

CHEMISTRY IN THE EARTH SYSTEM

NGSS

INTEGRATING CHEMISTRY AND EARTH SCIENCE

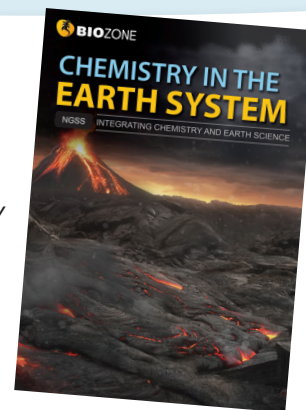


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Summary of BIOZONE's 3D Approach By Chapter

Science and Engineering Practices (SEPs), Crosscutting Concepts (CCCs), Disciplinary Core Ideas (DCIs), and Performance Expectations (PEs) for Instructional Segments 1-6 of the CA NGSS (Three Course Model): *Chemistry in the Earth System*. A skills chapter, which covers some of the background for Science and Engineering Practices, is also included. Performance Expectations are met within activities and/or the **Summative Assessments** concluding each Instructional Segment (IS).

IS1: COMBUSTION AND ENERGY TRANSFER

Page		Activity	Hub	SEP	DCI	CCC	PE
2	1	Boil 'em in Oil		Anchoring phenomenon			
3	2	Working in the Lab Environment	✓	3			
6	3	Everyday Chemistry	✓	1, 2, 3, 4	PS1.A	1, 2, 5	HS-PS1-3, HS-PS1-4
10	4	Observing Reactions	✓	2, 3, 5	PS1.B	2, 5	HS-PS1-4, HS-PS1-7
15	5	Energy in Food	✓	1, 2, 3, 4, 5	PS1.B, PS3.D	2, 4, 5, 7	HS-PS1-3, HS-PS1-4 HS-PS1-7, HS-PS3-1
23	6	Boil 'em in Oil Revisited					
24	7	Summative Assessment		2, 5	PS1.A, PS1.B	1, 5	HS-PS1-3, HS-PS1-4, HS-PS1-7

IS2: HEAT AND ENERGY IN THE EARTH SYSTEM

Page		Activity	Hub	SEP	DCI	CCC	PE
27	8	On the Move		Anchoring phenomenon			
28	9	Energy	✓	2, 3, 6	PS3.A	2, 3, 5, 7	HS-PS3-2
34	10	Order and Disorder	✓	2, 3, 6	PS3.A, PS3.B	3, 5, 7	HS-PS3-4
38	11	Kinetic Theory of Matter	✓	2, 5, 6	PS3.A, PS3.B	2, 4, 5	HS-PS3-1, HS-PS3-2
42	12	Modeling Energy Flow	✓	2, 3, 5	PS3.A, PS3.B, ETS1.B	2, 3, 4, 5	HS-PS3-1, HS-PS3-2, HS-ETS1-4
48	13	Energy in the Earth	✓	2, 4, 7	ESS2.A, ESS2.B	2, 3, 5	HS-ESS2-3
52	14	Evidence for Earth's Structure	✓	2, 4, 5, 7	ESS2.A, ESS2.B, PS4.A	1, 5	HS-ESS2-3
60	15	Energy Drives Plate Tectonics	✓	2, 7, 8	ESS2.B ESS2.C	1, 2, 3, 5	HS-ESS2-3
69	16	On the Move Revisited					
70	17	Summative Assessment		2	ESS2.A	5	HS-ESS2-3

IS3: ATOMS, ELEMENTS, AND MOLECULES

Page		Activity	Hub	SEP	DCI	CCC	PE
75	18	Burp!	✓	Anchoring phenomenon			
76	19	Properties and Patterns	✓	1, 2, 4	PS1.A	1	HS-PS1-1
80	20	The Atom	✓	2, 8	PS1.A	1, 2	HS-PS1-1
88	21	The Periodic Table	✓	2, 6	PS1.A	1, 2	HS-PS1-1
95	22	The Mole	✓	2, 3, 5, 6	PS1.A, PS1.B	1, 3, 5	HS-PS1-2, HS-PS1-7
108	23	Aqueous Reactions	✓	2, 3, 5	PS1.A, PS1.B	1, 3	HS-PS1-7
113	24	Burp! Revisited					
114	25	Summative Assessment		2, 5, 6	PS1.A, PS1.B	1, 5	HS-PS1-1, HS-PS1-2, HS-PS1-7

IS4: CHEMICAL REACTIONS

Page		Activity	Hub	SEP	DCI	CCC	PE
120	26	Hot! Too Hot!	✓	Anchoring phenomenon			
121	27	Molecular Structure	✓	2, 6	PS1.A, PS2.B	1, 2	HS-PS1-1, HS-PS1-2, HS-PS1-7
125	28	Properties of Matter	✓	2, 3, 4, 5, 6	PS1.A, PS2.B, PS3.C	1, 2	HS-PS1-3, HS-PS3-5, HS-PS2-4
135	29	Energy and Changes of State		2	PS1.B	2, 5, 7	HS-PS1-4

137	30	Energy and Chemical Reactions	✓	2, 3, 4, 5, 6	PS1.B	5, 7	HS-PS1-4
147	31	Reaction Rates	✓	2, 3, 4, 5, 6	PS1.B	1, 5, 7	HS-PS1-5
152	32	Hot! Too Hot! Revisited	✓				
153	33	Summative Assessment	✓	2, 5, 6	PS1.A, PS1.B, PS2.B	1, 5	HS-PS1-2, HS-PS1-4, HS-PS1-5, HS-PS2-4

IS5: CHEMISTRY OF CLIMATE CHANGE

Page		Activity	Hub	SEP	DCI	CCC	PE
158	34	It's Heating Up	✓	Anchoring phenomenon			
159	35	Combustion and Hydrocarbons	✓	5	PS1.B, PS3.D	2, 4, 5, 6	
162	36	Fuels and People	✓	2, 4, 5, 7	PS1.B, PS3.D, ESS3.A	2, 5	HS-ESS3-2
170	37	Atmospheric Chemistry	✓	1, 2, 4	ESS2.A, ESS2.D	2, 4, 5, 7	HS-ESS2-6, HS ESS 3-6
176	38	Global Warming and Climate Change	✓	2, 4	PS3.B, PS4.B, ESS2.A, ESS2.D, ESS3.D	2, 4, 5, 7	HS-ESS2-2, HS-ESS2-4, HS-ESS3-5
185	39	Soil Chemistry and Its Role in Climate Change	✓	7	ESS3.A, ETS1.C	2	HS-ES3-2, HS-ETS1-2
191	40	Living with Limited Resources	✓	7	ESS3.A, ETS1-C	2	HS-ESS3-2, ETS1-2
194	41	It's Heating Up Revisited					
195	42	Summative Assessment		2, 4, 7	ESS2.D, ESS3.A, ESS3.D, ETS1-C	2, 7	HS-ESS2-4, HS-ESS3-2, HS-ESS3-5, HS-ETS1-2

IS6: REACTION DYNAMICS AND OCEAN ACIDIFICATION

Page		Activity	Hub	SEP	DCI	CCC	PE
200	43	Seashells by the Seashore	✓	Anchoring phenomenon			
201	44	Reversible Reactions	✓	2, 3, 6	PS1.B	2, 4, 7	HS-PS1-5, HS-PS1-6, HS-PS1-7
209	45	Industrial Chemistry	✓	6	PS1.B, ETS1.C	7	HS-PS1-5, HS-PS1-6, HS-PS1-7
218	46	Ocean Chemistry	✓	3, 4, 5, 6	PS1.B, ESS2.A, ESS2.D, ESS3.D	2, 7	HS-PS1-5, HS-ESS2-2, ESS3-5, HS-ESS2-6
224	47	Seashells by the Seashore Revisited	✓	6	ESS2.D	2, 7	
225	48	Summative Assessment		4, 6	PS1.B, ESS2.A, ESS2.D	7	HS-PS1-5, HS-PS1-6, HS-ESS2-2, HS-ESS2-6

SEPs: BASIC SKILLS FOR CHEMISTRY STUDENTS

Page		Activity	Hub	SEP	DCI	CCC	PE
229	49	Nature of Science	✓	1, 6, 7, 8	NA	4	NA
231	50	Systems and System Models	✓	2	NA	4	NA
233	51	Observations and Assumptions	✓	1	NA		NA
235	52	Useful Concepts in Chemistry	✓	5	NA		NA
236	53	Standard Chemistry Equipment	✓	2, 3, 6	NA		NA
238	54	Experimenting in Chemistry	✓	3	NA		NA
239	55	Accuracy and Precision		3	NA		NA
240	56	Measurement and Quantitative Analysis	✓	2, 3, 6	NA		
242	57	Working With Numbers		5	NA		NA
243	58	Ratio and proportion in Chemistry	✓	5	NA	3	
245	59	Logbooks and Tables		3	NA		NA
246	60	Drawing and Interpreting Graphs		4, 5	NA	1, 2	
248	61	Describing the Data	✓	4, 5	NA	1	
250	62	Periodic Table	✓		NA	1	

Identifying CA CCSS Connections

The activities in *Chemistry in the Earth System* provide many opportunities to address the California Common Core State Standards (CA CCSS) for numeracy, literacy, and English language development. The incorporation of these standards provides students with numerous opportunities to practice and develop these key skills while exploring science.

Activities incorporating the CA CCSS Math Connections, ELA/ literacy, and ELD Connections specified in the California Science Framework are identified by codes (right) in the Teacher's Edition and on the Teacher's Digital Edition (TDE).

- ▶ A red calculator indicates a math connection.
- ▶ A blue pencil indicates an ELA/literacy or ELD connection.

A list of the specific Math Connections, ELA/ Literacy Connections and ELD Standards addressed in the CA NGSS framework can be found in the tables at the bottom of this page and on the following page.

BIOZONE recognizes that CA ELD Standards are not to be used in isolation, and are intended to be implemented in conjunction with ELA/ Literacy and other academic content standards. This is why you will see them appearing along with the relevant ELA/literacy connection in the following tables.

Activities incorporating a specified CA CCSS Math Connection are identified on the activity page by a red math symbol.

Activities incorporating a specified CA CCSS ELA/ Literacy Connections and ELD standards are identified on the activity page by a blue pencil symbol.

Figure 1: Cover crops can provide the nitrogen needed for optimal growth of corn.

Crop	Ag nitrogen per hectare
Radish	~200
Cowpeas	~150
Crimson clover	~100
Hairy vetch	~200
Sweet clover	~150
Nitrogen for optimal growth in corn	~100

Figure 2: Since 2000, anaerobic digesters on livestock farms in the US have reduced direct and indirect emissions by 34.6 MMTCO₂e (million metric tons CO₂ equivalent).

Year	Direct reductions (MMTCO ₂ e)	Indirect reductions (MMTCO ₂ e)
2000	0.5	0.5
2002	0.5	0.5
2004	0.5	0.5
2006	0.5	0.5
2008	0.5	0.5
2010	0.5	0.5
2012	0.5	0.5
2014	0.5	0.5
2016	0.5	0.5

Table 1: Soil loss for three tillage systems on a typical agricultural soil in Venezuela.

Treatment	Soil loss (tonne/ha)
Bare plot	73.8
Conventional tillage	17.3
Minimal tillage	2.1

Table 2: Effect of tillage regime on soil moisture retention at 0-10 cm depth under different crops two weeks after planting.

Tillage	Maize	Pigeon peas	Soybeans	Cowpeas
Plowed	9.7	10.8	7.3	12.3
No tillage	13.3	12.1	10.6	15.4

Table 3: Total soil carbon at four sites (VA, USA) under grazing or short rotation forestry.

Site	Regime	Soil C (tonne C/ha)
Site 1	MiG ₂₁	46.6*
	Ext ₂₁	40.4*
Site 2	MiG ₂₅	36.2
	Ext ₂₅	32.2
Site 3	MiG ₂	59.5*
	Ext ₂	45.1*
Site 4	MiG ₃	50.9*
	Ext ₃	42.8*

10. (a) Divide your class into groups and assign each group a different farming practice to research. (b) Present your group's findings to the class. The class must then decide collectively what goal and targets are required to conserve the soil resource and best manage it to sequester carbon. (c) It is not practical to implement all of these farming practices at the same time. In your original groups, select two farming practices that you think are compatible and would provide the greatest benefits in terms of use of the soil resource and reducing greenhouse gas emissions. Write your two practices below and briefly explain why you made this choice. Include a summary of the likely costs and benefits involved, including social, environmental, energetic, and economic considerations. Share your findings with the class.

IS1: COMBUSTION AND ENERGY TRANSFER

Activity number	Activity	CA CSS Math connection	CA CCSS ELA/Literacy & ELD connection
3	Everyday Chemistry	N-Q.1, MP.4	
5	Energy in Food	N-Q.1, MP.4	SL.11-12.5, ELD. PI.11-12.1, 5, 6, 9, 10
7	Summative Assessment	N-Q.1, MP.4	

IS2: HEAT AND ENERGY IN THE EARTH SYSTEM

Activity number	Activity	CA CSS Math connection	CA CCSS ELA/Literacy & ELD connection
10	Order and disorder	N-Q.1, MP.4	
11	Kinetic Theory of Matter	MP.2	
12	Modeling Energy Flow	MP.2	SL.11-12, 4, 5, WHST.9-12.7, 9 ELD PI.11-12.1, 5, 9, 10, 11
13	Energy in the Earth	N-Q.1, MP.4	
14	Evidence for Earth's Structure	N-Q.1, MP.4	
15	Energy Drives Plate Tectonics	N-Q.1	
17	Summative Assessment	N-Q.1	

IS3: ATOMS, ELEMENTS, AND MOLECULES

Activity number	Activity	CA CSS Math connection	CA CCSS ELA/Literacy & ELD connection
20	The Atom		SL.11-12.4, ELD PI.11-12.5, 6
21	The Periodic Table	N-Q.1-3, MP.4	
22	The Mole	N-Q.1-3, MP.2	WHST.11-12.2
23	Aqueous Reactions	MP.2	
25	Summative Assessment	MP.2	

IS4: CHEMICAL REACTIONS

Activity number	Activity	CA CSS Math connection	CA CCSS ELA/Literacy & ELD connection
28	Properties of matter	A-SSE.1a-b, 1a-b, N-Q.1, MP.2	
30	Energy and Chemical Reactions	MP.2, MP.4	WHST.11-12.7, 8, 9, ELD PI.11-12.6
31	Reaction Rates	N-Q.1, MP.4	
33	Summative Assessment	A-SSE.1a-b	

IS5: CHEMISTRY OF CLIMATE CHANGE

Activity number	Activity	CA CSS Math connection	CA CCSS ELA/Literacy & ELD connection
34	It's Heating Up		SL.9-10.1c-d, ELD PI.9-10.1, 2, 3, 11
35	Combustion and Hydrocarbons		SL.9-10.4, WHST.9-10.4, 9, 10 ELD PI.9-10.1, 3, 5
36	Fuels and People	N-Q.1, MP.4	WHST.9-10.4 ELD PI.9-10.11, PII.9-10.1
37	Atmospheric Chemistry	N-Q.1, F-LE.1b, MP.1, MP.4	
38	Global Warming and Climate Change	N-Q.1, S-ID.6, MP.1, MP.4	WHST.9-10.9 ELD PI.9-10.11, PII.9-10.1
39	Soil Chemistry and Its Role in Climate Change		SL.11-12.1c-d, ELD PI.9-10.1, 2, 3, 6
40	Living With Limited Resources		WHST.9-10.4, ELD PI.9-10.11
41	It's Heating Up Revisited		WHST.9-10.4, 6 ELD PI.9-10.2, 1, PII.9-10.1
42	Summative Assessment		WHST.9-10.4, ELD PI.9-10.6, 11

IS6: REACTION DYNAMICS AND OCEAN ACIDIFICATION

Activity number	Activity	CA CSS Math connection	CA CCSS ELA/Literacy & ELD connection
47	Seashells By the Seashore Revisited		SL.11-12.5, RST.11-12.1, 2

BASIC SKILLS FOR CHEMISTRY STUDENTS

Activity number	Activity	CA CSS Math connection	CA CCSS ELA/Literacy connection
49	The Nature of Science		SL.11-12.1, 3, 4, WHST.11-12.2 ELD PI.11-12.1, 3, 5, 6
56	Measurement and Quantitative Analysis	A-REI.2	
60	Drawing and Interpreting Graphs	N-Q.1, S-ID.7, MP.4	
61	Describing the Data	N-Q.1, S-ID.2-3	

The Contents: A Planning Tool

The contents pages are not merely a list of the activities in the student edition. Encourage your students to use them as a planning tool for their program of work. Students can identify the activities they are to complete and then tick them off when completed. The teacher can also see at a glance how quickly the student is progressing through the assigned material.

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The teacher can see at a glance how this student is progressing through this unit of work. Any concerns with progress can be addressed early.

Ticking off the activities as they are completed gives students a sense of progression and helps them to be more personally organized in their work.

Students can mark the check boxes to indicate the activities they should complete. This helps them to quantify the work to be done and plan their work.

IS2 Heat and Energy in the Earth System

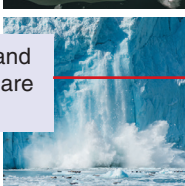
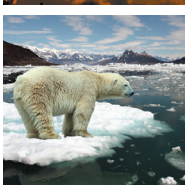
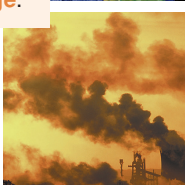
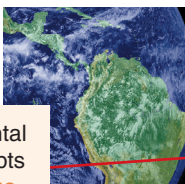
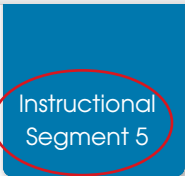
<i>Student Questions</i>	26
<input checked="" type="checkbox"/> 8 ANCHORING PHENOMENON	
On the Move	27
<input checked="" type="checkbox"/> 9 Energy	28
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<input type="checkbox"/> 15 Energy Drives Plate Tectonics	60
<input type="checkbox"/> 16 On the Move Revisited	69
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Identifying Learning Intentions and Goals

In developing *Chemistry in the Earth System*, we have embraced the three dimensions of the CA NGSS framework, emphasizing the application of ideas and skills to new scenarios. The activities in *Chemistry in the Earth System* have been specifically designed to address the **Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts** in a way that helps students to meet specific performance expectations.

In the Teacher's Edition and Teacher's Digital Edition all dimensions are embedded in the text and are color coded for easy identification (below). The performance expectations and California Environmental Principles and Concepts are also identified. It is important to note that this coding is a tool for the teacher and is not present in the Student Edition.

This identifies the Instructional Segment to which this chapter applies.



California Environmental Principles and Concepts are indicated in orange.

The relevant science and engineering practices are indicated in blue.

The relevant crosscutting concepts are indicated in green.

The relevant disciplinary core are indicated in orange.

The relevant performance expectation is indicated in red.

157

Chemistry of Climate Change

Activity number

Anchoring Phenomenon

It's heating up: Evidence shows the planet is warming.

34 41

What regulates weather and climate?

- 1 Describe the current composition of the Earth's atmosphere. Analyze and interpret graphs about the change in the composition of the Earth's atmosphere through history [SEP-4]. Are changes in atmospheric composition (e.g. levels of carbon dioxide, and methane) correlated with changes in the Earth's climate, e.g. war glaciation events [SEP-1] [ESS2.D]. Analyze data [SEP-4] for levels of atmospheric CO₂ and CH₄ to compare current levels to levels 30-50 years ago. What is the relationship between human developments in energy use and agriculture and changes in atmospheric composition over this period? [HS-ESS2-6] [HS-ESS3-6]
- 2 Develop or use a model [SEP-2] based on data to describe how carbon cycles through the biosphere (the living components of the Earth), the geosphere (the rocks and soil), and the atmosphere (the air) [ESS2.A] [CCC-4] [CCC-5] [HS-ESS2-6]. Refine your model to quantify these exchanges. What can such models tell us about what is happening to carbon in the atmosphere? [SEP-4] [EP&Cs: III] [CCC-2] [CCC-7] [HS-ESS3-6]
- 3 The vast majority of the Earth's energy input comes from the Sun. Most of this sunlight is absorbed and transformed into thermal energy [PS4.B] [CCC-5]. Complete a quantitative model [SEP-2] of the energy flows into, within and out of the Earth system [CCC-4]. Do the energy flows balance? [PS3.B] These energy flows are the basis for the climate systems [ESS2.D] [CCC-2] [CCC-5]. Analyze data to understand how energy flows have changed over the course of Earth's history [SEP-1] [ESS2.A]
- 4 Use your understanding of the Earth's atmosphere and molecular structures to the greenhouse effect. How does the greenhouse effect make the Earth a habitable planet? What are the important greenhouse gases and predict what would happen quantitatively if the volume of greenhouse gases in the atmosphere increased [SEP-2] [ESS2.A] [CCC-2] [HS-ETS2-4]. Recognize that the relationship between greenhouse gases in the atmosphere and the Earth's "thermal blanket" is made complex by feedbacks within components of the Earth system [CCC-4]. Use models to show how feedback loops in the Earth system affect climate, e.g. through altering ice cover and cloudiness [ESS2.A] [CCC-2] [HS-ESS2-2].

37 42

What effects are humans having on the climate?

- 5 In earlier chapters, you used combustion to investigate the energy content of food (fuel) and explored energy flows in both small and large systems [CCC-4]. In your food calorimetry experiment, mass that was apparently 'lost' was released as CO₂ and H₂O gas. The combustion of hydrocarbon fuels is no different [CCC-5]. In this chapter you will look at the effects [CCC-2] of fossil fuel combustion on the Earth system [CCC-4].
- 6 Use bond energies to calculate the enthalpy of complete combustion of some common fuels [PS1.B] [SEP-5]. Most hydrocarbons and similar fuels are used to provide energy [PS3.B]. Why are different types of fuels used for different purposes? How is the energy of the fuel molecule related to its use? [CCC-6]
- 7 Use graphs [SEP-2] and analyze data [SEP-4] [SEP-5] about fuel use, and describe the relationship between the consumption of fuels (particularly fossil fuels) and population growth [CCC-2]. Explain the relationship between available fuels, energy, and the development of technology. How has this changed in the last 200 years? For most of the industrial era, coal has been the fuel of choice. Evaluate [SEP-2] the benefits of extracting and using coal (or any other fossil fuel). Include references to its ability to provide usable energy [PS1.B] [PS3.D] [CCC-5] as well as the effect of its combustion on the environment [ESS3.A] [EP&Cs: V] [CCC-2] [HS-ESS3-2].
- 8 Analyze geoscience data [SEP-4] and climate models [SEP-2] to make connections between human combustion of fossil fuels, levels of greenhouse gases in the atmosphere, and predicted future climate change [ESS2.D] [ESS3.D] [CCC-2]. Use your feedback models in #4 [SEP-2] to identify linkages between components of the Earth system [CCC-4] and predict the impacts of continued increases in the Earth's average surface temperature [CCC-7] [HS-ESS3-5].
- 9 Evaluate competing solutions [SEP-7] to the problems associated with the use of limited natural resources. You should consider economic, social, and environmental costs, risks, and benefits [ESS3.A] [ETS1.C]. Consider how different solutions might reduce the effect [CCC-2] on the environment (e.g. of greenhouse gas emissions) while still providing for the needs of the growing human population [HS-ESS3-2] [HS-ETS1-2].

35 35 36 42 39 40 42

Guiding questions
These are the guiding questions outlined for *Chemistry in the Earth System* program.

38
The activity in the book related to these questions or statements. Some activities contribute to meeting the NGSS performance expectations.

36 42
A red number indicates the summative assessment for this chapter, where an NGSS performance expectation is addressed.

Scaffolded Learning

In developing *Chemistry in the Earth System* we have utilized the 5Es instructional model as a basis for developing materials to address all three dimensions of the CA NGSS framework: **disciplinary core ideas (DCIs)**, **science and engineering practices**, and **crosscutting concepts**. By successfully completing the activities, students can demonstrate competence in all three dimensions. This is central to meeting the performance expectations for *Chemistry in the Earth System* with confidence.

The Five Es

Engage:	make connections between past and present learning experiences.
Explore:	become actively involved in the activity.
Explain:	communicate the learning experience.
Elaborate:	expand on the concepts learned.
Evaluate:	assess understanding of the concepts.



BIOZONE encourages the development of the NGSS learner profile using the 5 Es model

BIOZONE's series for CA-NGSS is **phenomenon-based**. Students engage with phenomena through their own investigations and observations, through modeling and data analysis, and through collaborative work and discussion.

Using phenomena to drive inquiry promotes discussion and the sharing of ideas. The iterative approach presents opportunities to look at phenomena from several different perspectives. This allows students of all abilities to widen their thinking and understanding, increasing understanding each time the phenomenon is revisited.

Each IS begins with an **anchoring phenomenon** (right). In each instance, we have chosen a phenomenon that the student is probably familiar with, but which they cannot explain (or cannot explain fully). Teachers can use this activity to find out what the students already know (or think they know) before delving into the content more fully.

The subsequent activities in a chapter take the students, step by step, through phenomena that explore the ideas inherent in the anchoring phenomenon. By the time students revisit the anchoring phenomenon, they should be able to fully explain it.

2

1

Boil 'em in Oil

ANCHORING PHENOMENON: Cooking in oil produces different results from boiling in water
 Cooking oil and water are two common cooking mediums. Cooking oil is a mixture of fats. Its exact nature depends on the type of oil (e.g. olive oil, canola oil, coconut oil). Water, however, is a pure substance containing only molecules consisting of two hydrogen atoms joined to one oxygen atom (i.e. water molecules). The different nature of these two substances produces two quite different results when they are used for cooking. Look at the photos below of potatoes cooked in oil and in boiling water and the result of each treatment.

6

Boil 'em in Oil Revisited
23

Boiled or fried?
 ▶ During this chapter you have been investigating aspects of energy with respect to foods and other substances. From what you have found out you should now be ready to revisit the anchoring phenomenon at the start of the chapter. Why is there a different result when potatoes are placed in hot oil as opposed to being placed in hot water?

Each IS begins with an **anchoring phenomenon** (e.g. Boil 'em in Oil). By the time the students have worked through the activities in the chapter they should be able to fully explain it when it is revisited at the end of the chapter

1. Explain why aspects of e

2. No

3. H

4. In

3. Include

2. In terms of changes of state, why is it **never** a good idea to put out a fat or oil fire in a pan by pouring water on it?

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Scaffolding with the 5Es

The content of the *Chemistry in the Earth System* is organized into 7 chapters, corresponding to the six Instructional Segments (IS) and one chapter addressing basic skills. Each Instructional Segment begins with an introduction outlining learning goals and is immediately followed by the Anchoring Phenomenon. Engaging activities make up the bulk of each chapter, with each activity focusing on the student investigating and developing understanding of a phenomenon, applying that understanding to new scenarios, and/or developing a skill or essential science practice, such as graphing, data analysis, modeling, or evidence-based explanation.

Annotated diagrams and photographs are a major part of most activities and the student's understanding of the information is evaluated through questions and/or tasks involving data handling and interpretation. Tabs at the bottom of the page identify crosscutting concepts, science and engineering practices, and disciplinary core ideas as appropriate. Tabs also indicate if the activity is supported via [BIOZONE's Resource Hub](#), which provides online teacher and student support for specific aspects of the activity.

Each activity is presented as a logical sequence, in which understanding of an everyday or investigative phenomenon is developed progressively through exploration and explanation.

ENGAGE with phenomena

Each activity begins with a task to engage student thinking, asking them to review their current understanding of a phenomenon, or providing an interesting (if not yet fully explained) piece of information and setting the scene for the content to follow. Prior knowledge can also be assessed using the ENGAGE material.


108

23 Aqueous Reactions

ENGAGE: Solutions

- ▶ Have you ever made a flavored drink by adding powder from a sachet to a liter of water?
- ▶ In doing this you have produced a solution. It will have had a certain concentration, perhaps 100 grams of powder per litre or 100 g/L.
- ▶ Sometimes you may have added a concentrate to water to form a diluted solution. This might be adding a cordial or house hold ammonium solution to water.

1. In groups come up with a list of other solutions about the house that need diluting or making into a solution before they are used. Write your list here:



EXPLORE: Concentration

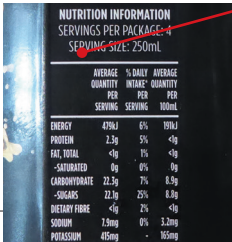
- ▶ So far in chemistry when we have referred to the amount of a substance we have used its mass in grams. In reality many substances you will come across will not be able to be easily weighed out because they are dissolved in solution. We must refer to their concentration, the amount of substance per liter. This might be as grams per liter (g/L) or, specifically in chemistry, moles per liter (mol/L). Consider the label on the right from a bottle of orange juice:

2. (a) What volume is a serving of orange juice? _____

(b) How many servings in 1 L (1000 mL) of orange juice? _____

(c) What is the concentration of potassium in g/L (1 g = 1000 mg)? _____

(d) What is the concentration of sugars per liter in g/L? _____



EXPLORE: Salt from the sea

- ▶ Sodium chloride is one of the most common chemicals used by humans. It is used to enhance flavor in food, in medicine (e.g. saline solution), thousands of tonnes are spread on roads every year to prevent ice forming, and it is an important ingredient in many industrial reactions. Approximately 280 million tonnes are produced every year.
- ▶ Much of this comes from the sea or salt lakes by evaporating seawater in huge shallow ponds (shown right). Seawater has a concentration of sodium chloride of about 35 g/L. Different seas and oceans have very slightly different salinities due to their position. For example the Mediterranean Sea is mostly enclosed and has a concentration of 38 g/L.
- ▶ Some lakes have very high salt concentration. The Great Salt Lake in Utah has a salt concentration of up to 317 g/L (right).

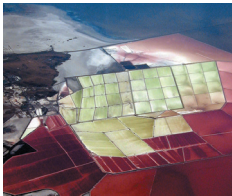
3. (a) Sodium chloride has a molar mass of 58.5 g/mol. How many moles of sodium chloride are in one liter of sea water? _____

(b) How many times more concentrated is than seawater is the Great Salt Lake? _____

(c) What is the concentration of the Great Salt Lake in moles per liter? _____

- ▶ Many metals can be found in seawater. Gold has a concentration of 1×10^{-11} grams per liter of seawater. That's 1 gram per 100 million tonnes of seawater.

4. Gold has a molar mass of 197.0 g/mol. What is the concentration of gold in seawater in moles per liter? _____



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PS1.A PS1.B P SPQ

Annotated diagrams, photographs, and graphs explain the content of the page, providing the information necessary to complete the activity.

Students are given enough information to complete the activity's tasks. To progress through the activity they may need to apply knowledge and information developed earlier in the activity. Answers to questions are not always directly available on the page. Students may need to analyze data or information and draw conclusions to answer the questions and progress to the next part of the activity. Students are sometimes asked to do further research or carry out their own research or investigation.

Related content is identified through the tab system. This activity also has supporting resources on [BIOZONE's Resource Hub](#) assigned to it.

EXPLORE sections encourage students to be independent learners and seek the answers to questions posed by the activity. They do this through investigation and by creating their own models, analyzing data, or interpreting diagrams. In this example students use an everyday example (food labels) to explore concentrations in a familiar context. They also explore a second example (salt production).

EXPLAIN sections deepen student understanding of phenomena by building on what they discovered through exploration. They are encouraged to use scientific principles and reasoning to construct explanations and devise solutions to the problems presented to them. Here students look at the importance of using standard solutions in chemistry. An investigation provides an opportunity to practice making standards. Through the investigation, students explain why it is important to adhere to certain rules and demonstrate use of $c = n/v$.


108

23 Aqueous Reactions

ENGAGE: Solutions

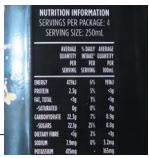
- Have you ever made a flavored drink by adding powder from a sachet to a liter of water?
- In doing this you have produced a solution. It will have had a certain concentration, perhaps 100 grams of powder per liter or 100 g/L.
- Sometimes you may have added a concentrate to water to form a diluted solution. This might be adding a cordial or house hold ammonium solution to water.

1. In groups come up with a list of other solutions about the house that need diluting or making into a solution before they are used. Write your list here:



EXPLORE: Concentration

So far in chemistry when we have referred to the amount of a substance we have used its mass in grams. In reality many substances you will come across will not be able to be easily weighed out because they are dissolved in solution. We must refer to their concentration, the amount of substance per liter. This might be six grams per liter (g/L) or, specifically in chemistry, moles per liter (mol/L). Consider the label on the right from a bottle of orange juice:



2. (a) What volume is a serving of orange juice?
 (b) How many servings in 1 L (1000 mL) of orange juice?
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 (d) What is the concentration of sugars per liter in g/L?

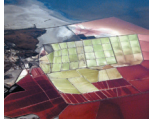
EXPLORE: Salt from the sea

Sodium chloride is one of the most common chemicals used by humans. It is used to enhance flavor in food, in medicine (e.g. saline solution), thousands of tonnes are spread on roads every year to prevent ice forming, and it is an important ingredient in many industrial reactions. Approximately 280 million tonnes are produced every year.

Much of this comes from the sea or salt lakes by evaporating seawater in huge shallow ponds (shown right). Seawater has a concentration of sodium chloride of about 35 g/L. Different seas and oceans have very slightly different salinities due to their position. For example the Mediterranean Sea is mostly enclosed and has a concentration of 38 g/L.

Some lakes have very high salt concentration. The Great Salt Lake in Utah has a salt concentration of up to 317 g/L (right).

3. (a) Sodium chloride has a molar mass of 58.5 g/mol. How many moles of sodium chloride are in one liter of sea water?
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 (c) What is the concentration of the Great Salt Lake in moles per liter?
 Many metals can be found in seawater. Gold has a concentration of 1×10^{-11} grams per liter of seawater. That's 1 gram per 100 million tonnes of seawater.
 4. Gold has a molar mass of 197.0 g/mol. What is the concentration of gold in seawater in moles per liter?



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110

7. Calculate the exact concentration of your standard flask from the mass you weighed at the start:

EXPLAIN: Creating standards

Standards are important in everyday life. We use standards for measuring other things against. Standards can be anything and people have come up with some interesting ones over time.

Examples include standards in height: e.g. storeys, as in "It was 5 storeys tall". We don't know exactly how high that is, but we get the idea. Other odd standards include jumbo jets ("the Wright brothers first flight was less than the wingspan of a jumbo jet"), or football fields, or elephants.

5. Write down some everyday standards you measure things against (they don't have to be strange):

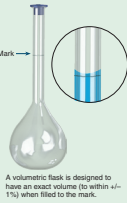
When trying to find out the concentration of a solution we first need a standard to measure the unknown concentration against. This is called a **standard solution**. Standard solutions are made up in volumetric flasks. Placing a known mass of a compound in the flask and then filling up to the mark with distilled water will produce a volume with a known and precise concentration against which other solutions can be measured.

In chemistry, it is the number of atoms or ions involved in a reaction that matters. To know this, we must know the number of moles of reactants. In a solution, the number of moles is expressed as moles per liter (mol/L). When we refer to the concentration of a solution we are referring to mol/L. To calculate a solution's concentration we can use a mass/volume ratio.

The tasks and questions provided consolidate their understanding and this is reinforced when they are required to communicate their ideas in writing or to their peers

INVESTIGATION 3.5: See appendix for equipment list.

- Add about 1.3 grams of anhydrous Na_2CO_3 to a clean, dry beaker. Record the precise mass you have weighed.
- Dissolve the powder in distilled water.
- Clean and rinse a 250 mL volumetric flask with distilled water. Using a funnel, transfer the Na_2CO_3 solution to the volumetric flask, rinsing the beaker with distilled water to ensure all the Na_2CO_3 is transferred.
- Add distilled water to the flask until it is about half full. Stopper the flask and invert several times to ensure the Na_2CO_3 solution is thoroughly mixed.
- Fill the flask almost to the mark. Then use a wash bottle or dropper to fill the flask to the mark so that the meniscus sits on the mark. Do not overfill or you will not be able to calculate a precise concentration.
- Stopper the flask and mix again.
- This is your primary standard. You will use it to standardize other solutions.



A volumetric flask is designed to have an exact volume (to within +/- 1%) when filled to the mark.

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ELABORATE sections provide opportunities for students to demonstrate deeper understanding by elaborating on new phenomena or using their experience to refine engineering solutions to relevant problems. Here students use the standard solution of sodium carbonate they have made to determine the concentration of a solution of HCl.

EVALUATE sections provide opportunities for **formative assessment** (if you wish). In this example, students standardize their sodium carbonate solution and apply what they have learned in previous sections to determine the concentration of ethanoic acid in a sample of vinegar via titration.

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8. Calculate the exact concentration of your standard flask from the mass you weighed at the start:

(a) Why should distilled water be used to make up a standard solution instead of tap water?
 (b) What should you do if you overfill your volumetric flask?

Primary standards should be made from solid compounds with a high molar mass. This reduces measuring errors. Explain why measuring out a high mass solid such as sodium carbonate is a more accurate way of making a standard than weighing out a low molar mass solid like sodium hydroxide:


ELABORATE: Standardizing HCl

The sodium carbonate solution can now be used to standardize other solutions that are more suitable for testing unknown solutions against. This is done by **titration**.

You lab supply of hydrochloric acid (HCl) may be 1 mol/L. This is too concentrated for the volumetric analysis of many solutions. You must produce a 0.1 mol/L solution and standardize it using your sodium carbonate solution.

INVESTIGATION 3.6: See appendix for equipment list.

- Place 50 mL of 1 mol/L HCl into a clean, dry 100 mL beaker. Using a 25 mL (or similar volume) pipette transfer 25 mL (or similar) to a clean, dry 250 mL volumetric flask.
- Add distilled water to the flask until it is about half full. Stopper the flask and invert several times to ensure the HCl solution is thoroughly mixed.
- Fill the flask almost to the mark. Then use a wash bottle or dropper to fill the flask to the mark.
- Rinse a 50 mL burette with the HCl solution, then place the burette in a clamp stand and fill it with the HCl solution.
- Transfer four 20 mL samples of Na_2CO_3 solution into four clean 100 mL conical flasks. Add two drops of methyl orange indicator to each flask.
- Record the initial burette volume. Add the HCl solution from the burette to the Na_2CO_3 while swirling the flask until the indicator just changes color (the **equivalence point**).
- Record the final volume and calculate the difference. This is the **titre** (the minimum volume of a solution needed to reach the end point in a titration). Do not use this volume in your final calculations (it is a just trial to become familiar with the volume of HCl solution required).



Burette reading	Trial titration	First titration	Second titration	Third titration
Initial reading				
Final reading				
Difference (titre)				

8. Carry out the titration at least three more times and record the volume added for each in the table.

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10. Balance the equation for sodium carbonate and hydrochloric acid: $\text{Na}_2\text{CO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$

11. (a) Calculate $n(\text{Na}_2\text{CO}_3)$ in the conical flask:
 (b) Calculate $n(\text{HCl})$ used:
 (c) Calculate the average (mean) volume of HCl solution used:
 (d) Calculate the concentration of HCl in the volumetric flask:


EVALUATE: Finding the concentration of ethanoic acid in vinegar

A standard sodium hydroxide solution is useful for testing the acid concentration of various solutions. It must be standardized whenever it is used as it tends to absorb carbon dioxide from the air, which can change the concentration.

In the following investigations, you will standardize a solution of NaOH from the lab supply then immediately use it to calculate the concentration of ethanoic (acetic) acid in a store bought white vinegar.

INVESTIGATION 3.7: See appendix for equipment list.

- Add 50 mL of 1 mol/L NaOH solution to a clean, dry 100 mL beaker. Transfer 25 mL to a 250 mL volumetric flask using a 25 mL pipette.
- Alternatively weigh 1 gram of solid NaOH in a 100 mL beaker and dissolve with distilled water before transferring to a volumetric flask.
- Following the same procedure as to produce the HCl earlier, dilute the NaOH by filling the volumetric flask up to the mark with distilled water.
- Rinse a burette with the dilute NaOH solution. Then fill the burette with the solution.
- Rinse a pipette with your standardized HCl solution then pipette four 20 mL samples into four clean, dry 100 mL conical flasks.
- Add two drops of phenolphthalein indicator to the conical flasks. This will turn pink when the HCl/NaOH reaction is complete.
- Again, you will need to carry out at least three titrations plus a trial run. Use the table at the bottom of the page to record your results.
- Record the initial burette volume. Add the NaOH solution from the burette to the HCl while swirling the flask until the indicator just changes color. Record the final volume and calculate the difference (the titre).
- Carry out the titration at least three more times and record the volume added for each.



The titration is complete when the phenolphthalein turns a slight pink.

Burette reading	Trial titration	First titration	Second titration	Third titration
Initial reading				
Final reading				
Difference (titre)				

12. Balance the equation for sodium hydroxide and hydrochloric acid: $\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$

13. (a) Calculate $n(\text{HCl})$ in the conical flask:
 (b) Calculate the average (mean) volume of NaOH solution used:
 (c) Calculate $n(\text{NaOH})$ used:
 (d) Calculate the concentration of NaOH in volumetric flask:

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The structure of Chemistry in the Earth System promotes differential instruction, and has been designed to cater for students of all abilities. BIOZONE's collaborative approach to science inquiry encourages students of all abilities to share their ideas and knowledge with their peers while at the same time broadening their own understanding of phenomena. There are several ways you can use Chemistry in the Earth System to implement differential instruction in your classroom:

► **BIOZONE's Resource Hub** contains support materials for students of all abilities. The Resource Hub provides:

- **Short animations and videos:** Another way to approach the material covered in *Chemistry in the Earth System*. Students can view short videos (often with Spanish subtitles) to help them understand concepts or procedures. This approach is helpful to all students, but can be especially valuable for striving students.
- **Interactive spreadsheets:** These support activities requiring more complex data handling or modeling. Students can manipulate the data and see the consequences of these actions directly. These modeling activities can be utilized by all students, but gifted students may find the freedom of exploration particularly valuable as they can manipulate the spreadsheet more widely and explore to a deeper level if they wish.
- For teachers and more able students we have included the **source material** used to develop some activities. Capable or inquisitive students can view this material and develop a deeper understanding of the material covered.

► **Red flag codes** beside a section or question (on the Teacher's Edition or Teacher's Digital Edition) indicate that students may need extra guidance from the teacher to complete them. They may also indicate questions that can be used as extension material to challenge gifted students. These activities are also identified in the extended contents of this guide.

► **ELD support** is provided throughout *Chemistry in the Earth System*. English language learners progress through the ELD continuum while accessing high-quality science content the same time. It is worth noting that BIOZONE's scaffolded, inquiry-based approach, with an emphasis on collaboration, is in keeping with recommendations outlined in Chapter 4 of the ELD standards. In particular teachers can carefully structure collaborative learning practices that promote small-group discussion among students about, for example, the scientific information they read. Such practices foster comprehension and promote acquisition of vocabulary and understanding of language structure. *Ref: Heller and Greenleaf 2007; Klingner et al. 2004; Kosanovich, Reed, and Miller 2010; Short, Echevarría, and Richards-Tutor 2011; Vaughn et al. 2011.*

ELABORATE: Bond energies

It takes energy to break a chemical bond. Energy is released when a bond is formed. The difference between the amount of energy used to break a bond and the energy released when new bonds form will determine if the reaction is endothermic or exothermic.

Average bond enthalpy is the energy required to break one mole of a specified bond type in a gaseous state. By knowing the bond enthalpies of the reactants and products in a reaction we can calculate the overall enthalpy of the reaction without having to carry out any experiments.

Consider the following reaction:

Average bond enthalpy
413 kJ/mol
498 kJ/mol
805 kJ/mol
464 kJ/mol

For any reaction
 $\Delta H_r = \text{the sum of the bond enthalpies in reactants} - \text{the sum of the bond enthalpies in products}$

For the reaction above there are (4 x C-H bonds + 2 x O=O bonds) - (2 x C=O bonds + 4 x O-H bonds).
 Thus: (4 x 413 + 2 x 498) - (2 x 805 + 4 x 464) = 2648 - 3466 = -818 kJ/mol for the combustion of CH₄.

The measured enthalpy of combustion for methane is 882 kJ/mol. The discrepancy is due to the use of average bond enthalpies (for example the enthalpies of C-H vary from 439 kJ/mol to 411 kJ/mol depending on the molecule and its state).

32. At the start of this activity, you compared and calculated the enthalpy of combustion of three alcohols. You were also given the measured enthalpies of combustion for each alcohol. Now you can calculate the enthalpy of combustion using bond energies and compare this to the measured combustion enthalpy and your original answer.

The bond enthalpies you will need are C-C 347 kJ/mol, C-H 413 kJ/mol, C-O 358 kJ/mol, O-O 498 kJ/mol, C=O 805 kJ/mol, C-H 464 kJ/mol.

To make it simpler, we will assume that there is complete combustion with the only products formed being H₂O and CO₂.

(a) Review your balanced equation for methanol on page 135. Write out the number of each type of bond in the reactants and products for the combustion of methanol (bonds are C-H, C-O, O-H, C=O) (it may help to draw the structures of each molecule involved).

(b) Use the bond enthalpies to calculate the enthalpy of combustion for one mole of methanol.

(c) Calculate the enthalpy of combustion for ethanol:

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12 Modeling Energy Flow

EXPLORE: Energy2D

Computer simulations reproduce the behavior of a system using a computer. They provide a way to predict and model changes in a system by altering specific conditions within that system. Computer simulations allow us to examine complex systems and run many simulations in a short space of time without having to experiment with a physical system. The results of simulations are more accurate when the simulation closely models the real system.

During the simulation, you can transfer us to investigate heat transfer in a system by altering specific conditions within that system. Computer simulations allow us to examine complex systems and run many simulations in a short space of time without having to experiment with a physical system. The results of simulations are more accurate when the simulation closely models the real system.

In this activity, you will use Energy2D to model all three types of heat transfer (conduction, convection, and radiation).

Energy2D

Download Energy2D via the link on **BIOZONE's Resource Hub** or from <http://energy.concord.org/energy2d/index.html>

When you open the program you will see the screen on the right. Become familiar with the tools (below).

Drawing tools let you draw the object you want to investigate. You can add thermometers and anemometers to measure temperature and wind speed.

You can add particles, fans, clouds and other objects to investigate their effect on your model. You can graph the temperature changes using the graphing tool.

Zoom. This is important as the simulation starts at a scale larger than you would probably use the lab. You may need to zoom in to draw small objects or zoom out to draw large objects like houses.

Getting familiar with Energy2D

Follow the instructions below to run a simple simulation looking at heat and temperature and conduction. This will help you to become familiar with using Energy2D.

1. Click on the **Examples** tab at the top of the screen. Select **Heat and Temperature** then **Thermal Equilibrium Between Identical Objects from the drop down menu (right)**. You will see the screen shown below right.
2. Run the simulation for 10 seconds (push stop to end the simulation). You can stop and start the simulation at any time. For this example, the timer has been slowed down. You can do this by right-clicking on the workspace and selecting **Properties**. To set the timer to real time, set the **Time Steplength** to 0.1. This allows you to easily observe the changes in both thermometers during the simulation period.
3. You can view the simulation as a graph. After you have run your simulation click the graph icon to view the graph. If you would like to see the data graphed as the simulation runs, simply click on the graph icon before you click Run.

Now you are familiar with the simulation you will carry out some investigations involving conduction, convection, and radiation.

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◀ A red flag beside a section or question indicates that students may need some extra guidance from the teacher to complete this material. It may also highlight questions that can be used as extension material to challenge gifted students. These activities are also identified in the extended contents of this guide (CG3-CG4).

◻ A computer monitor indicates an activity where a device will be needed to carry out part or all of an activity. The activity may require access to online simulations (e.g. Energy2D), the interactive spreadsheets on **BIOZONE's Resource Hub**, or specific external websites suggested by BIOZONE as part of a student investigation. Computer models can be used by students to explore, elaborate and evaluate content.

A Phenomenon Based Approach

Throughout Chemistry in the Earth System, students are given opportunities to explore phenomena through simple experiments. These **investigative phenomena** are opportunities for students to develop competency in laboratory procedures, to practice and refine skills in observation and analysis, and to manipulate data. Some investigations act as stimulus material while others require students to take what they have already learned and apply their knowledge to a more complex scenario.

The investigations provide an excellent opportunity for collaborative work and will stimulate discussion and the sharing of ideas. You may wish to pair students of different abilities together. Confident students can guide and encourage less able students and, in this relaxed environment, striving students will be encouraged to share their own observations and thoughts. Collaboration through paired practical work provides an excellent opportunity for English language learners to interact in meaningful ways to extend their English language and scientific vocabulary.

Each investigation is clearly numbered (sequentially through the chapter). A list of the equipment and chemicals required for each investigation is provided in the appendix. Only standard equipment is used (no special kits are required).

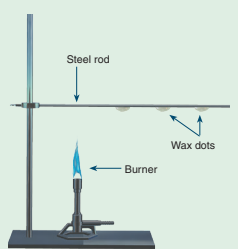
The investigations provide students with health and safety information at the start of the investigation.

- ▶ Ensure your students read through the procedure fully *before beginning* the investigation.
- ▶ Highlight any hazardous or important steps, and make sure the students follow your directions.
- ▶ IS1 contains basic safety guidelines for working in a laboratory. Students should complete these activities before they begin their own investigations.

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INVESTIGATION 2.1: See appendix for equipment list.

- Place wax dots along a steel rod at 2 cm intervals starting 25 cm from one end. Attach the rod to a clamp stand as pictured so that the first wax dot is 15 cm from the point directly above the Bunsen burner.
- Set the Bunsen burner flame to blue and start a timer.
- Observe the effect on the wax dots. Record the time for each dot to start melting.
- Let the steel rod cool down, then set the flame to a yellow flame and repeat the procedure.



Wax dot	Time to start melting (blue flame)	Time to start melting (yellow flame)
1		
2		
3		

- Remove the steel rod and replace it with a copper rod. Carry out the investigation again, this time on the blue flame only. Record the results in the table right:
- Repeat step 5 above using an aluminum rod. Record the result in the table right:

Wax dot	Time to start melting (copper rod)	Time to start melting (aluminum rod)
1		
2		
3		

11. (a) Was there a time difference for each wax dot to start melting when the blue flame was applied? What was it?

(b) Was there a time difference for each wax dot to start melting when the yellow flame was applied? What was it?

plain why there was a difference in time between the first dot melting when a blue flame was applied and low flame was applied?

is to represent the particles in the metal wire, draw a diagram to represent how you think the energy of the melting the wax dots:

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EXPLORE: Energy changes in reactions

You have already seen some exothermic reactions. These are often associated with the release of light and a flame, but not always. The following investigation demonstrates exothermic and endothermic reactions.

INVESTIGATION 4.5: See appendix for equipment list.

The chemicals you will be using are all irritants. Wear eyewear and gloves.



- For each of the following reactions measure the initial and final temperature and record them in the table below:
- To a 25 mL beaker add 1 gram of solid sodium hydroxide with 20 mL of water and mix.
- To a 25 mL beaker add 1 gram of solid ammonium chloride to 10 mL of water and mix.
- To a 25 mL beaker add 5 mL of 1 mol/L hydrochloric acid to 5 mL of 1 mol/L sodium hydroxide.
- Mix 1 gram of solid ammonium thiocyanate with 10 mL of water and mix.

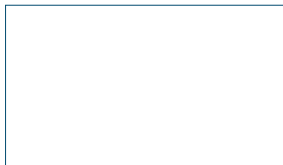
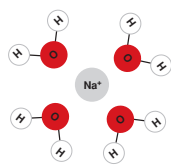
$\text{NaOH}_{(s)} \rightarrow \text{NaOH}_{(aq)}$				
$\text{NH}_4\text{Cl}_{(s)} \rightarrow \text{NH}_4\text{Cl}_{(aq)}$				
$\text{HCl}_{(aq)} + \text{NaOH}_{(aq)} \rightarrow \text{NaCl}_{(aq)} + \text{H}_2\text{O}_{(l)}$				
$2\text{NH}_4\text{SCN}_{(s)} + \text{Ba}(\text{OH})_2 \cdot 8\text{H}_2\text{O}_{(s)} \rightarrow \text{Ba}(\text{SCN})_2_{(s)} + 2\text{NH}_3_{(g)} + 10\text{H}_2\text{O}_{(l)}$				

Chemical hazards and required PPE (where applicable) are clearly identified on the investigation.

18. Consider the first reaction of solid NaOH forming aqueous NaOH (i.e. dissolving NaOH). Note that NaOH is an ionic substance. When it dissolves, the ionic bonds are broken.

- (a) Does breaking an ionic bond require energy? _____
- (b) Hydrogen bonds between water molecules are also broken when the NaOH dissolves. Does breaking these bonds require energy? _____

(c) The final step in the dissolving of NaOH is the formation of bonds between the Na^+ and OH^- ions and the polar water molecules. The diagram below left shows how the water molecules orientate around the Na^+ ion. In the space below right draw a similar diagram to show how the water molecules orientate around the OH^- ion.



- (d) Does forming the bonds between the water molecules and the Na^+ and OH^- ions require energy or release energy? _____

The investigations have been designed using everyday materials and equipment easily found in most high school laboratories. No special kits are required.

California Environmental Principles and Concepts

The California Environmental Principles and Concepts (EP&Cs) have been incorporated into Chemistry in the Earth System to increase environmental literacy. This in accordance with the requirements of the California Education and the Environment Initiative (EEI). Within *Chemistry and the Earth System*, the EP&Cs material provides examples and context for students to study the relationship between humans and the natural world. For example, how does the carbon dioxide released from burning fossils fuels affect the oceans?

Activities containing EP&Cs are easily identified in Chemistry in the Earth System.

- ▶ In the Teacher's Edition (and Teacher's Digital Edition) the EP&Cs are identified in the chapter front in **orange**. For example: Evaluate the costs and benefits of extracting and using coal (or any other fossil fuel). Include reference to its ability to provide usable energy as well as the effect of its combustion on the environment [EP&Cs: V].
- ▶ **Orange** boxes within specific activities clearly identify where EP&Cs are covered (see below).
- ▶ The specific EP&C code (e.g. EP&C V) is identified on the page so you know exactly which principle is being covered.

The specific EP&C is clearly identified on the page.

CA EP&Cs III & IV:

Human practices can alter the cycles and processes that operate within natural systems (III c).

The byproducts of human activity are not readily prevented from entering natural systems and may be beneficial, neutral, or detrimental in their effect (IV b).

The capacity of natural systems to adjust to human-caused alterations depends on the nature of the system as well as the scope, scale, and duration of the activity and nature of its by-products. (IV c).

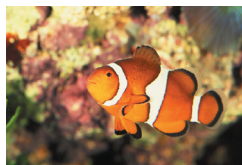
Carbon dioxide

▶ The burning of fossil fuels produces energy for humans needs but also vast quantities of carbon dioxide, some of which is absorbed by the oceans.

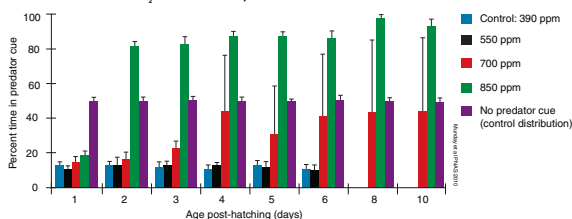
▶ The natural alkalinity of the oceans acts to a certain degree as a buffer against the acidifying nature of CO₂. Continued absorption of CO₂ shifts the carbonate-bicarbonate equilibrium in favor of bicarbonate.

Ocean acidification and fish

- ▶ A lower ocean pH does not only affect animals that build shells. New studies on fish show that increased CO₂ can affect their behavior and ultimately their chances of survival.
- ▶ A study of the behavior of clownfish (*Amphiprion percula*) (right) was carried out by raising larval clownfish in seawater at ambient CO₂ (390 ppm), 550 ppm, 700 ppm and 850 ppm CO₂.
- ▶ At each CO₂ concentration, the larval fish were given a choice of water streams. One contained the chemical cue of a natural predator and the other did not. The results are shown in the graph below. For each set of trials, there was also an untreated control, where both water streams lacked the predator cue (purple bars).

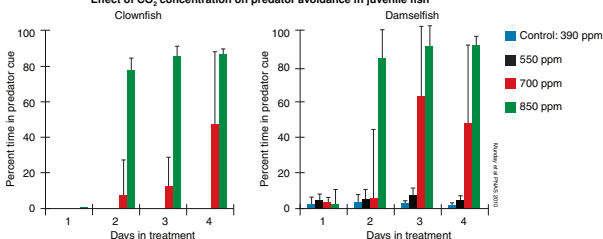


Effect of CO₂ concentration on predator avoidance in larval clownfish



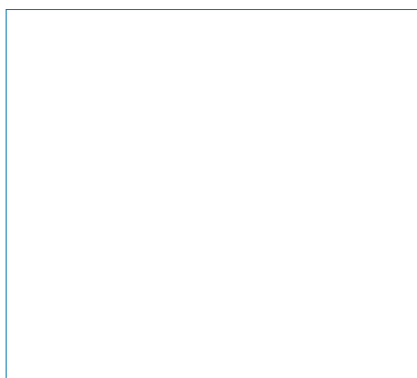
- ▶ The clown fish were tested for predator avoidance again at the settlement stage (transformation to a juvenile). These were compared to wild caught damselfish (*Pomacentrus wardi*) that were also treated with the same levels of CO₂. The graph below shows their behavior at different levels of CO₂.

Effect of CO₂ concentration on predator avoidance in juvenile fish



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10. Use the table on page 173 and your spreadsheet to develop a diagram that models the carbon cycle:

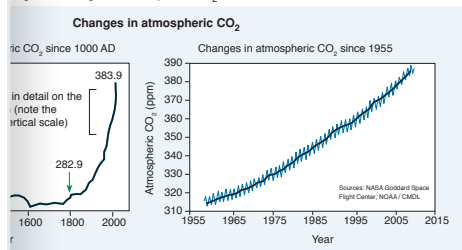


CA EP&Cs III: Natural systems proceed through cycles and processes that are required for their functioning (III a). Human practices can alter the cycles and processes that operate within natural systems (III c)

Carbon cycling

- ▶ The carbon cycle is a natural system in which the element carbon moves between reservoirs via biological and geological pathways.
- ▶ Humans can alter the carbon cycle by moving carbon from one reservoir (fossil fuels) and adding it to another (the atmosphere) without there being an equivalent return pathway.

Atmospheric carbon dioxide
long term changes to atmospheric CO₂.



Relationship between atmospheric carbon dioxide, the human population and use of fuels. These fuels may be having on the atmosphere and the Earth.

ETS SEPs, DCIs, and performance expectations as indicated in the CA-NGSS framework are met through appropriately integrated engineering and design challenges. Typically tasks include analyzing problems, developing solutions using engineering, evaluating a design solution based on costs and benefits, or modeling a design solution.

The three dimensions of the NGSS framework appropriate to each design challenge are indicated in the chapter introduction of the Teacher's Edition (and Teacher's Digital Edition) and indicated through the tab system on the activity itself. Such tasks are usually examples of 'ELABORATE' as they involve the students applying what they learned to solve a problem. As such, they also make good tasks for formative or summative assessment.

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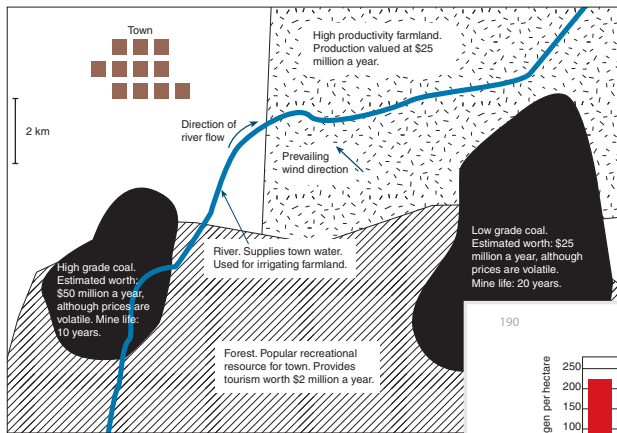
EVALUATE: Are coal and oil worth it?

CA EP&Cs V: The spectrum of what is considered in making decisions about resources and natural systems and how those factors influence decisions (V a)

Is it worth it?

- ▶ The effort in and return from exploiting a resource must be considered. Put simply, "Is it worth it?"
- ▶ This question must consider not only the energy return but the economical, social, and environmental aspects of that return.
- ▶ Is it worth removing 100 hectares of forest for 10,000 barrels of oil or 10,000 tonnes of coal? Does the type of forest matter? What value do we place on the services provided by the forest, including recreation and aesthetics, shelter, air and water purification, climate moderation, and protection from erosion.

11. The diagram below shows a simplified map of a region where two possible areas could be surface-mined for coal. Use the information below and in this activity to evaluate the costs and benefits of mining at each proposed site. Produce a reasoned argument for which mine site is best.



In this ETS example, students are asked to evaluate the costs and benefits of mining coal at two different site. They must evaluate a range of factors and decide which option is best. Cost, productivity, effect on the nearby township and its water supply, and tourism are all considered. The activity provides an excellent example of how ETS can be linked to achieve CA EP&Cs outcomes.

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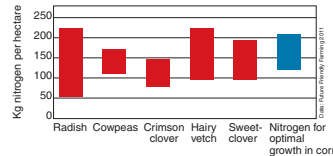


Figure 1: Cover crops can provide the nitrogen needed for optimal growth of corn.

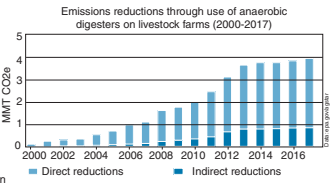


Figure 2: Since 2000, anaerobic digesters on livestock farms in the US have reduced direct and indirect emissions by 34.6 MMTCO₂e (million metric tons CO₂ equivalent).

Treatment	Soil loss (tonne/ha)
Bare plot	73.8
Conventional tillage	17.3
Minimal tillage	2.1

Table 1: Soil loss for three tillage systems on a typical agricultural soil in Venezuela.

Tillage Regime	Moisture retention in soil (%)			
	Maize	Pigeon peas	Soybeans	Cowpeas
Plowed	9.7	10.8	7.3	12.3
No tillage	13.3	12.1	10.6	15.4

Table 2: Effect of tillage regime on soil moisture retention at 0-10 cm depth under different crops two weeks after planting.

Site	Regime	Soil C (tonne C/ha)
Site 1	MiG ₂₁	46.6*
	Ext ₅₀₊	40.4*
Site 2	MiG ₂₅	36.2
	Ext ₅₀₊	32.2
Site 3	MiG ₅	59.5*
	Ext ₅₀₊	45.1*
Site 4	MiG ₃	50.9*
	Ext ₅₀₊	42.8*

Table 3: Total soil carbon for the top 50 cm of soil at four sites (VA, USA). MiG = Management-intensive grazing or short rotational grazing. Ext = extensive grazing (low stocking continuous). Subscript refers to number of years under that regime. Asterisks indicate a significant different between management treatments.



Data from numerous field studies indicate short rotation grazing regimes (MiG) can increase productivity and lead to substantially higher soil carbon. In one study of grazing regimes in the southeastern US (Conant, 2003), total organic soil carbon average 22% greater under MiG. However, the benefits are dependent on available moisture and the findings may not apply to arid lands or during drought conditions.

During this activity, students work in groups to evaluate the effects of seven farming practices on soil sustainability and carbon emissions. After presenting their findings to the class, the entire class must debate the merits and limitations of each and collectively set goals to conserve the soil resource, reduce emissions from soil, and increase soil storage of carbon.

This activity not only provides excellent practice in analyzing a real life problem and seeing how a technological solution can help to solve it, but the collaborative nature of the work is beneficial to English language learners.

10. (a) Divide your class into seven groups. Each group should choose one of the farming practices described on the previous page and evaluate its features and design in terms of its capacity for sustainable use of a resource (soil) and its ability to sequester carbon and reduce greenhouse gas emissions. Some additional data has been provided in the tables and figures above. You may use this information and any other research or case studies to support your evaluation (visit the [BIOZONE Resource Hub](#) for more information). Summarize the main points of your group's evaluation in a shared document, including any supporting evidence.

(b) Present your group's findings to the class. The class must then decide collectively what goal and targets are required to conserve the soil resource and best manage it to sequester carbon.

(c) It is not practical to implement all of these farming practices at the same time. In your original groups, **select two** farming practices that you think are compatible and would provide the greatest benefits in terms of use of the soil resource and reducing greenhouse gas emissions. Write your two practices below and briefly explain why you made this choice. Include a summary of the likely costs and benefits involved, including social, environmental, energetic, and economic considerations. Share your findings with the class.



The Nature of Science

The Nature of Science combines established information with new knowledge to constantly refine what we know about the natural world. Eight Nature of Science understandings are presented in the NGSS document. Four are associated most closely with Science and Engineering Practices, and four with the Crosscutting Concepts. Because the Nature of Science understandings have been incorporated into most activities in *Chemistry in the Earth System*, we have not identified them specifically on the activity page. Some examples of activities relating to the eight Nature of Science understandings are illustrated below. The subheading to which they relate is also given.

Nature of science understandings most closely associated with science and engineering practices

11 Finding the nucleus

1. What was the question that Rutherford, Geiger and Marsden wanted to answer with their experiment?

2. How did they design their experiment to answer the question?

3. What were the expected results of the experiment?

4. How did the actual results differ from the expected results?

5. How did Rutherford explain the difference between the expected and actual results?

EXPLORE: Finding the nucleus

Under the direction of Ernest Rutherford, Hans Geiger and Ernest Marsden carried out a series of experiments to answer what question scientists thought atoms were like at the ground. They discovered the presence of a nucleus inside atoms.

Classically, atoms were thought to be a uniform sphere of positive charge with negatively charged electrons embedded throughout. Rutherford's experiment showed that atoms have a small, dense, positively charged nucleus.

Based on calculations from earlier atomic models, it was expected that the alpha particles would pass straight through the gold foil or be only slightly deflected.

Instead for alpha particles were often and occasionally "bounced" back at more than 90°.

Scientific investigations use a variety of methods.

Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge

12 The outer structure of the Earth - discovering the Moho

1. In 1909, Andrius Mohorovičić was studying seismic waves from an earthquake in the Zagreb region of the Balkans. He noticed that seismic waves of P and S waves from the earthquake arrived at his station at different times than expected. He noticed a sharp increase in the velocity of P and S waves at a depth of about 600 km. This was the Moho.

2. How did Mohorovičić explain the increase in the velocity of P and S waves at the Moho?

3. How did the actual results differ from the expected results?

4. How did Rutherford explain the difference between the expected and actual results?

EXPLORE: The outer structure of the Earth - discovering the Moho

In 1909, Andrius Mohorovičić was studying seismic waves from an earthquake in the Zagreb region of the Balkans. He noticed that seismic waves of P and S waves from the earthquake arrived at his station at different times than expected. He noticed a sharp increase in the velocity of P and S waves at a depth of about 600 km. This was the Moho.

Mohorovičić noticed a distinct zone of P and S waves and a difference in the velocity of P and S waves.

His work resulted in the discovery of the Mohorovičić Discontinuity.

How do you think the change in velocity at the Moho is related to the change in the density of the Earth's outer layer?

Scientific knowledge is based on empirical evidence.

Scientific knowledge is based on empirical evidence.

13 Thomson's model of the atom

1. What was the question that Thomson wanted to answer with his experiment?

2. How did he design his experiment to answer the question?

3. What were the expected results of the experiment?

4. How did the actual results differ from the expected results?

5. How did Thomson explain the difference between the expected and actual results?

EXPLORE: Thomson's model of the atom

Thomson's model of the atom was based on the discovery of the electron. He proposed that the atom was a sphere of positive charge with negatively charged electrons embedded throughout. This model was called the plum pudding model.

Rutherford's model of the atom was based on the discovery of the nucleus. He proposed that the atom was a sphere of positive charge with a small, dense, positively charged nucleus in the center. This model was called the nuclear model.

Scientific knowledge is open to revision in light of new evidence.

Most scientific knowledge is quite durable but is subject to change based on new evidence and/or reinterpretations of existing evidence.

50 Systems and System Models

1. What was the question that you wanted to answer with your experiment?

2. How did you design your experiment to answer the question?

3. What were the expected results of the experiment?

4. How did the actual results differ from the expected results?

5. How did you explain the difference between the expected and actual results?

EXPLORE: Systems and System Models

A system is an interacting set of matter and energy. It is a collection of parts that work together to perform a function. A system can be as simple as a pot on a stove or as complex as a cell.

A model is a representation of a system that helps us understand how it works. A model can be as simple as a drawing or as complex as a computer simulation.

Models are useful for understanding how a system works. They help us to see the parts of the system and how they interact. They also help us to predict how the system will behave under different conditions.

Science models, laws, mechanisms, and theories explain natural phenomena.

Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.

Nature of science understandings most closely associated with crosscutting concepts

10 The nature of science - a brief overview of atomic theory

1. What was the question that you wanted to answer with your experiment?

2. How did you design your experiment to answer the question?

3. What were the expected results of the experiment?

4. How did the actual results differ from the expected results?

5. How did you explain the difference between the expected and actual results?

EXPLORE: The nature of science - a brief overview of atomic theory

The nature of science is a way of knowing. It is a way of asking questions and finding answers. It is a way of testing ideas and theories. It is a way of building on what we already know.

The development of atomic theory is a good example of the nature of science. It shows how scientists use evidence to build a model of the atom. It shows how scientists use models to test their ideas and theories. It shows how scientists use models to predict how the atom will behave under different conditions.

Science is a way of knowing.

Scientific knowledge has a history that includes refinement of, and changes to, theories, ideas, and beliefs over time.

11 Getting to know the periodic table

1. What was the question that you wanted to answer with your experiment?

2. How did you design your experiment to answer the question?

3. What were the expected results of the experiment?

4. How did the actual results differ from the expected results?

5. How did you explain the difference between the expected and actual results?

EXPLORE: Getting to know the periodic table

The periodic table is a table of elements. It is a way of organizing the elements so that we can see their similarities and differences. It is a way of seeing how the elements are related to each other.

The periodic table is organized into groups and periods. The groups are the columns of elements. The periods are the rows of elements.

The elements in the same group have similar properties. The elements in the same period have similar properties.

Scientific knowledge assumes an order and consistency in natural systems.

Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and will continue to do so in the future.

12 Evidence for Earth's Structure

1. What was the question that you wanted to answer with your experiment?

2. How did you design your experiment to answer the question?

3. What were the expected results of the experiment?

4. How did the actual results differ from the expected results?

5. How did you explain the difference between the expected and actual results?

EXPLORE: Evidence for Earth's Structure

The Earth has an internal structure. It is made up of several layers. The layers are the crust, the mantle, and the core.

The crust is the outermost layer. It is the layer that we live on. It is made of solid rock.

The mantle is the layer below the crust. It is made of hot, molten rock. It is the layer that is responsible for the Earth's magnetic field.

The core is the innermost layer. It is made of iron and nickel. It is the layer that is responsible for the Earth's magnetic field.

Science is a human endeavor.

Technological advances have influenced the progress of science and science has influenced advances in technology.

14 Evidence for Earth's Structure

1. What was the question that you wanted to answer with your experiment?

2. How did you design your experiment to answer the question?

3. What were the expected results of the experiment?

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Science addresses questions about the natural and material world.

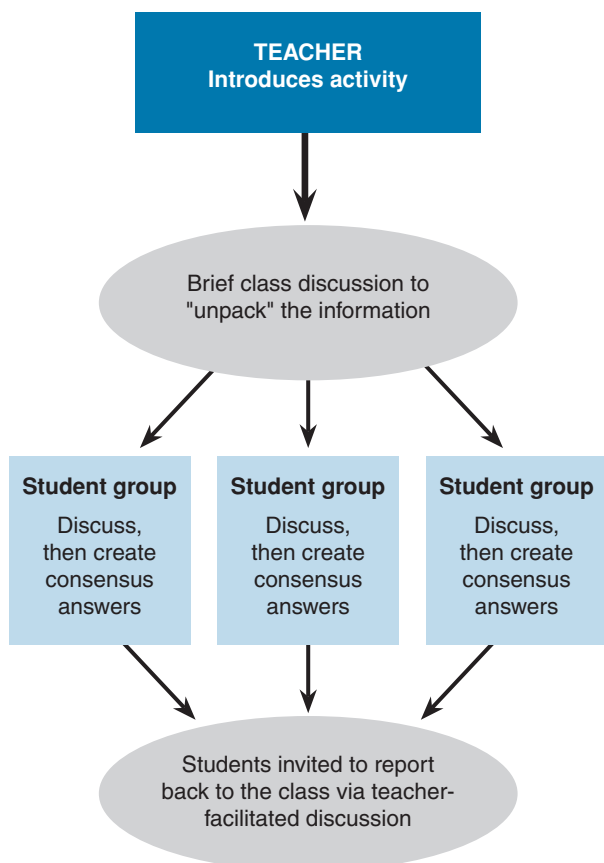
Scientific knowledge indicates what can happen in natural systems - not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.

Teaching Strategies for Classroom Use

Achieving effective differential instruction in classes is a teaching challenge. Students naturally have mixed abilities, varying backgrounds in the subject, and different language skills. Used effectively, BIOZONE's student books and supporting resources can make teaching a mixed ability class easier. Here, we suggest some approaches for differential instruction.

MAKING A START

Regardless of which activity you might be attempting in class, a short introduction to the task by the teacher is a useful orientation for all students. For collaborative work, the teacher can then divide the class into appropriate groups, each with a balance of able and less able students. Depending on the activity, the class may regroup at the end of the lesson for discussion.



Using collaboration to maximize learning outcomes

- The structure of *Chemistry in the Earth System* allows for a flexible approach to unpacking the content with your students.
- The content can be delivered in a way to support collaboration, where students work in small groups to share ideas and information to answer and gain a better understanding of a topic, or design a solution to a problem.
- By working together to ask questions and evaluate each other's ideas, students maximize their own and each other's learning opportunities. They are exposed to ideas and perspectives they may not have come up with on their own.
- Collaboration, listening to others, and voicing their own ideas is valuable for supporting English language learners and developing their English and scientific vocabularies.
- Use a short, informal collaborative learning session to get students to exchange ideas about the answer to a question. Alternatively, collaboration may take a more formal role that lasts for a longer period of time (e.g. assign groups to work together for a practical activity, to research an extension question, or design a solution to a problem).



The teacher introduces the topic. They provide structure to the session by providing background information and setting up discussion points and clear objectives. Collaboration is emphasized to encourage participation from the entire group. If necessary, students in a group can be assigned specific tasks.



Students work in small groups so everyone's contribution is heard. They collaborate, share ideas, and engage in discourse. The emphasis is on discussing questions and formulating a consensus answer, not just sharing ideas.



At the end of the session, students report back on their findings. Each student should have enough knowledge to report back on the group's findings. Reporting consists primarily of providing answers to questions, but may involve presenting a report, model, or slide show, or contributing to a debate.

Peer to peer support



- **Peer-to-peer (collaborative) learning** can be used for any activities, but is particularly valuable for more challenging activities in which the content is more complex or the questions require students to draw on several areas of their knowledge to synthesize an answer. Examples of such activities include investigative activities, activities with a design component, or activities involving data analysis, graphing, and evaluation.
- Stronger peers can assist weaker students and both groups benefit from verbalizing their thoughts and presenting them to a group. Students for whom English is a second language can ask their peers to explain unfamiliar terms (both scientific and English) and this benefits the understanding of both parties.
- **Practical investigations** are an ideal vehicle for peer-to-peer learning. Students can work in groups or pairs and their results and observations prompt them to voice their questions and think about how they could use the information obtained to describe phenomena or answer specific questions. There are also opportunities for students to collaborate using online simulations (e.g. **Energy2D** shown below).

12

EVALUATE: Heat of fusion of ice
 It is accepted that 333 J of heat is needed to melt one gram of ice. But what result do you get when you actually carry out an experiment to test this value?

▶ **INVESTIGATION 1.3:** See appendix for equipment list.
Record your measurements in the table (below right)

1. Weigh the mass of a dry polystyrene cup (your calorimeter).
2. Add 100 mL of hot tap water (>50°C) to the cup. If your water is not hot enough, heat it gently over a Bunsen burner before adding it to your polystyrene cup. Record the mass of the cup and hot water.
3. Using a thermometer, determine the temperature of the hot water.
4. Add two ice cubes into the cup. Gently stir them until they are melted. Record the lowest temperature reached during this stage. This is your final temperature.
5. Determine the mass of the cup, water, and melted ice:
6. Calculate the heat of fusion of ice (show your working in the space below).

Students work in pairs or small groups to determine how much energy is needed to melt ice. They compare their own results to a theoretical value and discuss between themselves (and other groups) why variations may have occurred.

Sharing ideas and observations promotes scientific dialogue.

Mass (g)	
Hot water mass (g)	
Total mass of hot water (g)	
Temperature of hot water (°C)	
Temperature of hot water (°C)	
Temperature change (°C)	
Calorimeter, hot water	
Calculated mass of ice cubes (g)	

You can determine how close your result is to the accepted (ideal) value by calculating the percentage error. In this instance the ideal value is 333.3 J/g. The equation for measuring percentage error is:

$$\frac{\text{experimental value} - \text{ideal value}}{\text{ideal value}} \times 100$$

16. Calculate the percentage error for your investigation here (show your working): _____

17. (a) One student obtained a very large percentage error. What could be the possible sources of this?

(b) How could they take steps to reduce this? _____

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Energy Flow

produce the behavior of a system using...
 s and
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 ftware
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Students carry out computer simulations to study heat transfer. They can compare simulated results to the results they obtained in their own investigations. This provides an opportunity for peer discussion to account for any differences.

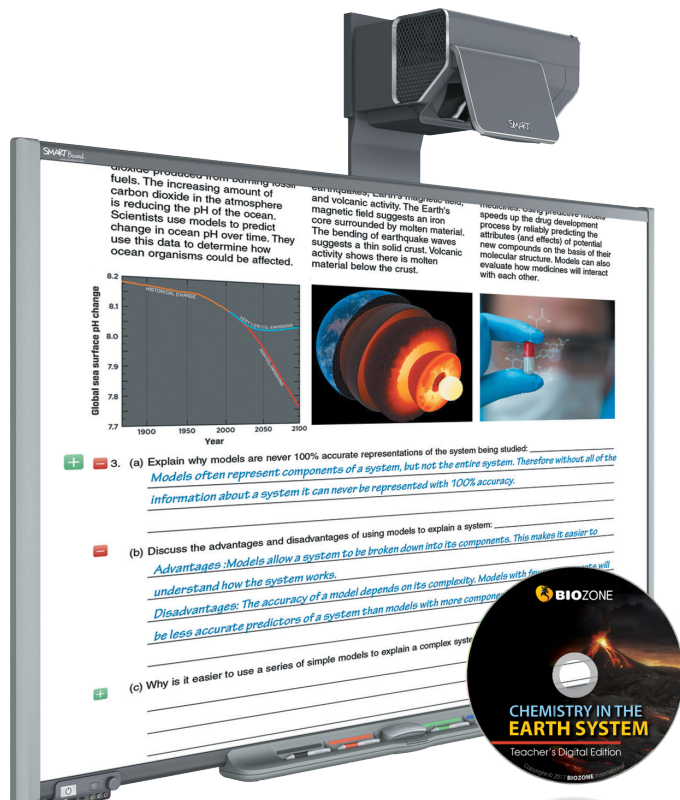
Any new ideas or questions arising from the discussion can easily be tested on the simulation.

You can graph the temperature changes using the graphing tool.
 parts at a scale larger than you need to zoom in to objects like houses.

Workspace
 Run and reset the simulation.
 Scale

the simulation looking at this will help you to
 the screen.
Thermal Equilibrium
 p down menu (right).
 t.
 stop to end the simulation at any time. You can slow down, You can speed up and selecting at the Time slider to observe the simulation period.
 r you have run the graph. If you stop the simulation runs, click Run.
 carry out some of radiation.

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Interactive revision of tasks in class

- The **Teacher's Digital Edition** provides a digital rights managed (DRM) version of the student book as PDF files. It features useful HIDE/SHOW answers, which can be used to review activities in class using a data projector or interactive whiteboard (left).
- Students benefit from the feedback in class, where questions can be addressed, and teachers benefit by having students self-mark their work and receive helpful feedback on their responses.
- This approach is particularly suited to activities with questions requiring a discussion, as students will be able to clarify some aspects of their responses. Stronger students can benefit by contributing to the explanatory feedback and class discussion.

NGSS as collaboration and discovery

- BIOZONE's *Chemistry in the Earth System* provides multiple chances for collaboration and discovery. By working together and sharing ideas, students are exposed to different perspectives and levels of knowledge about a particular phenomenon.
- NGSS requires deeper student engagement with less emphasis on facts and more on understanding. By exploring principles and concepts within a context students are more easily able to apply these principles to new phenomena.
- BIOZONE's *Chemistry in the Earth System* uses the CA NGSS as a framework to develop student understanding by providing a range of activities. These begin by getting students to think about and share what they already know and then build on this knowledge by providing opportunities to explore and explain phenomena.

Student A is capable. He helps to lead the discussion and records the others ideas in a structured way.

Students B and C are also capable but less willing to lead discussion they will add ideas to the discussion but need a little direction from A to do so.

Student D is less able but gains ideas and understanding from the discussion of students A, B, and C. She may add to the discussion as she gains confidence in the material being studied.



Formative and Summative Assessment

Chemistry in the Earth System provides ample opportunity for students to demonstrate their understanding and proficiency in all three dimensions of the standards. Opportunities for both formative and summative and assessment are provided.

As this series has been written specifically for the CA-NGSS Three Course Model, all activities (including assessments) are three-dimensional in their approach, with the goal to enable achievement of specific performance expectations. Performance expectations (PE) are not always met through completion of one activity or assessment, but through completion of a connected suite of tasks (as intended by the framework).

Assessments involve a variety of tasks as appropriate to a 3D approach, e.g., constructing models, analyzing and interpreting data, explaining, and communicating understanding through short and long answers, drawings, calculations, group work, design, and problem solving. The structure of the tasks is such that students use specific science and engineering practices and apply relevant crosscutting concepts to demonstrate their understanding of disciplinary core ideas.

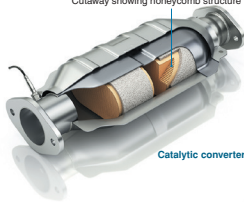
Formative assessments can be chosen by the teacher to determine how a student’s knowledge is progressing within a selected topic. We suggest that ‘ELABORATE’ and ‘EVALUATE’ sections of activities be used for formative assessment. These may incorporate some aspect of a performance expectation with the goal being to build confidence. Teachers can revise their instruction, revisit material, or set further tasks if a student is having difficulty with the material. Revisiting the Anchoring Phenomenon near the end of each instructional segment also provides a way to evaluate student understanding.

ELABORATE: Catalysts

Catalysts are important in many everyday and industrial reactions. Catalysts are chemicals that increase the rate of a reaction by lowering the activation energy required for the reaction to proceed.

- They do this by offering an alternative reaction pathway or orientating the reactants into the best positions for a reaction.
- Catalysts are not used up in the reaction.
- One of the most common everyday reactions involving a catalyst occurs in **catalytic converters**. These are found in the exhaust systems of gasoline and diesel fueled cars.
- The incomplete combustion of fuel and the reaction of nitrogen at high temperature with oxygen produces harmful gases (e.g. CO, NO). Catalytic converters convert these into less harmful gases (e.g. CO₂).

Cutaway showing honeycomb structure

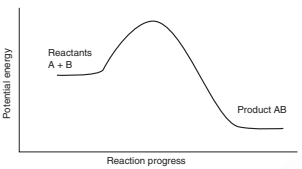


Catalytic converter

14. Study the image of the catalytic converter shown above right. The catalytic compounds coat the honeycomb like inner structure of the converter. Why do you think the converter has this honeycomb like structure?

15. The catalytic converter operates at about 400°C, using the heat of the exhaust to maintain the temperature. Below this temperature the catalytic reactions are less successful. Why does the catalyst need to operate at a higher temperature?

16. The graph below shows the reaction of two reactants A and B without a catalyst. Sketch onto the graph a line showing the reaction in the presence of a catalyst:



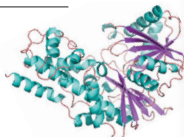
Potential energy

Reactants A + B

Product AB

Reaction progress

- Living organisms are essentially a massive collection of chemical reactions. Every action we carry out, such as bending a finger, breathing, or digesting food involves hundreds of millions of chemical reactions.
- Most reactions in living organisms involve **enzymes**. Enzymes are biological catalysts, which vastly increase the rate of reactions.
- Recall that aerobic respiration begins with the process of glycolysis. There are nine different reaction ‘steps’ in glycolysis. Each step has its own enzyme to catalyze the reaction.
- Enzymes have very specific three dimensional shapes that are able to attract and orientate the reactants so that a reaction occurs.



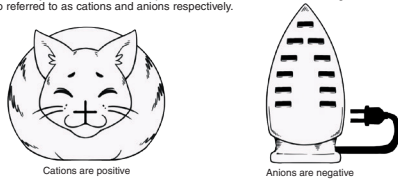
Hexokinase (above) catalyzes the first step in glycolysis.

17. It is estimated that there are 75,000 kinds of enzymes in the human body. Explain why so many enzymes are needed:

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ELABORATE: Important ions

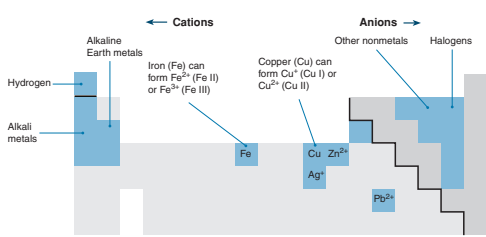
You should realize by now that metals form positive ions and non metals form negative ions. Positive and negative ions are also referred to as cations and anions respectively.



Cations are positive

Anions are negative

Important monoatomic ions you should know are shown below:



← Cations →

Alkaline Earth metals

Alkali metals

Hydrogen

Iron (Fe) can form Fe²⁺ (Fe II) or Fe³⁺ (Fe III)

Copper (Cu) can form Cu⁺ (Cu I) or Cu²⁺ (Cu II)

Other nonmetals

Halogens

Fe

Cu

Zn²⁺

Ag⁺

Pb²⁺

19. Explain why first group elements always form an ion with a single positive charge:

20. Would you expect the element carbon to form a cation or an anion? Explain your reasoning:

21. Explain why nonmetals do not form cations:

22. What can be said about any elements that are in the same group number of the periodic table?

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Summative assessments at the close of each instructional segment can be used as a formal testing moment to evaluate student skills, understanding, and application of knowledge of the material covered. They are designed to meet part or all of one or more performance expectations. The performance expectations they cover are identified in the chapter introduction for the instructional segment, and also in the tables summarizing BIOZONE's 3D approach by chapter earlier in this guide (CG5-CG6).

Summative assessments ask students to undertake a variety of different tasks. They may include:

- ▶ Short answer questions
- ▶ Long answer questions
- ▶ Graphing
- ▶ Data analysis and interpretation
- ▶ Modeling

70

17 Summative Assessment

1. What do you understand by the term energy? _____

2. Why does a metal rail feel cold on a cold morning? _____

3. Heat energy always flows in a specific direction. large scales how this drives plate tectonics on Earth? _____

71

▶ This part of this activity uses Google Earth. Google Earth is freely available online at <https://www.google.com/earth/>. Type Google Earth into your search engine or follow the link on the [BIOZONE Resource Hub](#) for this activity.

5. Launch Google Earth. On the left hand side of the screen there are menu icons. Click on the **Voyager** icon, the one that looks like a ship's wheel. Find the **Layers** tab and click it. Scroll down until you see the **Seafloor age** globe. Click this. A layer will be added to the globe showing the ages of the seafloor around the globe. Rotate the globe around to the Atlantic Ocean.

(a) Where are the youngest rocks in the Atlantic found? _____

(b) What is their age? _____

(c) Where are the oldest rocks in the Atlantic found? _____

(d) What is their age? _____

(e) Notice that parts of the continents are shaded blue. How old are these rocks? _____

(f) Why would these rocks be this age? _____

(g) In general where are the youngest rocks of the Earth's ocean floor found? _____

6. Exit the Seafloor age. Google Earth is able to import .kml or .kmz files. These files contain data that adds layers to the globe. First, go to <https://earthquake.usgs.gov/learn/kml.php> or follow the link at the [BIOZONE Resource Hub](#).

i) Download the **Tectonic Plate Boundaries** file. Save it where you can find it easily. Return to Google Earth.

ii) Click on the **My Places** tab, then click **Import KML** file.

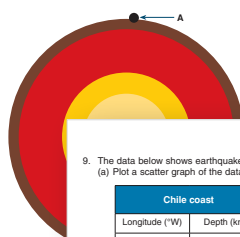
iii) Click **Open** file and navigate to where you have saved the file. You can save the imported file to Google Earth so that it is also available when you open Google Earth

iv) Once the file is imported, several layers will appear. Click off the **My Places** tab to hide it.

7. (a) Label the layers of the Earth in the diagram below.

(b) Beside your labels note whether the layer is solid or liquid.

(c) There was an earthquake at point A on the diagram below. Draw lines to show how the P and S-waves of the earthquake would move through the Earth and identify where they could (or could not) be detected on the surface.



72

(d) Explain why the waves are detected in this area? _____

8. Draw a diagram in the space below to show it. You should make sure your diagram has five significant in plate tectonics.

73

9. The data below shows earthquake depths recorded off the coast of Chile with respect to longitude (East/West) position:

(a) Plot a scatter graph of the data on the grid provided:

Chile coast	
Longitude (°W)	Depth (km)
67.5	180
68.3	130
62.3	480
62.0	600
69.8	30
69.8	55
67.7	120
67.9	140
69.2	35
68.6	125
68.1	145
65.2	295
69.7	50
68.2	160
66.2	230
66.3	215
68.5	140
68.1	130

(b) Add a line of best fit through the data points:

(c) Draw a diagram below to show how the tectonic plates are moving near the Chile coast. Include relevant labels:

10. Study the images below. Place them in order of first event to last event. Explain your order of events in terms of entropy:

A

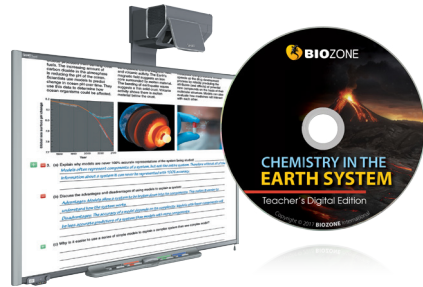
B

C

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The Teacher's Digital Edition

The *Teacher's Digital Edition* is a DRM product, sold separately, and aimed primarily at extending the pedagogical tools at a teacher's disposal. Many of the features of this resource have been developed in response to requests from teachers themselves.



Digital copy of the Model Answers (non-printable). Suggested answers are provided to most activities.

This Classroom Guide is provided as a printable PDF.

A digital (PDF) version of the student edition (non-printable). Use the interactive buttons to HIDE or SHOW the answers.

Teacher's Digital Edition
 ▶ Show and hide answers on-screen using the digital version of the workbook. Several pages and multiple-part answers with the click of a button. Provided with Zoom in/out capabilities to show detail.

Model Answers
 ▶ The Model Answers booklet provides suggested answers for the activities in the book. Model Answers are also provided as a download in the PDF of the workbook.

Resource HUB
 ▶ Most activities are supported online via BIOZONE's Resource Hub, which provides direct access to supplementary reading, animations, videos, 3D models, and reference papers.
 www.biozonehub.com
 Enter code: CES1-9211

Classroom Guide
 ▶ A comprehensive guide to the Living Earth. It provides strategies for use with students of different abilities and for a variety of tasks, including assessment.

Spreadsheets and Statistics
 ▶ Microsoft Excel® Spreadsheets directly support activities involving computational modelling, or data handling and analysis. Click here to view the ICT activities available.

Presentation Media
 ▶ Sample from IS5 & IS6. Presentation Media is included. Enhance your presentations with these high quality color, fully editable: Powerpoint/Keynote slides.
 ▶ Add or delete slides
 ▶ Change the order of slides
 ▶ Edit the wording

Access BIOZONE's Resource Hub directly from this link for a range of resources to support the activities.

Link to Excel® spreadsheets for all activities with a data analysis component.

A BONUS sample copy from the planned presentation media for IS5 and IS6 is included. It is fully editable.

Examples of models
 ▶ Models are commonly used in science to understand a system better and describe what will happen under different conditions.
 ▶ Some models are predictive. A model can be used to predict what will happen under different conditions. The information can be used to determine how all the components in a system may be affected. Examples of predictive models are those used to develop weather patterns and the effect of increased levels of carbon dioxide on ocean weather patterns and the effect of increased levels of carbon dioxide on ocean weather patterns and the effect of increased levels of carbon dioxide on ocean weather patterns.
 ▶ There are many different ways to model systems (e.g. mathematical or visual) and these can help us to understand it better.

Modeling changes in the ocean
 The oceans act as a carbon sink, absorbing much of the carbon dioxide produced from burning fossil fuels. The increasing amount of carbon dioxide in the atmosphere is reducing the pH of the ocean. Scientists use models to predict change in ocean pH over time. They use this data to determine how ocean organisms could be affected.

Modeling the Earth's structure
 The Earth's structure can be modeled using data from earthquakes, Earth's magnetic field and volcanic activity. The Earth's magnetic field suggests an iron core surrounded by molten material. The bending of earthquake waves suggests a thin solid crust. Volcanic activity shows there is molten material below the crust.

13. Draw a diagram to show the equipment you might use to prevent energy being lost during the heating of the ice/water:

Insulated/reflective container
 Water vessel
 Heat source
 Water surrounds the source and exhaust

14. How does the heating of water give us a way to calculate the amount of energy needed to heat 1 g of water?
 Water absorbs the energy and this can be measured. Calculate the energy absorbed by the water and then calculate the energy needed to heat 1 g of water.

ELABORATE: Heat of fusion, heat of vaporization
 ▶ The table below shows the melting point, boiling point, and heat of fusion for common substances at standard atmospheric pressure. Pressure is used as a reference condition for physical analysis.

Substance	Melting point °C	Boiling point °C
O ₂	-218	-183
H ₂ O	0	100
NaCl	801	1465

15. Using the data table above and the information provided, calculate the heat energy required to melt 40 g of ice at 0 °C and then to raise the temperature of the water to 20 °C. The specific heat of liquid water is 4.2 J °C⁻¹ g⁻¹.

Pipette volume error

Volume dispensed 200 ul pipette	Volume dispensed 1000 ul pipette
191	164
192	165
193	166
194	167
195	168
196	169
197	170
198	171
199	172
200	173
201	174
202	175
203	176
204	177
205	178
206	179
207	180
208	181
209	182
210	183
211	184
212	185
213	186
214	187
215	188
216	189
217	190
218	191
219	192
220	193
221	194
222	195
223	196
224	197
225	198
226	199
227	200
228	201
229	202
230	203
231	204
232	205
233	206
234	207
235	208
236	209
237	210
238	211
239	212
240	213
241	214
242	215
243	216
244	217
245	218
246	219
247	220
248	221
249	222
250	223
251	224
252	225
253	226
254	227
255	228
256	229
257	230
258	231
259	232
260	233
261	234
262	235
263	236
264	237
265	238
266	239
267	240
268	241
269	242
270	243
271	244
272	245
273	246
274	247
275	248
276	249
277	250
278	251
279	252
280	253
281	254
282	255
283	256
284	257
285	258
286	259
287	260
288	261
289	262
290	263
291	264
292	265
293	266
294	267
295	268
296	269
297	270
298	271
299	272
300	273

3. (a) Explain why models are never 100% accurate representations of a system. Models often represent components of a system and therefore provide less accurate predictors of a system's behavior.

(b) Discuss the advantages and disadvantages of using models to represent a system. Advantages: Models allow a system to be understood how the system works. Disadvantages: The accuracy of a model depends on the quality of the data used to create it. Models are less accurate predictors of a system's behavior.

(c) Why is it easier to use a series of simple models to represent a system than a single complex model?

Use the interactive buttons to reveal the answers as you work through the activity on-screen.

Activities that manipulate data using formulae are supported by spreadsheets. These include all data and comments on graphical analysis.