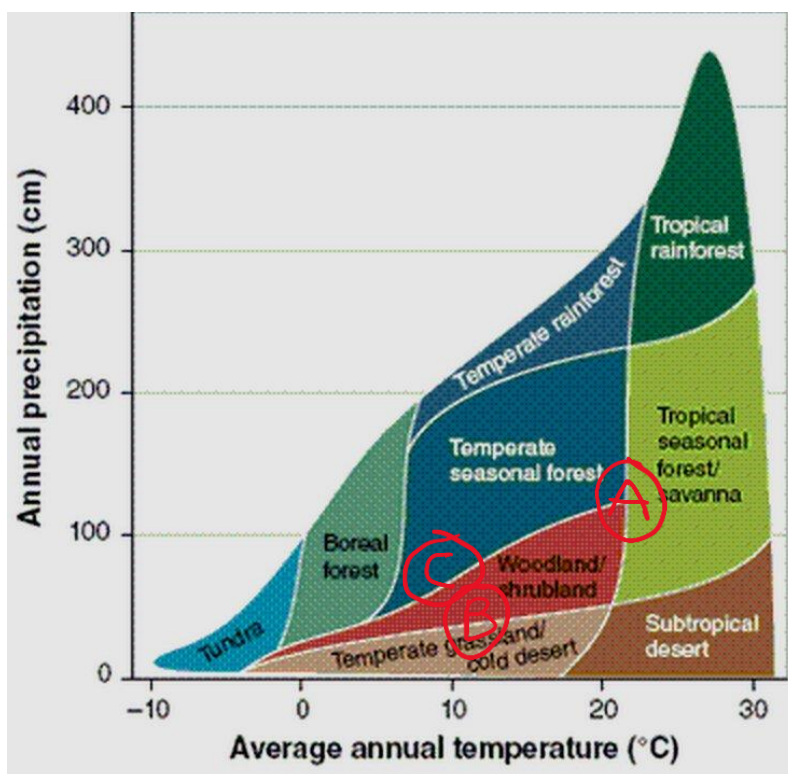


Image source

Australian Plant Society.com.au

36. Evaluate which location (A, B or C) is likely to have ecosystems with the highest Net Primary Productivity (abundance of life) and biodiversity? Justify your answer by referring to biotic and abiotic factors. (4 marks)

Example: A would probably have the highest NPP and diversity because it would have high levels of solar energy of light and heat combined with the highest rainfall. Increase in abiotic resources means more growth/biomass from photosynthesis so most plants, herbivores carnivores and decomposers.

1 mark- ecosystem A selected

1 mark each point justified, refers to biotic and abiotic factors.

CMA1 A

Analyses evidence with reference to models and/or theories and develop evidence-based conclusions and evaluates limitations.

37. This is an energy pyramid showing how energy moves in this ecosystem.

CMA1 E  
Identifies fundamental property.

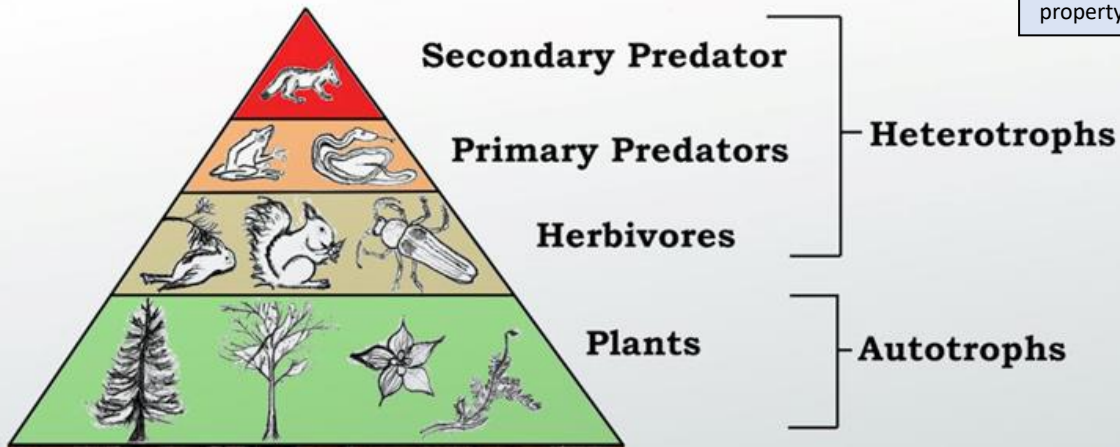


Image source  
Wikipedia.org

a) Identify the source of energy for this energy pyramid and ecosystem (1 mark)

The Sun

b) Analyse how energy is lost as you go up the energy pyramid. (4 marks)

Energy is lost as you go up the food chain from respiration, for Kinetic energy from movement, for digestion and reproduction.

CMA2 B  
Analyses the applications of theories and models using evidence.

Or

Energy decreases as it moves up trophic levels as energy is lost as metabolic heat when organisms from one level are consumed by organisms from the next level.

(1 mark)

As heat to the environment (1 mark)

To decomposition and decomposers (1 mark)

About 10% of the initial energy is now available for next consumer (1 mark)

**Part C – Long Answer Section**

**(11 marks)**

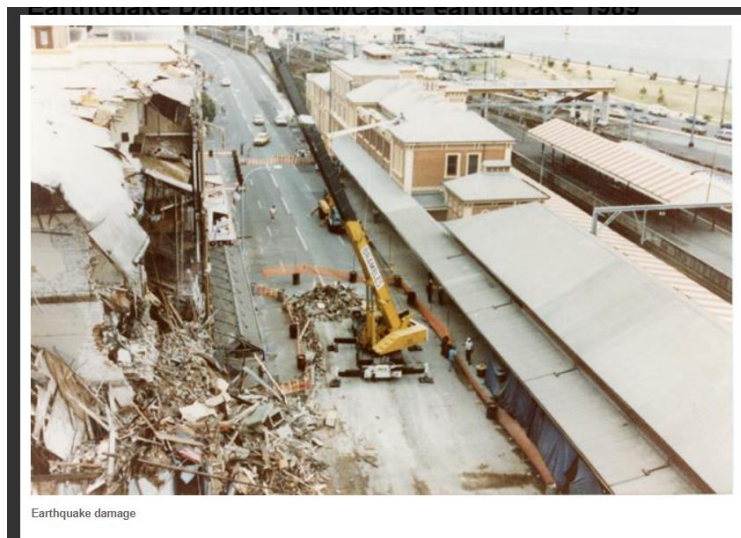
**38. Explain** why high magnitude earthquakes such as the 1989 Newcastle earthquake are rare on mainland Australia (2 marks).

High magnitude earthquakes usually occur on tectonic plate boundaries (1 mark)

There are no tectonic plate boundaries within the Australian continent (1 mark)

CMA3 C  
Explains evidence with reference to models and develops evidence based conclusions

**39. Evaluate** the economic, social, and environmental implications of strengthening Australia's precautions against earthquake hazards (9 marks).



Raymond King, Earthquake Damage: Newcastle earthquake 1989 Hunter Street, 1989, Hunter Photo, BankNewcastle Libraries, No. 583 000003

C2 A  
Evaluates the influence of social and economic factors on Science.

1 mark	Introduction – identify the subject area and define the criteria or standards against which the subject will be evaluated.
2 marks	<p>Paragraph on <b>economic implications</b></p> <p>Presents ideas in a clear, coherent manner with a well-structured argument and logical flow. Provides examples and evidence to support analysis.</p> <p>For example: upfront costs, long-term savings, insurance implications, and economic stability.</p>
2 marks	<p>Paragraph on <b>social implications</b></p> <p>Presents ideas in a clear, coherent manner with a well-structured argument and logical flow. Provides examples and evidence to support analysis.</p>

	For example: public safety, community resilience, and equity considerations or other examples. Offers insights into how strengthening precautions can promote social cohesion.
2 marks	<p>Paragraph on <b>environmental implications</b></p> <p>Presents ideas in a clear, coherent manner with a well-structured argument and logical flow. Provides examples and evidence to support analysis.</p> <p>For example: resource consumption, sustainable design practices, and potential interactions with other natural hazards.</p>
1 mark	Draw reasoned conclusion and provide recommendations or judgement based on evaluation.
1 mark	Correct use of scientific terminology

**END OF TEST**

### Score and Grade Matrix for Best Fit grade Judgement

	A	B	C	D	E
1					1
2				1	
3					1
4				1	
5			1		
6			1		
7			1		
8					1
9				1	
10				1	
11			1		
12				1	
13				1	
14			1		
15				1	
16				1	
17				1	
18				1	
19				1	
20			1		
21 /3				3-2	1
22 /2		2	1		
23 /3			3	2	1
24 /3		3	2-1		
25 /3		3	2	1	
26 /2		2-1.5	1		
27 /4			4-3	2-1	
28 /6				6-4	3-1
29 a /1				1	
29 b /2			2	1	
30 /2				2-1.5	1
31 /2			2	1	
32 /3			3-2	1	
33 /4		4-3	2-1		
34 /4	4-3.5	3	2-1		
35 /3		3-2	1		
36 /4	4	3	2-1		
37a /1					1
37b /4		4	3	2-1	
38 /2			2	1	
39 /9	9-7	6-5	4-3	2-1	

### Weighting of questions according to maximum grade achievable

A	B	C	D	E
17	21	22	23	4

Outstanding	Coverage of BSSS Accredited Courses	High	Reliability
Outstanding	Bias Awareness	Outstanding	Levels of Thinking
Outstanding	Student Engagement	Outstanding	Academic Integrity

### 1. Coverage of BSSS Accredited Courses

Outstanding Coverage of BSSS Accredited Courses – Assessment tasks are strategically planned for alignment with Achievement Standards, unit goals and content descriptors. Assessments are not too big: assessing irrelevant content or criteria; nor too small: missing important content or criteria

**Comments:** The task presents an integrated coverage of both knowledge, skills and understanding without being overly lengthy or assessing irrelevant content. The general capabilities and cross curriculum priorities are integrated into the assessment. The task is well structured and scaffolds questions to enhance accessibility for students.

### 2. Reliability

High Reliability – Assessment tasks and marking are thoughtfully designed to remove large variation in measurements except for the key knowledge, skills and understanding of the student in the unit.

**Comments:** The task instructions and questions/possible options are clear for students. The questions cover a broad range of course material allowing measurement of knowledge, skills and understanding.

### 3. Bias Awareness

High Bias Awareness - The suite of assessment tasks is designed that promote the diverse needs of gender, socio-economic status, disabilities and/or cultures, and that do not marginalise or favour a student or group of students, or advantage or disadvantage certain background knowledge or ways of thinking.

**Comments:** Bias is determined across the suite of tasks in a portfolio; hence no individual task will be rated outstanding. However, there are no identifiable sources of bias in the task, it is accessible to students from a wide range of backgrounds and has no special requirements that would favour one group of students over another. The variety of multiple choice, short and extended response questions supports different learning styles.

#### 4. Levels of Thinking

High Levels of Thinking – Clear assessment tasks are designed that allow students to engage at progressively higher cognitive demands. The suite of assessments demonstrates that there are expectations for all learners at all levels of learning and opportunities for extending all learners are planned for. Assessment tasks are flexible and varied, covering a range of assessment modes.

**Comments:** The task provides sufficient scaffolding to allow students at the D/E level to demonstrate what they are capable of, while presenting opportunities for A level students to extend themselves. The verbs are carefully chosen to reflect cognitive demands, guided by Bloom’s taxonomy to support the required level of thinking.

#### 5. Student Engagement

High student Engagement – Assessment tasks are strategically planned to engage students. Assessment tasks are explicitly and purposefully connected to contemporary issues or student lived experiences, interests, or prior knowledge. The suite of assessment tasks clearly supports student ownership.

**Comments:** Success and what is being asked of the student in all aspects of the tasks are clear from the instructions. There are range of interesting questions that engage with contemporary issues and illustrations to engage attention and aid in comprehension.

#### 6. Academic Integrity

Outstanding Academic Integrity - Students are required to engage in genuine deep learning at a level of challenge appropriate to the student and tasks make provision for sense making or knowledge construction. Assessment is designed to ensure authenticity from students and requires individualised responses.

**Comments:** This is an exam under test conditions. The summative nature of the test allows for preparation. However, with non-routine problems in the A and B grade questions, both requires students to provide answer that have not been pre-learned. Assessment is designed to encourage original thinking from students and require individualised responses that will be different.



# Earth and Environmental Science

Assessment Task Two: Exam

Student Work: A Grade Script

Year 11 Annotated Tasks and  
Student Work

## Part A – Multiple Choice Section

20 marks

1 mark per question

Circle the most correct answer

1. Which is **not** one of Earth's major systems?

- a) Atmosphere
- b) Biosphere
- c) Geosphere
- d) Genosphere



CMA1 E  
Identifies system  
component.

2. New oceanic crust is being made along:

- a) Convergent plate boundaries
- b) Destructive plate boundaries
- c) Divergent plate boundaries
- d) All of the above



CMA1 D  
Makes a decision about  
system components.

3. Which of the following group of islands has been formed over a mantle plume or hotspot?

- a) Indonesian volcanic islands
- b) Japanese volcanic islands
- c) Caribbean volcanic islands
- d) Hawaiian volcanic islands



CMA1 E  
Identifies interactions

4. Compressional forces in the Earth's crust can result in:

- a) Folding
- b) Reverse faulting
- c) Thrust faulting
- d) All of the above



CMA1 D  
Identifies correct factors

## Magnetic Polarity

Questions 5 and 6 relate to Figure 1. below.

5. During geological history, the Earth's magnetic field has undergone numerous reversals of polarity. In the last 10 million years, there have been, on average 3 or 4 reversals per million years.

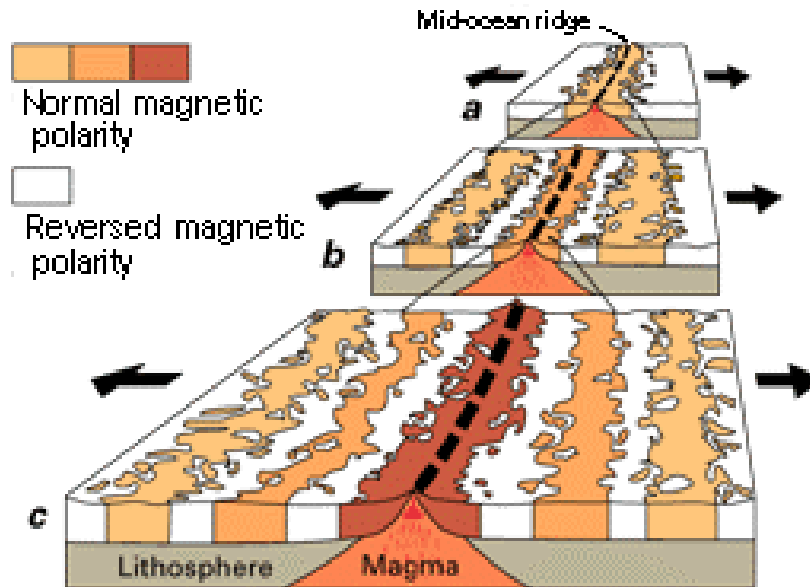


Figure 1.

The darker stripes on Figure 1 represent new oceanic crust formed when magnetic polarity was:

- a) Same as present
- b) Opposite to present
- c) In the process of changing
- d) Insufficient information to know which polarity

CMA3 C  
Develops evidence based conclusions.

6. Magnetic polarity striping as represented by Figure 1, provides evidence of:

- a) Isostasy
- b) Subduction
- c) Sea-floor spreading
- d) All of the above

CMA3 C  
Explains evidence with reference to models and theories.

7. Two tectonic plates have the following characteristics.

Tectonic plate	% of boundary subducting	% of boundary divergent	Plate speed (cm/year)
1	35.1	32.5	7.5
2	2.4	34.9	1.5

This data is empirical evidence that the main cause of plate motion is:

- a) Mantle convection
- b) Slab pull ✓
- c) Ridge push
- d) Trench suction

CMA2 C  
Explains application of models using evidence in familiar contexts.

8. Energy from the sun is formed through which process?

- a) Nuclear fission
- b) Nuclear fusion ✓
- c) Electrical fusion
- d) Electrical synthesis

CMA1 E  
Identifies process.

9. The land warms up faster in the sun and cools faster at night compared with the sea. This is because rock and soil, compared with water, has a:

- a) higher specific heat value
- b) a lower specific heat value ✓
- c) different latent heat of fusion
- d) different latent heat of vaporisation

CMA1 D  
Describes fundamental properties.

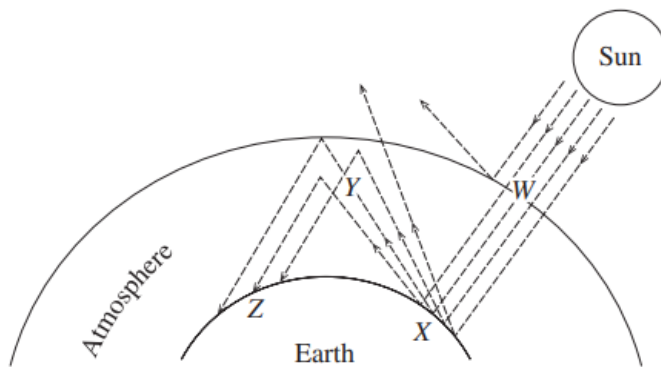
10. Due to the Coriolis Effect, which direction are ocean currents deflected in the Southern Hemisphere?

- a) The right
- b) Straight
- c) The left
- d) All of the above



CMA1 D  
Describes fundamental properties.

11. The diagram shows a model of solar energy transformations occurring in the atmosphere, producing the greenhouse effect.



KEY

W	X	Y	Z
Solar radiation enters the atmosphere	Majority of solar radiation is absorbed by Earth's surface and then re-emitted as infrared radiation	Some infrared radiation escapes but most is trapped by the atmosphere	Reabsorption of trapped infrared radiation by Earth's surface

CMA2 C  
Explains functions of system components, with reference to models, using evidence.

Which statement correctly explains the 'enhanced' greenhouse effect?

- a) Increased melting of ice caps increased the reflection of solar radiation from the surface at X
- b) Increased ozone levels led to greater absorbance of solar radiation by Earth's surface at X
- c) A hole in the ozone layer decreased the solar radiation being reflected by the atmosphere at W
- d) Increased carbon dioxide levels have increased the trapping of infrared radiation in the atmosphere at Y



12. Which processes are driven by energy from the sun?

- a) Volcanic eruptions, earthquakes, photosynthesis
- b) Photosynthesis, ocean currents, water cycle
- c) Wind currents, photosynthesis, tectonic plate movement
- d) Ocean currents, Coriolis effect, volcanic eruptions

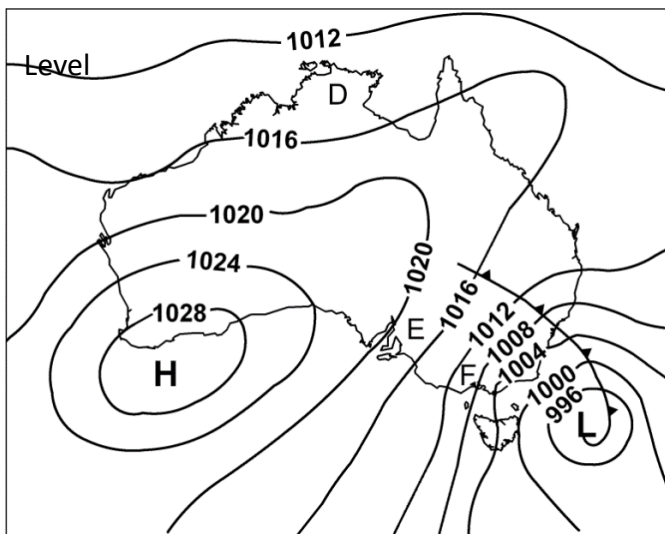
CMA3 D  
Describes evidence and develops conclusions with reference to models and/or theories.

13. If an object has a greater mass than the fluid it can displace, that object is said to have:

- a) Buoyancy
- b) Neutral buoyancy
- c) Negative buoyancy
- d) All of the above

CMA3 D  
Develops conclusions with some reference to models and/or theories.

14. Here is a weather chart of Australia for tomorrow. Luckily you study Earth and Environmental Science and can explain what it means to your friend.



CMA2 C.  
Incorrect response

What is the weather likely to be like tomorrow in Canberra?

- a) Windy and rain likely
- b) No wind, very clear skies
- c) Very hot and windy
- d) No wind and rain likely

15. Which is **not** one of the three primary gases responsible for most of the atmospheric absorption of energy?

- a) Nitrogen (N<sub>2</sub>)
- b) Ozone (O<sub>3</sub>)
- c) Carbon dioxide (CO<sub>2</sub>)
- d) Water vapor (H<sub>2</sub>O)

✓

CMA 1 D  
Describes the fundamental properties with some description of system components.

16. Which is **not** a cause of ocean currents:

- a) Winds
- b) Temperature differences
- c) Salinity variations
- d) Polarity of water

✓

CMA 1 D  
Describes the fundamental properties, with some description of system components.

17. Each hemisphere contains three cells in which air circulates through the entire depth of the atmosphere. The three cells are:

- a) Hadley, Ferrel, Polar
- b) Hadley, Ferrel, Glacial
- c) Hadley, Glacial, Polar
- d) Ferrel, Glacial, Polar

✓

CMA 2 D  
Describes applications of models.

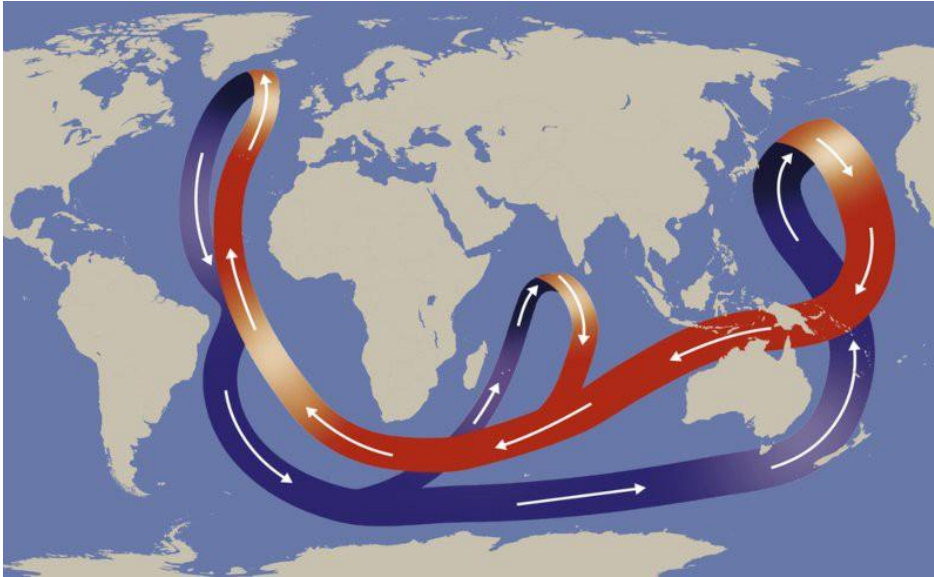
18. Which is not a source for major processes on Earth?

- a) The Sun and sunlight
- b) Geothermal Energy
- c) Radio waves
- d) Rotational Energy

✓

CMA 3 D  
Asserts conclusion with some reference to models.

19. What is this image showing?



CMA 2 D  
Develops conclusion with  
some reference to models.

- a) Surface currents of the ocean
- b) Global air movement
- c) Deep ocean currents (thermohaline circulation)
- d) Coriolis force (prevailing westerlies)

✓

20. How are clouds formed?

- a) Warm buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form around condensation nuclei
- b) Cold buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form around condensation nuclei
- c) Warm buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form from condensing water droplets
- d) Cold buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form from evaporation of water droplets

✓

CMA 3 C  
Explains evidence with  
reference to models.

**DEVELOPING THE THEORY OF PLATE TECTONICS**

21. New scientific theories are often proposed before there is a convincing driving mechanism or before there is strong evidence to show that the theory is correct. **Describe** three pieces of evidence used by Alfred Wegener to support his theory of continental drift. (3 marks)

*Continents fit like puzzle pieces ✓*

*Fossil records ✓*

*Rock types 1/2*

*2.5*

CMA 3 D  
Describes evidence used to develop conclusions. Answer could be improved by matching rocky types with structural similarities  
2.5 of 3 marks

22. **Describe** a serious weakness in Alfred Wegener’s theory when he proposed it in 1912. (2 marks)

*He had no evidence as to how the continents were moving. He believed that the spinning of Earth provided enough force to move the continents. This was debunked immediately, but his theory was still considered. ✓*

CMA 3 B  
Assesses evidence regarding the Plate Tectonic model  
2 of 2 marks

23. **Explain** how measuring the paleomagnetism in basalt provided evidence that the seafloors were spreading either side of mid-ocean ridges. (3 marks)

*At ocean ridges, the iron in basalt was magnetised in a way that showed the changing polarity of the Earth. At midocean ridges where new crust is formed, the new basalt is characterised by the Earth’s current magnetic state, when the polarity of Earth changes, so does the new rock, this creates bands of changing basalt over time. The mirrored bands of rock, with changing magnetic properties, provide evidence that over time the sea floor has been spreading.*

CMA 3 C  
Explains evidence demonstrating an understanding of the model.  
3 of 3 marks

## AUSTRALIA

24. Eastern Australia has been travelling over a series of hot spots that have left basaltic volcanic rocks scattered along the Great Dividing Range.

Mt Kaputar in northern NSW is a basaltic shield volcano that erupted about 18 million years ago and Mt Canobolas in NSW is a basaltic shield volcano that erupted about 12 million years ago. The two mountains are 380 km apart.

Analyse this data to:

Calculate the speed (in centimetres per year or cm/year) and state the movement direction of the Australian continent. (3 marks)



Moved 380Km in 6 million years.

$$380/6 = 63.33\text{Km/million years}$$

$$63.33/1000 = 0.6333 \text{ M/1000 years}$$

$$63\text{cm}/100 \text{ years}$$

$$0.63 \text{ cm/year}$$

$$\text{Speed} = 0.63\text{cm/year} (63\text{mm/year})$$

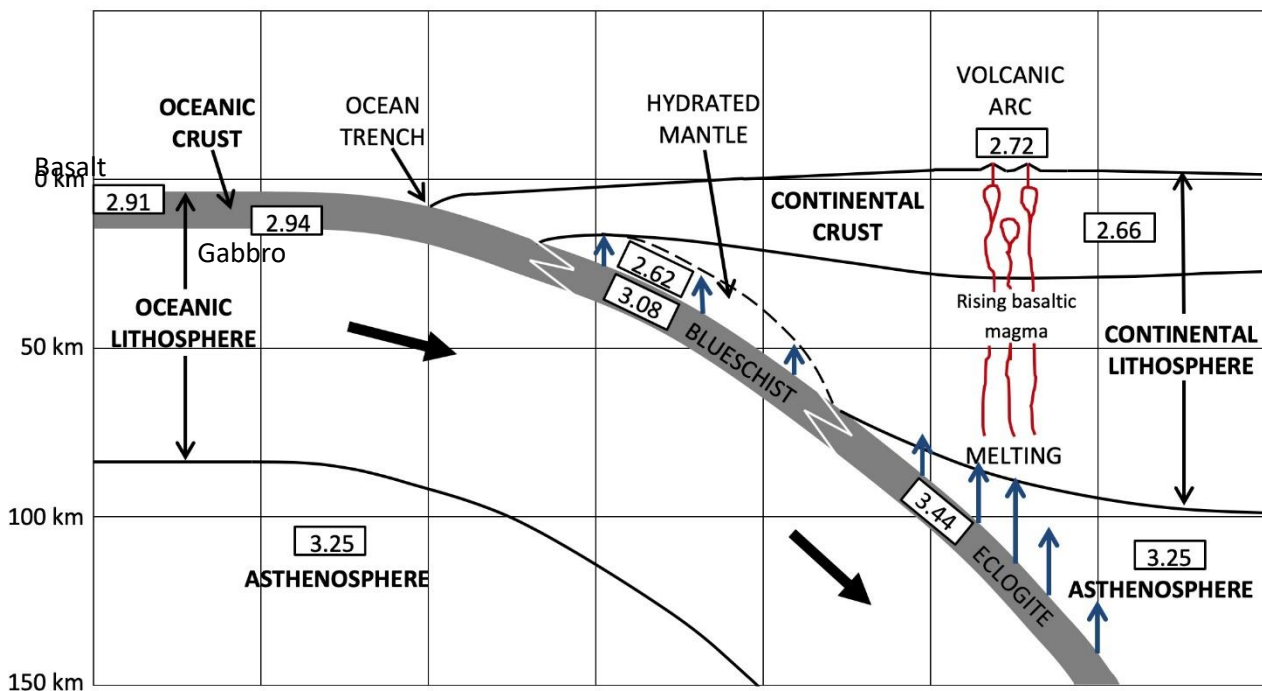
$$\text{Direction} = \text{Southwest}$$

CMA1 B  
D achieved - utilises the information system to complete some of calculations but minor errors.

1 of 3 marks

## WHAT DRIVES PLATE TECTONICS?

Cross-section of a subduction zone with rock densities in  $g/cm^3$ .



**25. Justify** why the metamorphism of basalt and gabbro in oceanic crust to blueschist and then eclogite is a probable cause for subducted plates descending into the mantle (a mechanism called slab pull). (3 marks)

*The rock has metamorphosed so that eclogite is the densest (3.44) followed by blueschist (3.08) and then gabbro (2.94) and basalt (2.91). The rocks follow a pattern from least dense (right) to most dense (left). The rock with the highest density is going to subduct because it's the heaviest (eclogite). This in turn is pulling along the rest of the crust down into the mantle. This demonstrates slab pull. All the rocks especially eclogite is denser than the continental crust (2.66). Further eclogite is dense enough to sink below the asthenosphere (3.25).*

3

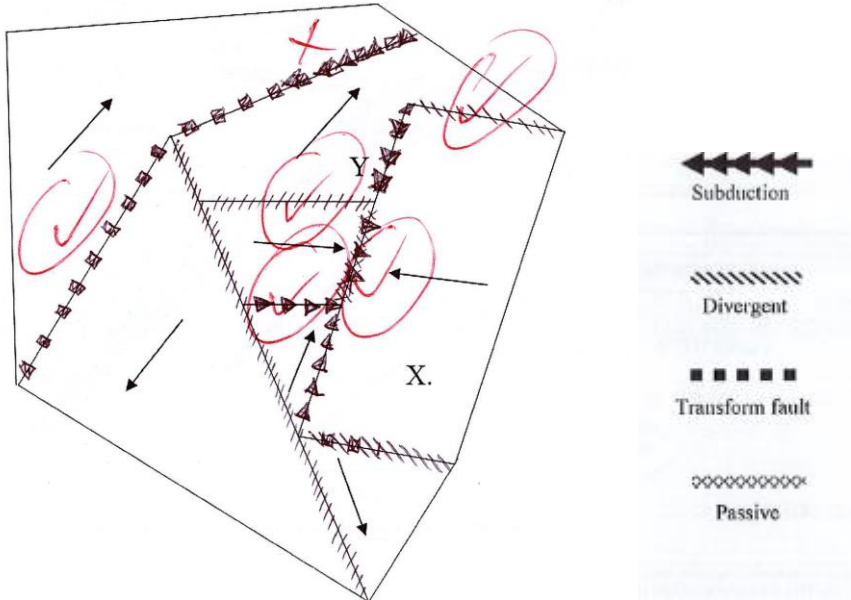
CMA 3 B  
Assesses evidence and  
analyses data to support  
conclusion.

3 of 3 marks

**PLATE MOVEMENT AND TYPES OF PLATE BOUNDARIES**

26. The symbols opposite represent different types of plate boundaries. The diagram below represents several crustal plates moving in the direction indicated by the arrows.

**Add these symbols to the diagram** to indicate the type of plate boundaries that exists between the plates for **four** plate boundaries. (2 marks)



CMA3 B  
 Analyses the information showing an understanding of plate movement models. Minor error does not detract sufficiently from band judgement.  
 2 of 2 marks

**Volcanoes X. and Y**

27. **Identify** the type of volcano that forms in location X and location Y (2 marks)

**Explain** what would cause the volcanoes to form in each location (2 marks)

<p>Volcano X.</p> <p><i>In the middle of the plate- would form due to a hotspot. Would probably be quite shallow – wide rather than taller, due to the less pressure, rather than at convergent boundaries.</i></p> <p><i>-not very active</i></p>
<p>Volcano Y.</p> <p><i>On the edge and probably formed at a convergent plate where one plate was subducted. The subduction caused a lot of pressure pushing magma up forming the volcano. Would be taller because of this pressure. Active site at the time of its emergence and probably still active because of its position and plates still rubbing together.</i></p>

CMA3 C  
 Analysed the evidence to make valid conclusions.  
 4 of 4 marks

28. **Draw** a cross section of **two** tectonic plate boundary types (2 marks)  
**State** the geological features that occur at these boundaries (2 marks)  
**Identify** a location where each boundary is found (2 marks)

**Divergent Boundary diagram:**



Features present: *mid ocean ridges, black smokers, round rocks, valleys*

Location where boundary is found: *East African Rift Valley*

**Transform Boundary diagram:**



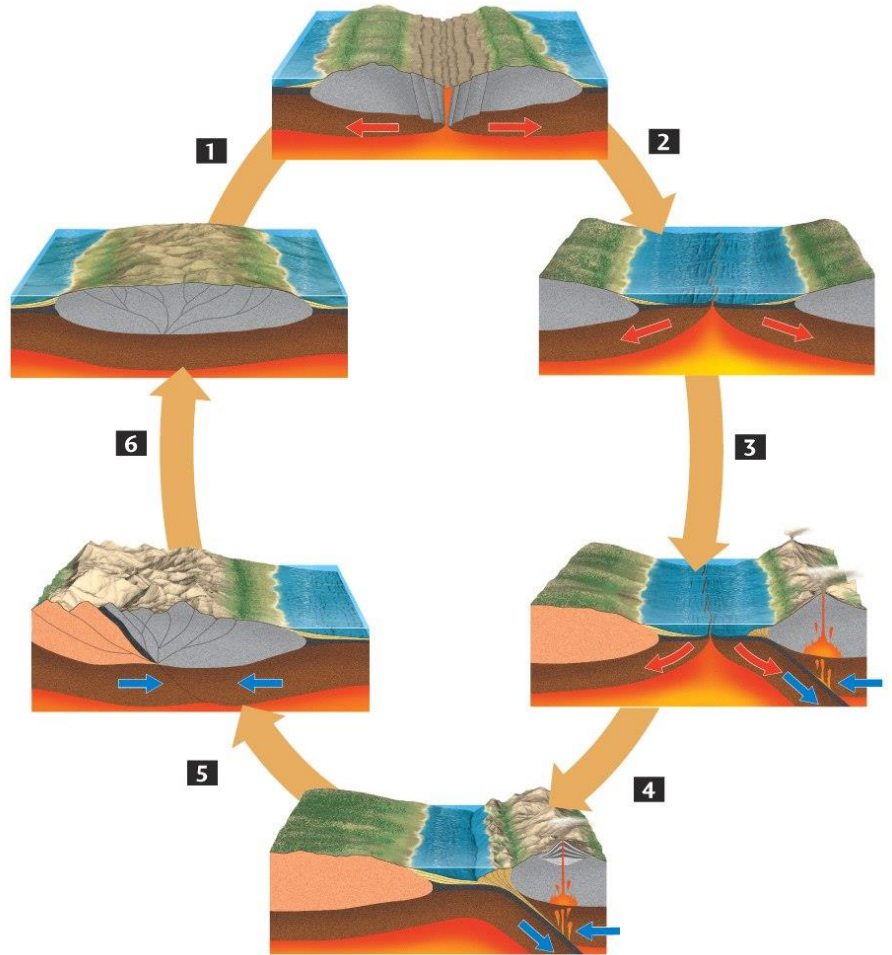
Features present: *earthquakes, fault lines, fissures in the earth*

Location where boundary is found *San Andreas Fault*

6

CMA1 D  
 Draws correct scientific diagrams and identifies relevant concepts  
 6 of 6 marks

29. The Wilson Cycle describes a cycle of supercontinents breaking up (1), moving further apart as oceans widen (2), the development of subduction zones (3), the ocean narrowing (4), collision (5) and reforming the supercontinent (6). Australia separated from Antarctica about 45 million years ago. (3 marks)



(a) What stage in the Wilson Cycle best describes the current state of Australia and Antarctica?

2 ✓

(b) **State** locations in the modern world where the following stages are occurring.

Stage 3:

ring of fire--Indonesia ✗

Stage 5:

Nepal- Mountains ✓

CMA 1 D (Part A) and C (Part B)  
 Uses some data from the diagrams to respond, but an error in location  
 2 of 3 marks

## WEATHER AND CLIMATE

30. **List 4** factors that affect the average temperature of a location. (2 marks)

?  
*Wind, location in relation to the equator, ocean temperature/currents, topographical features*

CMA1 D  
One factor (wind) lacking sufficient detail for a description.

1.5 of 2 marks

31. **Explain the difference** between weather and climate? Include an example of weather data and climate data in your answer. (2 marks)

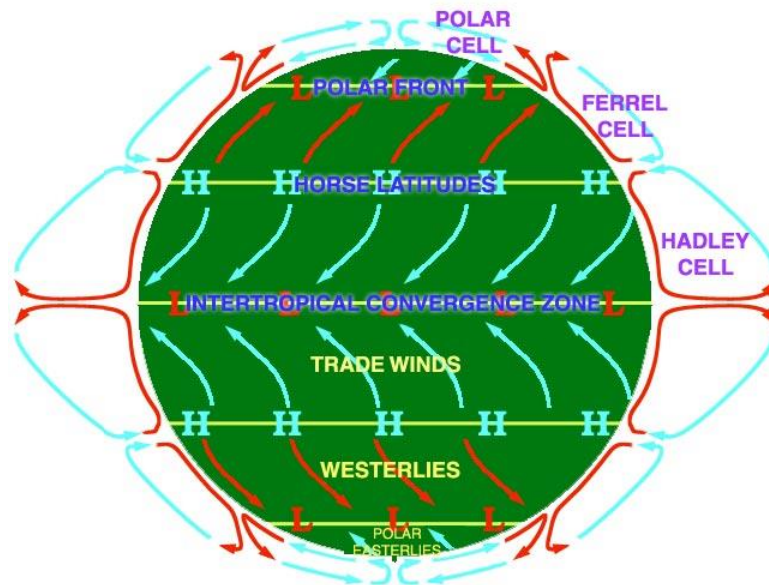
*Weather is daily and climate is average long term weather condition. Weather is mainly impacted by the winds, e.g. today's weather is cloudy (21°C), warm, and low winds. But right now, the average climate in summer (calculated across many years at this time) is hot, dry, (in Canberra), low winds.*

CMA1 C  
Explains the functions of system components to develop conclusion. Relevant examples included.

2 of 2 marks

## GLOBAL CLIMATE

The Intertropical Convergence Zone (ITCZ) is located where the Sun is directly overhead at midday. In spring and autumn, the ITCZ is close to the Equator. The ITCZ migrates north of the Equator during the Southern Hemisphere winter and south of the Equator during the Southern Hemisphere summer.



CMA1 C  
Partially explains how cell system functions to give the low-pressure zone. Answer requires more detail about how the process occurs.

2 of 3 marks

32. **Explain** why a low-pressure zone develops at the ITCZ? (3 Marks)

*Because there is a lot of wind. Wind accumulates at places with lower pressure. The pressure has to do with a lot of things but mainly the gravitational forces of the sun. When the sun is near the equator – pressure is taken away from the closest point (the equator), making wind rush into its space to reach equilibrium.*

33. **Analyse** how tropical heat is redistributed towards the poles and evaluate why this is important for life on Earth. (4 marks)

*Hot air rises and in the ITCZ zones, trade winds, push it out into the atmosphere and it gets caught up into the Hadley cells and makes its way to the poles. This cycle is important for life on earth because organisms rely on the cycle of change. Hot air gets redistributed into the polar regions and cold air comes into the tropics. Without this there would be no regulation and it would get very hot at the equator and very cold (too cold) at the poles, making (too hot) conditions unfavourable for life.*

CMA1: A:  
Evaluates the fundamental properties and processes of the atmospheric cell systems.

4 of 4 marks

## Southern Oscillation Index (SOI) & El Niño and La Niña

### 34. Compare and Contrast El Niño and La Niña (4 marks)

The SOI is the currents in the Pacific ocean that move around and distribute warm and cold water to the East or West Pacific. El Nino and La Nina are seasons in which display this cycle if there is more warm water in the east or west Pacific. When its La Nina in Australia, warm water accumulates and the west pacific get warmer. When its El Nino the opposite happens, the warm water moves away and the cold water takes its place. These currents are driven by winds, and temperature of water (salinity) the cold water, high salinity, sinks while the warm water stays at the top of the ocean.

CMA1 A  
Analyses the fundamental properties of a system and the effects of factors across the system, demonstrating an understanding of El Nino/La Nina interactions.  
3.5 of 4 marks

## CLIMATES, BIOMES AND ECOSYSTEMS

A, B and C are three locations in Australia: A is in the Northern Territory, B is in South Australia and C is in Western Australia. Their average annual temperature and average annual rainfall are given below.

CMA3 B

Assesses evidence with reference to the biome model to form evidence-based conclusions.

2 of 3 marks

- D. NT, 27°C 106cm
- E. SA 19°C 22cm
- F. WA 15°C 54cm

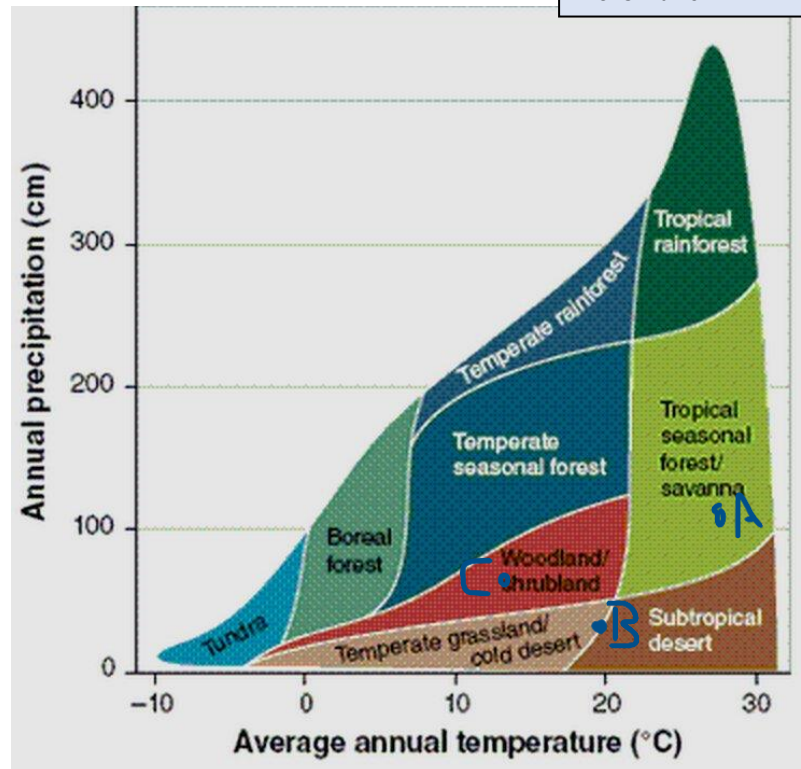
35. Plot A, B and C on the graph and state the Australian biome in which each belongs. (3 marks)

Biomes:

A: *Tropical seasonal forest/ savanna* ✓

B: *subtropical desert* ✗

C: *Woodland/shrubland* ✓



36. Evaluate which location (A, B or C) is likely to have ecosystems with the highest Net Primary Productivity (abundance of life) and biodiversity? Justify your answer by referring to biotic and abiotic factors. (4 marks)

*A is most likely to have the highest biodiversity and NPP. This is because it has the highest rainfall (106cm) and temperature (27°C). These conditions favour plants and their ability to photosynthesise. An abundance of plants bring about lots of organisms that feed on them. Additionally, in this biome there will be a lot of nutrients cycling in the soil which improves plant growth. The abundance of biodiversity also creates a loop, - the plants and animals evolve to compete for resources and in a pace like this, evolution is fast tracked because of the completion.* ✓

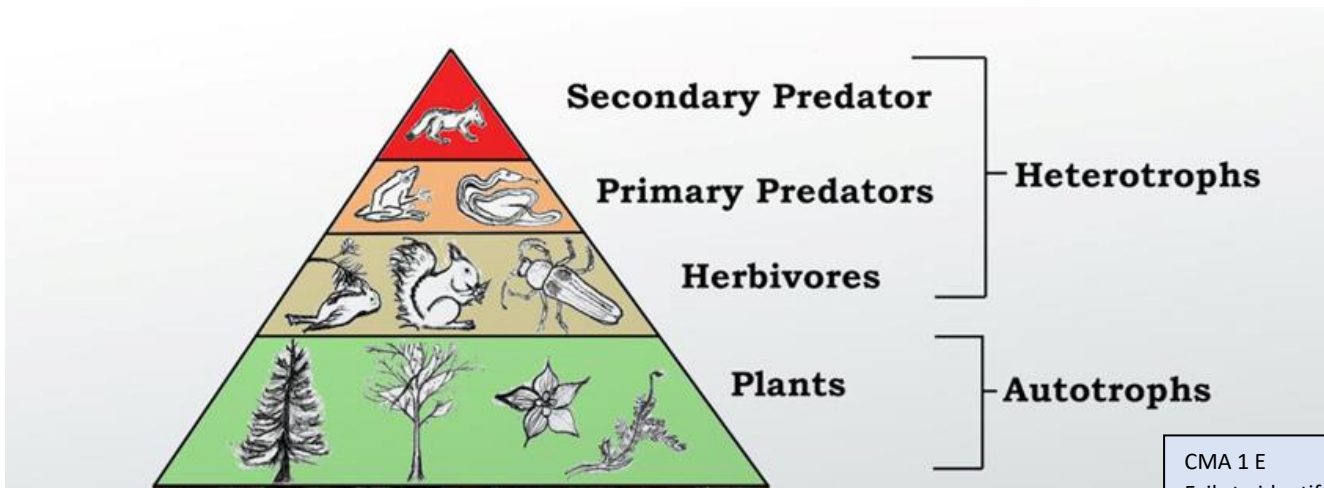
CMA1 A

Evaluates the properties and functions of the ecosystem and the effect of factors on them to develop a logical conclusion.

4 of 4 marks

4

37. This is an energy pyramid showing how energy moves in this ecosystem.



- a. **Identify** the source of energy for this energy pyramid and ecosystem (1 mark)

*autotrophs (plants/producers)*

X

- b. **Analyse** how energy is lost as you go up the energy pyramid. (4 marks)

*The 10% rule demonstrates this. The plants are the only income of energy to heterotrophs so when they are eaten, their energy is obtained – but only 10%. The rest is lost elsewhere whether it's for reproduction, movement or growing. The herbivore need to eat a lot of plants to get their small amount of energy. As you go up the pyramid the energy needs of each organism increases. This could be because they are bigger and need more energy to survive.*

4

CMA 1 E  
Fails to identify  
fundamental property.

0 of 1 mark

CMA2 B  
Analysed the nature of the  
system with reference to  
the movement of nutrients  
through food webs and has  
looked at some limitations  
that apply to energy  
transfer.

4 of 4 marks

Part C – Long Answer Section

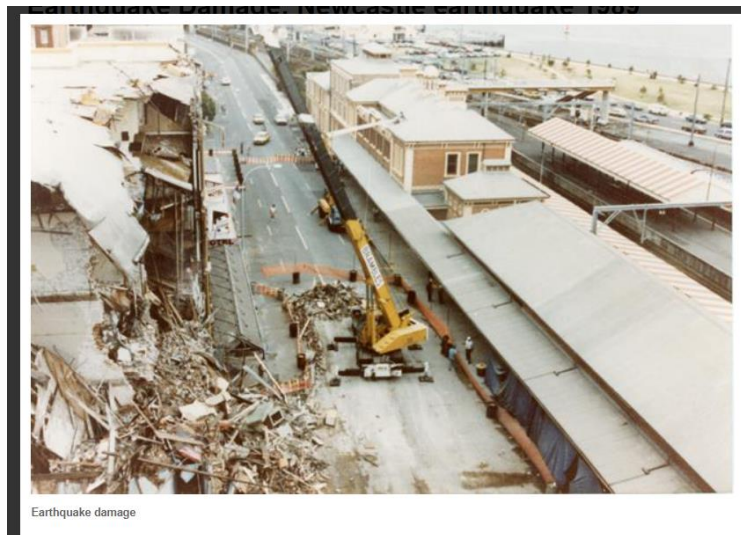
(11 marks)

38. **Explain** why high magnitude earthquakes such as the 1989 Newcastle earthquake are rare on mainland Australia (2 marks).

CMA 3 C  
Describes evidence with reference to plate tectonic model and develops evidence-based conclusions.  
2 of 2 marks

*High magnitude earthquakes usually occur on tectonic plate boundaries as the plates move relative to one another. There are no tectonic plate boundaries within the Australian continent, so high magnitude earthquakes are rare. ✓*

39. **Evaluate** the economic, social, and environmental implications of strengthening Australia's precautions against earthquake hazards (9 marks).



Raymond King, Earthquake Damage: Newcastle earthquake 1989 Hunter Street, 1989, Hunter Photo, BankNewcastle Libraries, No. 583 000003

C2 - A  
Evaluates the influence of social and economic factors of Earthquakes on the Australian continent.  
9 of 9 marks

*Australia is less vulnerable to seismic activity than other countries due to its location away from tectonic plate boundaries. However, ensuring Australia is prepared against earthquake hazards remains crucial for ensuring safety, long-term sustainability, and societal well-being.*

*Economically, investing in earthquake preparedness involves substantial costs upfront, including infrastructure, implementing building codes, and enhancing emergency response systems. However, the long-term benefits outweigh these initial upfront costs. By minimizing the potential damage from earthquakes, Australia can avoid significant economic losses caused by infrastructure damage, business disruptions, and insurance claims.*

*Socially, taking precautions against earthquake hazards prioritises a commitment to public safety and welfare. Communities become more resilient to disasters, reducing the risk of injury, displacement, and loss of life. Additionally, proactive measures such as public education campaigns create a culture of preparedness, encouraging individuals to take steps to protect themselves and their families. This also promotes social cohesion by encouraging collaboration between government agencies, communities, and private sector stakeholders in disaster planning and response efforts.*

*Environmentally, mitigating earthquake risks presents both opportunities and challenges. On one hand, implementing earthquake retrofitting measures and enforcing stricter building codes can reduce the environmental impact of earthquakes by minimising structural damage and preventing hazardous materials from being released into the environment. However, strategies such as implementing land use restrictions in some areas, may inadvertently disrupt habitats or alter natural landscapes. Therefore, it's crucial to find a balance between protecting human lives and minimizing adverse effects on the environment through careful planning and sustainable practices.*

*In conclusion, strengthening Australia's precautions against earthquake hazards provides economic, social, and environmental benefits. Despite the initial upfront costs, the advantages of safety, well-being and sustainability justify these investments. Through a focus on proactive measures and collaborative stakeholder engagement, Australia can effectively reduce any potential impacts of earthquakes.*

9

#### END OF TEST

- **Part A: Multiple Choice Section (1 mark each)** **19 / 20**
- **Part B: Short Answer Section (marks as indicated)** **48.5 / 56**
- **Part C: Long Answer Section (marks as indicated)** **11 / 11**

**Total marks: 78.5 / 87**

**90 %**

Score and Grade Matrix for Best Fit grade Judgement

	A	B	C	D	E
1					1/1
2				1/1	
3					1/1
4				1/1	
5			1/1		
6			1/1		
7			1/1		
8					1/1
9				1/1	
10				1/1	
11			1/1		
12				1/1	
13				1/1	
14			0/1		
15				1/1	
16				1/1	
17				1/1	
18				1/1	
19				1/1	
20			1/1		
21 /3				2.5/3-2	1
22 /2		2/2	1		
23 /3			3/3	2	1
24 /3		3	2	1/1	
25 /3		3/3	2	1	
26 /2		2/2-1.5	1		
27 /4			4/4-3	2-1	
28 /6				6/6-4	3-1
29 a /1				1/1	
29 b /2			2	1/1	
30 /2				1.5/2-1.5	1
31 /2			2/2	1	
32 /3			2/3-2	1	
33 /4		4/4-3	2-1		
34 /4	3.5/4-3.5	3	2-1		
35 /3		2/3-2	1		
36 /4	4/4	3	2-1		
37a /1					0/1
37b /4		4/4	3	2-1	
38 /2			2/2	1	
39 /9	9/9-7	6-5	4-3	2-1	



# Earth and Environmental Science

Assessment Task Two: Exam

Student Work: C Grade Script

Year 11 Annotated Tasks and  
Student Work

Circle the most correct answer

1. Which is **not** one of Earth's major systems?

- a. Atmosphere
- b. Biosphere
- c. Geosphere
- d. Genosphere

CMA1 E Level Identifies system component.

2. New oceanic crust is being made along:

- a. Convergent plate boundaries
- b. Destructive plate boundaries
- c. Divergent plate boundaries
- d. All of the above

CMA1 D Level Making a decision about system components.

3. Which of the following group of islands has been formed over a mantle plume or hotspot?

- a. Indonesian volcanic islands
- b. Japanese volcanic islands
- c. Caribbean volcanic islands
- d. Hawaiian volcanic islands

CMA1 E Level Identifies interactions.

4. Compressional forces in the Earth's crust can result in:

- a. Folding
- b. Reverse faulting
- c. Thrust faulting
- d. All of the above

CMA1 D Level, Decision on effect of factors

Magnetic Polarity

Questions 5 and 6 relate to Figure 1. below.

5. During geological history, the Earth's magnetic field has undergone numerous reversals of polarity. In the last 10 million years, there have been, on average 3 or 4 reversals per million years.

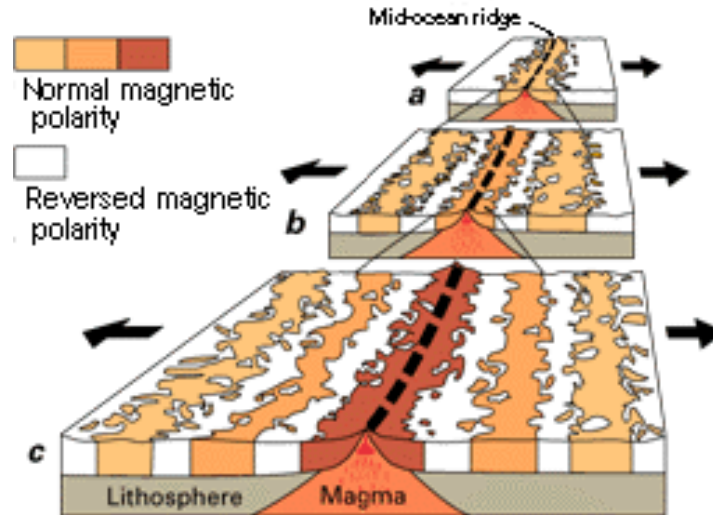


Figure 1.

The darker stripes on Figure 1 represent new oceanic crust formed when magnetic polarity was:

- a. Same as present
- b. Opposite to present
- c. In the process of changing
- d. Insufficient information to know which polarity

CMA3 C level  
Incorrect response

6. Magnetic polarity striping as represented by Figure 1, provides evidence of:

- a. Isostasy
- b. Subduction
- c. Sea-floor spreading
- d. All of the above

CMA3 C Level, explains evidence with reference to models and theories.

7. Two tectonic plates have the following characteristics.

Tectonic plate	% of boundary subducting	% of boundary divergent	Plate speed (cm/year)
1	35.1	32.5	7.5
2	2.4	34.9	1.5

This data is empirical evidence that the main cause of plate motion is:

- a. Mantle convection
- b. Slab pull
- c. Ridge push
- d. Trench suction

CMA2 C Level, explains application of models using evidence in familiar contexts.

8. Energy from the sun is formed through which process?

- a. Nuclear fission
- b. Nuclear fusion
- c. Electrical fusion
- d. Electrical synthesis

CMA1 E Level, identifies process.

9. The land warms up faster in the sun and cools faster at night compared with the sea. This is because rock and soil, compared with water, has a:

- a. Higher specific heat value
- b. Lower specific heat value
- c. Different latent heat of fusion
- d. Different latent heat of vaporisation

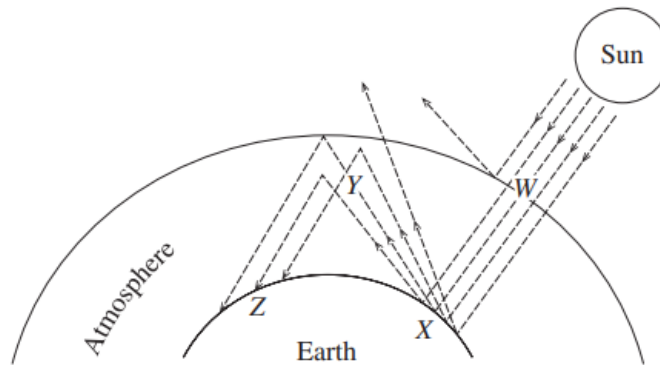
CMA1, D level  
Incorrect response

10. Due to the Coriolis Effect, which direction are ocean currents deflected in the Southern Hemisphere?

- a. The right
- b. Straight
- c. The left
- d. All of the above

CMA 1 Level D, describes fundamental properties.

11. The diagram shows as model of solar energy transformations occurring in the atmosphere, producing the greenhouse effect



KEY

W	X	Y	Z
Solar radiation enters the atmosphere	Majority of solar radiation is absorbed by Earth's surface and then re-emitted as infrared radiation	Some infrared radiation escapes but most is trapped by the atmosphere	Reabsorption of trapped infrared radiation by Earth's surface

Which statement correctly explains the 'enhanced' greenhouse effect?

CMA2 Level C, explains functions of system components, with reference to models using evidence.

- a. Increased melting of ice caps increased the reflection of solar radiation from the surface at X
- b. Increased ozone levels led to greater absorbance of solar radiation by Earth's surface at X
- c. A hole in the ozone layer decreased the solar radiation being reflected by the atmosphere at W
- d. Increased carbon dioxide levels have increased the trapping of infrared radiation in the atmosphere at Y

12. Which processes are driven by energy from the sun?

- a. Volcanic eruptions, earthquakes, photosynthesis
- b. Photosynthesis, ocean currents, water cycle
- c. Wind currents, photosynthesis, tectonic plate movement
- d. Ocean currents, Coriolis effect, volcanic eruptions

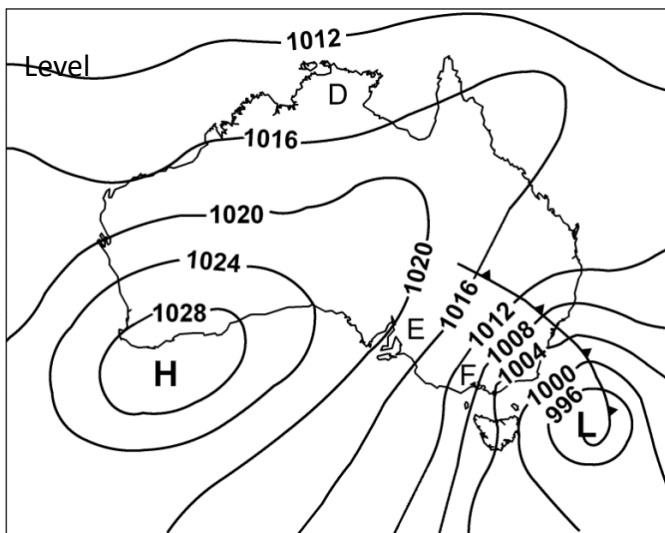
CMA3 D Level, describes evidence and develops conclusions with reference to models

13. If an object has a greater mass than the fluid it can displace, that object is said to have:

- a. Buoyancy
- b. Neutral buoyancy
- c. Negative buoyancy
- d. All of the above

CMA3 D Level, develops conclusions with some reference to models and/or theories.

14. Here is a weather chart of Australia for tomorrow. Luckily you study Earth and Environmental Science and can explain what it means to your friend.



What is the weather likely to be like tomorrow in Canberra?

- a. Windy and rain likely
- b. No wind, very clear skies
- c. Very hot and windy
- d. No wind and rain likely

CMA1 C level, explains the functions of a system process and the effect of factors.

15. Which is **not** one of the three primary gases responsible for most of the atmospheric absorption of energy?

- a. Nitrogen (N<sub>2</sub>)
- b. Ozone (O<sub>3</sub>)
- c. Carbon dioxide (CO<sub>2</sub>)
- d. Water vapor (H<sub>2</sub>O)



CMA1, D level  
Incorrect response

16. Which is **not** a cause of ocean currents:

- a. Winds
- b. Temperature differences
- c. Salinity variations
- d. Polarity of water



CMA1, D level  
Incorrect response.

17. Each hemisphere contains three cells in which air circulates through the entire depth of the atmosphere. The three cells are:

- a. Hadley, Ferrel, Polar
- b. Hadley, Ferrel, Glacial
- c. Hadley, Glacial, Polar
- d. Ferrel, Glacial, Polar



CMA2 D Level, Describes applications of models.

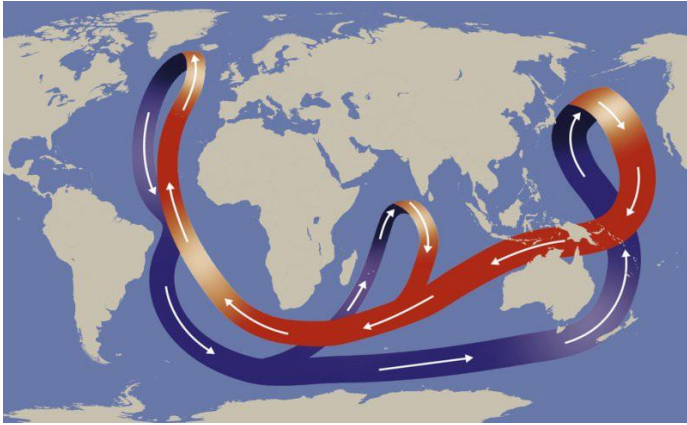
18. Which is not a source for major processes on Earth?

- a. The Sun and sunlight
- b. Geothermal Energy
- c. Radio waves
- d. Rotational Energy



CMA3 D Level, asserts conclusion with some reference to models.

19. What is this image showing?



CMA2 D Level, Develops conclusion with some reference to models.

- a. Surface currents of the ocean
- b. Global air movement
- c. Deep ocean currents (thermohaline circulation)
- d. Coriolis force (prevailing westerlies)



20. How are clouds formed?

CMA3 C Level,  
Incorrect response

- a. Warm buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form around condensation nuclei
- b. Cold buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form around condensation nuclei
- c. warm buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form from condensing water droplets
- d. cold buoyant air rises, cooling of air to dew point, cooling results in condensation of water, clouds form from evaporation of water droplets



DEVELOPING THE THEORY OF PLATE TECTONICS

21. New scientific theories are often proposed before there is a convincing driving mechanism or before there is strong evidence to show that the theory is correct. **Describe** three pieces of evidence used by Alfred Wegener to support his theory of continental drift. (3 marks)

*Fossils* ✓  
*Mountain range configuration* ✓  
*All continents fit like a jigsaw puzzle* ✓

3

CMA3 D Level, 3 marks. Describes evidence, and develops conclusions, with some reference to models and/or theories.

22. **Describe** a serious weakness in Alfred Wegener’s theory when he proposed it in 1912. (2 marks)

*Incomplete data was a massive weakness in his theory. He was unable to fully explain how the continents drifted apart, meaning many scientists didn’t believe the theory.*

2

CMA3 B Level, 2 marks: Assessed evidence and referred to limitations of model.

23. **Explain** how measuring the paleomagnetism in basalt provided evidence that the seafloors were spreading either side of mid-ocean ridges. (3 marks)

*It showed that on either side of the mid-ocean ridges there was the same magnetic field pattern on the other side, showing it spreading apart as the Earth flips.*

2

CMA3 D achieved. 2/3 marks. Student has described the evidence with reference to the model, but specific reference to magnetite crystals would answer the question better.

## AUSTRALIA

24. Eastern Australia has been travelling over a series of hot spots that have left basaltic volcanic rocks scattered along the Great Dividing Range.

Mt Kaputar in northern NSW is a basaltic shield volcano that erupted about 18 million years ago and Mt Canobolas in NSW is a basaltic shield volcano that erupted about 12 million years ago. The two mountains are 380 km apart.

Analyse this data to:

Calculate the speed (in centimetres per year or cm/year) and state the movement direction of the Australian continent. (3 marks)



$$K \text{ to } C = 380\text{km}$$

$$18,0000 - 120000 = 60000$$

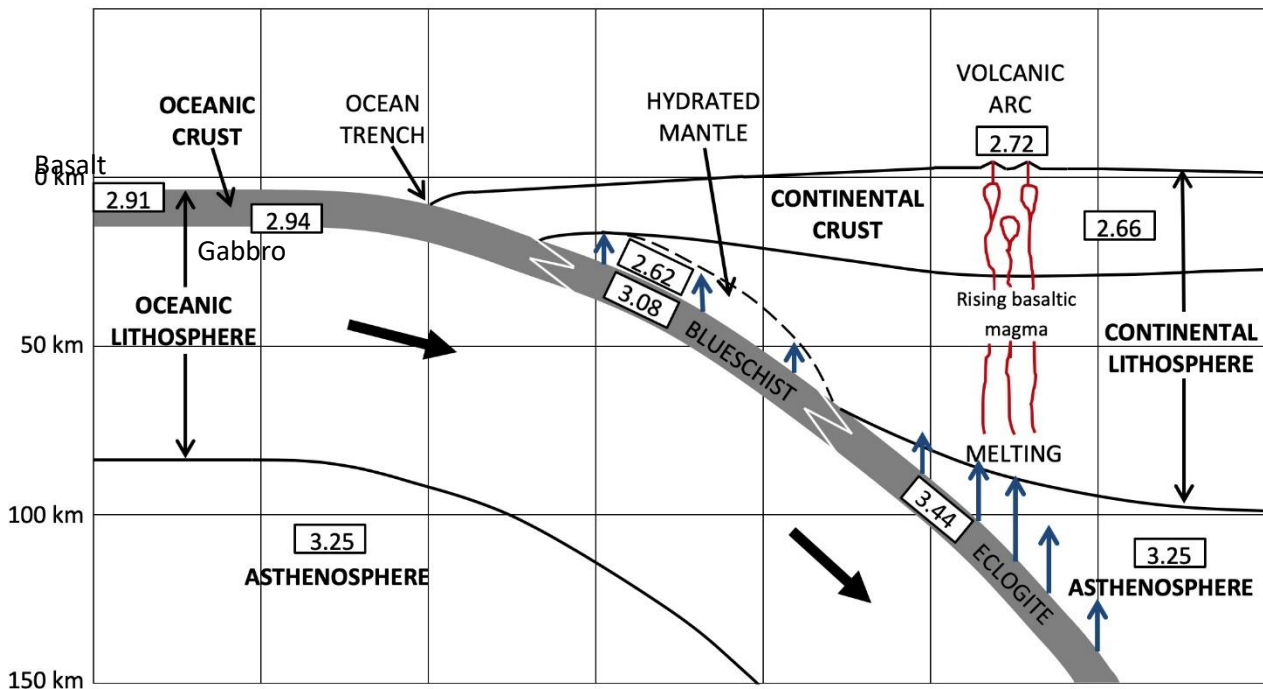
$$38000000 / 60000 = 633.33 \text{ cm/year}$$

1.5

CMA 1, C Level achieved, 1.5 marks: Student has not achieved at a higher level due to decimal place errors in calculations.

## WHAT DRIVES PLATE TECTONICS?

Cross-section of a subduction zone with rock densities in  $g/cm^3$ .



25. **Justify** why the metamorphism of basalt and gabbro in oceanic crust to blueschist and then eclogite is a probable cause for subducted plates descending into the mantle (a mechanism called slab pull). (3 marks)

*The metamorphism of basalt and gabbro makes the oceanic crust more dense than the continental crust causing it to subduct under the continental crust through slab pull into the mantle.*

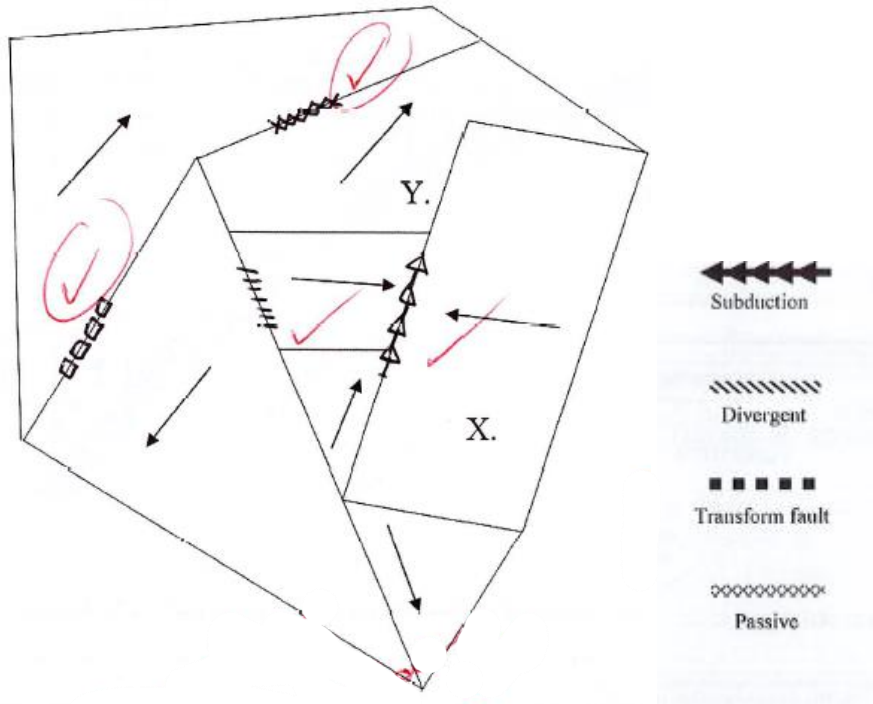
2

CMA3 C Level, 2 marks, explained the evidence and explained data to support conclusion.

**PLATE MOVEMENT AND TYPES OF PLATE BOUNDARIES**

26. The symbols opposite represent different types of plate boundaries. The diagram below represents several crustal plates moving in the direction indicated by the arrows.

**Add these symbols to the diagram** to indicate the type of plate boundaries that exists between the plates for **four** plate boundaries. (2marks)



1.5

CMA3 B Level, 1.5 points, assesses evidence with reference to models and develops evidence based conclusions, but by not fully labelling the boundaries, their conclusions are not clear.

**Volcanoes X. and Y**

27. **Identify** the type of volcano that forms in locations X and location Y (2 marks)

**Explain** what would cause the volcanoes to form in each location (2 marks)

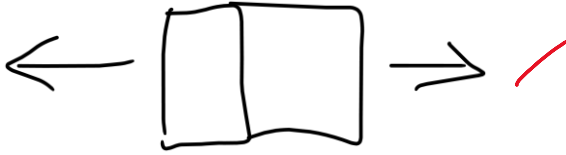
CMA 3 D Level achieved. One possible process identified from evidence, response would have been enhanced by clear justification. Y is incorrect.

<p>Volcano X.</p> <p><i>Volcano formed from a hotspot of magma rising up and creating holes. Or volcano forming from plates pushing against each other forming an inactive volcano.</i></p>	<p>Volcano Y.</p> <p><i>Hot spot volcanoes formed from magma and hot air rising up from the pressure forming an active volcano.</i></p>
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28. **Draw** a cross section of **two** tectonic plate boundary types (2 marks)  
**State** the geological features that occur at these boundaries (2 marks)  
**Identify** a location where each boundary is found (2 marks)

CMA1: D: 4 points, student has successfully described/drawn the boundaries. Drawings would have been enhanced by more detail. Students

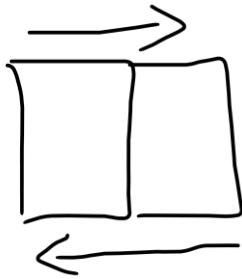
**Divergent Boundary diagram**



Features present: *ocean trenches, volcanoes* ✓

Location where boundary is found *mountain ranges* ✗

**Convergent Boundary (continent/continent)**



Features present: *mountains* ✓

Location where boundary is found *Andes Mountains* ✗

4

29. The Wilson Cycle describes a cycle of supercontinents breaking up (1), moving further apart as oceans widen (2), the development of subduction zones (3), the ocean narrowing (4), collision (5) and reforming the supercontinent (6). Australia separated from Antarctica about 45 million years ago.

a) What stage in the Wilson Cycle best describes the current state of Australia and Antarctica? (1 mark)

6 ~~X~~

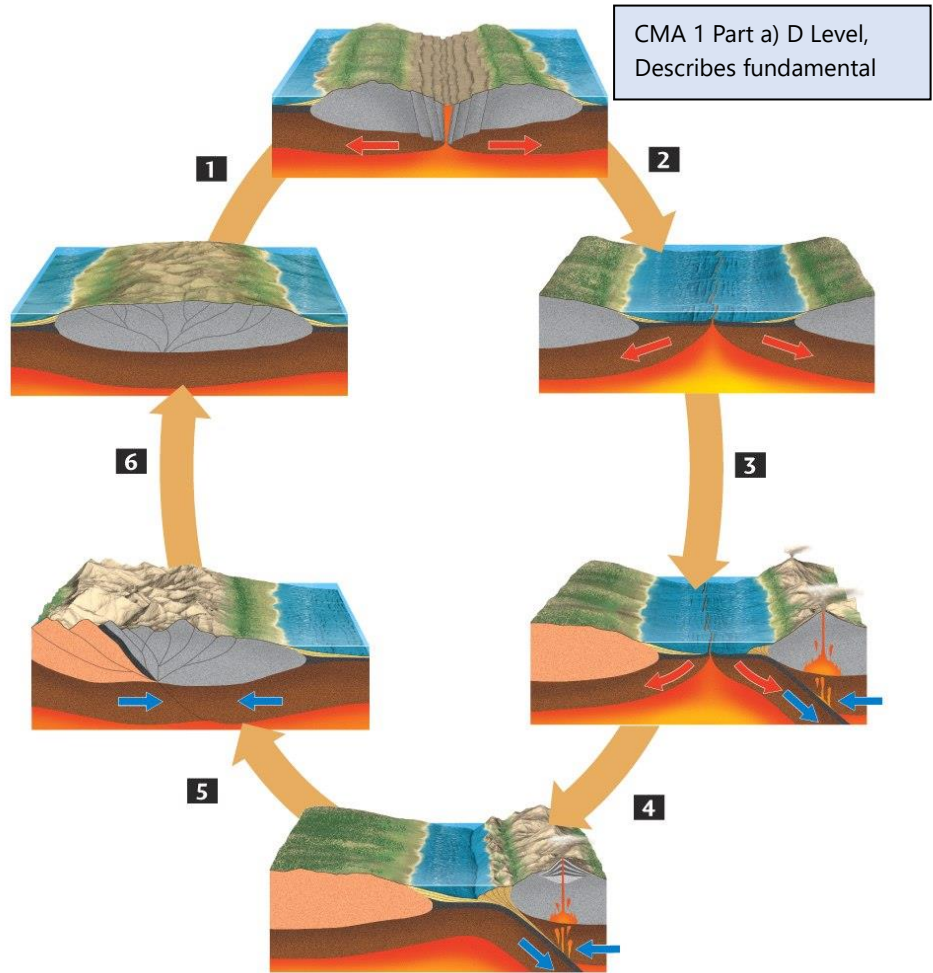
b) **State** locations in the modern world where the following stages are occurring. (2 marks)

Stage 3:

Hawaii ~~X~~

Stage 5:

New Zealand ✓



CMA 1 Part a) D Level, Describes fundamental

CMA3 Part b) D level achieved, 1 mark. Student does not consistently explain evidence with reference

## WEATHER AND CLIMATE

30. **List** 4 factors that affect the average temperature of a location.  
(2 marks)

*Latitude, distance from the sea, prevailing winds, height from sea*

1.5

CMA1 D Level, 1 .5 points  
Identifies three of four  
accurate factors affecting  
temperature.

31. **Explain** the difference between weather and climate and give an example of  
weather data and climate data. (2 marks)

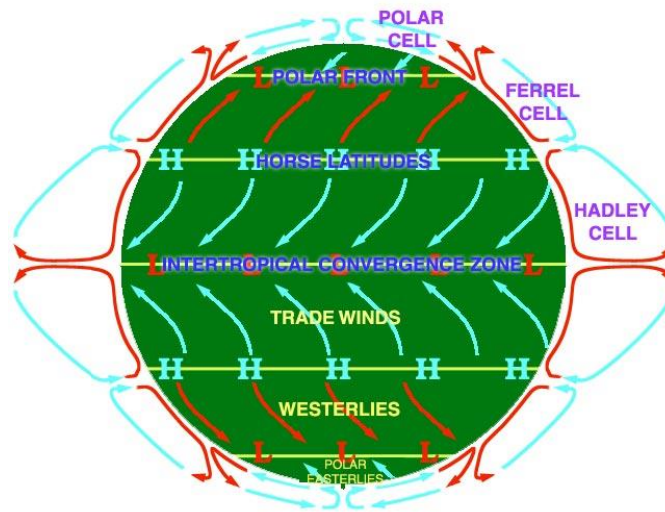
*Climate is the long term patterns and conditions whereas weather is the state of the  
atmosphere in a certain place and time. Climate data is rising or dropping temperatures  
and weather data winds for the day measured over an extended period of time.*

✓ 2

CMA1 C Level, 2 marks.  
Student has been  
successful in explaining  
the functions of weather  
system components.

## GLOBAL CLIMATE

The Intertropical Convergence Zone (ITCZ) is located where the Sun is directly overhead at midday. In spring and autumn, the ITCZ is close to the Equator. The ITCZ migrates north of the Equator during the Southern Hemisphere winter and south of the Equator during the Southern Hemisphere summer.



32. **Explain** why a low-pressure zone develops at the ITCZ? (3 Marks)

CMA1 D level achieved, 1 point, Student partially explains cause and effect in one aspect but not the three required.

*Because the trade winds from both directions are pushed together causing lower pressures.*



33. **Analyse** how tropical heat is redistributed towards the poles and evaluate why this is important for life on Earth. (4 marks)

*It is redistributed by the trade winds and through ocean currents. Without heat leaving the equator it would be too hot for any living organism to live near it and without the heat being redistributed towards the poles, then it would be too cold for the living organisms to live far away from the equator.*



CMA1 C level achieved, 1 point, Attempts analysis of the significance of fundamental property of global climate. Provides justification in very general terms and would be better if specific examples of winds and currents were named as evidence of argument.

## Southern Oscillation Index (SOI) & El Niño and La Niña

CMA1: C grade achieved: 2 points. A simplistic description of phenomena and general explanation of effects in general terms. Answer could be improved by referring to scale or different effects at different times. Some use of scientific terminology.

34. **Compare** and **Contrast** El Niño and La Niña (4 marks)

*El Nino is the warmed weather and air being moved towards the Southern hemisphere by the trade winds. It tends to be hotter and more dry in Australia in an El Nino period. La Nina is the movement of cold air and it tends to the cold and wet during La Nina periods in Australia. This is determined by the Pacific ocean water temperatures in the east and west.*

2

## CLIMATES, BIOMES AND ECOSYSTEMS

A, B and C are three locations in Australia: A is in the Northern Territory, B is in South Australia and C is in Western Australia. Their average annual temperature and average annual rainfall are given below.

CMA3 C level achieved. 2 points, partially assesses evidence with reference to models of climate and develops mostly accurate evidence-based conclusions.

- G. NT, 27°C 106cm
- H. SA 19°C 22cm
- I. WA 15°C 54cm

35. **Plot** A, B and C on the graph and then **state** the Australian biome in which each belongs. (3 marks)

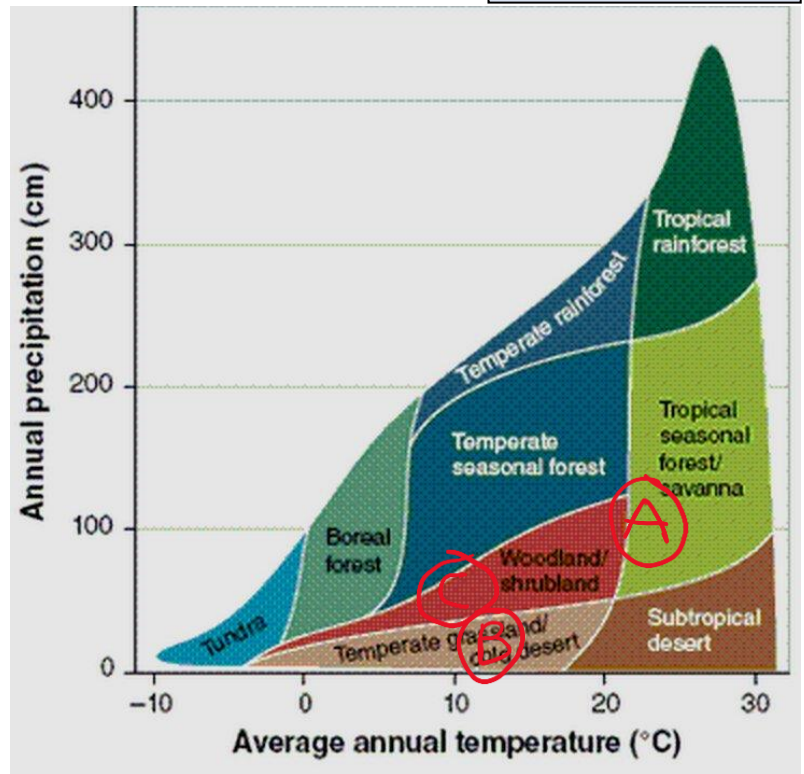
Biomes:

A: *Tropical seasonal forest/ savannah* ✓

B: *subtropical desert* ✗

C: *Woodland/shrubland* ✓

2



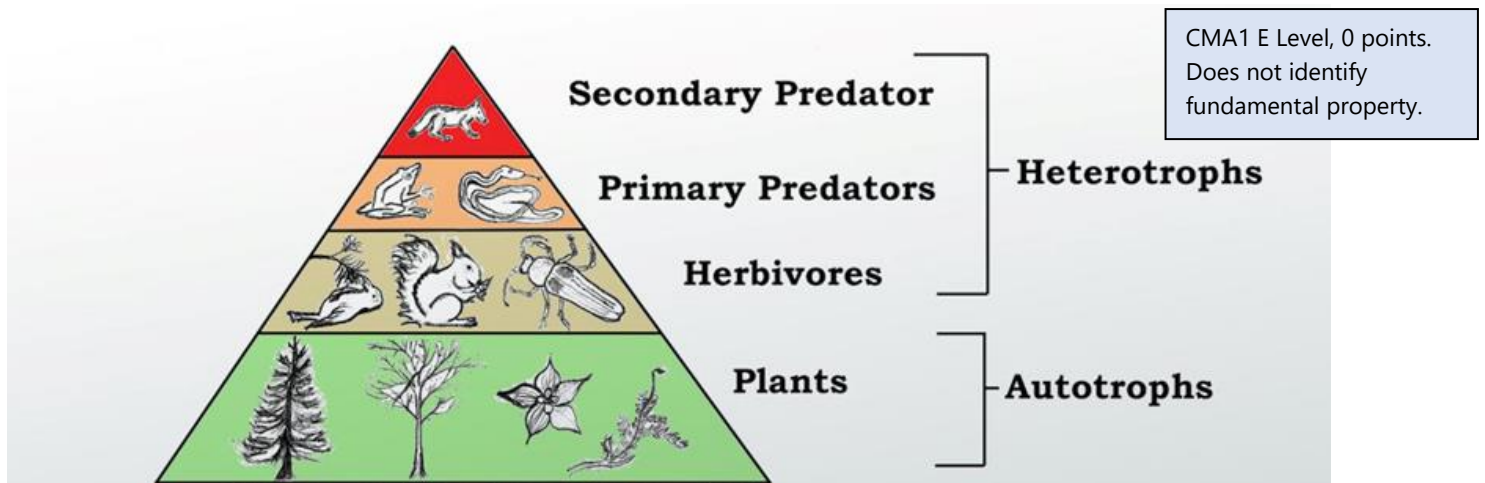
36. **Evaluate** which location (A, B or C) is likely to have ecosystems with the highest Net Primary Productivity (abundance of life) and biodiversity? **Justify** your answer by referring to biotic and abiotic factors. (4 marks)

*A would have the highest net primary productivity due to the different abiotic factors in this region due the higher amount of annual precipitation the plant life would flourish meaning the animal life will also grow since there is enough food source to support many different species and ecosystems.*

2

CMA1 A Level, C achieved. 2 points. Simple explanation in general terms. Answer could be improved with a discussion of temperature and abiotic factors.

37. This is an energy pyramid showing how energy moves in this ecosystem.



a) Identify the source of energy for this energy pyramid and ecosystem (1 mark)

*autotrophs*

X

b) **Analyse** how energy is lost as you go up the energy pyramid. (4 marks)

*Energy is lost from the 10% rate as you move up the pyramid. 10% of that energy is consumed by the above animals and the rest is lost to the surrounding area. Heterotrophs have to consume more plants or animals in the lower levels to get more energy because as you move up to secondary predator they receive only a little amount of energy from their prey.*

2

CMA2, D Level achieved 2 points. Student has described energy movement through food pyramids but not energy loss. Has not been able to clearly justify their ideas with developed examples to show a more in-depth analysis. Some use of scientific terminology, but not in a developed example that would indicate genuine analysis or understanding.

## Part C – Long Answer Section

38. **Explain** why high magnitude earthquakes such as the 1989 Newcastle earthquake are rare on mainland Australia (2 marks)

*Australia does not have high-magnitude earthquakes because it is located in the middle of the Indo-Australian tectonic plate.*

CMA3: D level achieved; student has demonstrated a basic understanding of causes of earthquakes. To improve, student needed to link to instability at tectonic plate boundaries.

**Evaluate** the economic, social, and environmental implications of strengthening Australia's precautions against earthquake hazards (9 marks).

Raymond King, Earthquake Damage: Newcastle earthquake 1989 Hunter Street, 1989, Hunter Photo, BankNewcastle Libraries, No. 583 000003

*Strengthening Australia's precautions against earthquake hazards has several important implications. Economically, upgrading buildings would be costly and might lead to higher taxes, but it could also create jobs. It would improve public safety by reducing injuries and deaths during earthquakes. Environmentally, using resources for upgrades could increase pollution and habitat destruction, but stronger buildings would mean less damage and waste in the long run. Overall, the costs and environmental impacts are significant, but the benefits in safety and job creation are important.*

C2 A level, C Level achieved. Student explains the social and economic implications of earthquakes in Australia. Some use of scientific terminology. To improve the response the student needs to elaborate on each implication and provide a more detailed analysis.

4

**END OF TEST**

- **Part A: Multiple Choice Section (1 mark each)** **15 / 20**
- **Part B: Short Answer Section (marks as indicated)** **31.5 / 56**
- **Part C: Long Answer Section (marks as indicated)** **5 / 11**

**Total marks: 51.5 / 87    59 %**

### Score and Grade Matrix for Best Fit grade Judgement

	A	B	C	D	E
1					1/1
2				1/1	
3					1/1
4				1/1	
5			0/1		
6			1/1		
7			1/1		
8					1/1
9				0/1	
10				1/1	
11			1/1		
12				1/1	
13				1/1	
14			1/1		
15				0/1	
16				0/1	
17				1/1	
18				1/1	
19				1/1	
20			0/1		
21 /3				3/3-2	1
22 /2		2/2	1		
23 /3			3	2/2	1
24 /3		3	1.5/2-1		
25 /3		3	2/2	1	
26 /2		1.5/2-1.5	1		
27 /4			4-3	1/2-1	
28 /6				4/6-4	3-1
29 a /1				0/1	
29 b /2			2	1/1	
30 /2				1.5/2-1.5	1
31 /2			2/2	1	
32 /3			3-2	1/1	
33 /4		4-3	1/2-1		
34 /4	4-3.5	3	2/2-1		
35 /3		2/3-2	1		
36 /4	4	3	2/2-1		
37a /1					0/1
37b /4		4	3	2/2-1	
38 /2			2	1/1	
39 /9	9-7	6-5	4/4-3	2-1	