BIOZONE

CHEMISTRY IN THE EARTH SYSTEM

NGSS | INTEGRATING CHEMISTRY AND EARTH SCIENCE

FREE SAMPLE
for classroom trial
This sample packet may be photocopied and trialled in the classroom.

The Earth's Moving Surface

ANCHORING PHENOMENON: The surface of the Earth is constantly moving

Early Jurassic | Late Cretaceous | Present day Earth

The image on the far right above shows Earth as we know it today. The image on the left shows the Earth as we understand it looked during the early Jurassic period about 180 million years ago, based on a variety of evidence collected over the last hundred years. The continents have separated and rejoined many times over the billions of years of Earth's history. Continental drift describes the movement of the continents over the surface of the Earth. It was not until the 1960s that the theory of plate tectonics, which describes this movement, was confirmed. There is still a lot we do not understand about how this occurs, but clearly it involves massive energy sources beneath the Earth.

1. Write down five things that you know about continental drift in the space below:

   (a) ______________________________

   (b) ______________________________

   (c) ______________________________

   (d) ______________________________

   (e) ______________________________

2. Discuss your ideas with other people in your class. Do they have different ideas to you? Can they add to your current knowledge? Summarize their ideas:

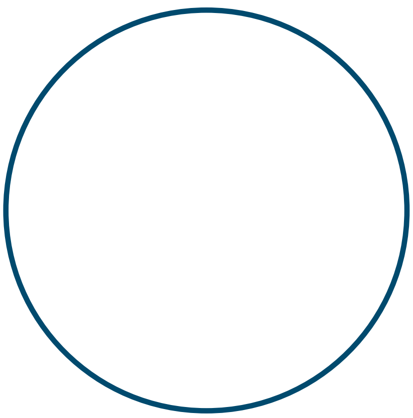
   ____

   ____

   ____

   ____

3. The circle below represents a cross section of the Earth. Fill in the circle with what you think the Earth looks like in cross section. Add labels to your diagram.



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12 Energy

ENGAGE: There she blows!

The photograph right shows an eruption of lava from Mauna Ulu, a volcanic cone on the island of Hawaii. The lava bubbling from the vent is glowing red hot whereas lava that emerged earlier has cooled and appears black.

Where has the energy in the lava (which has a temperature greater than 1000°C) come from? Why does the lava emerge as a fountain? What causes the lava to cool?

1. Have you ever seen volcanic activity of any sort? If so, describe it: ______

2. Water boils at 100° C. Think how long it takes a kettle to boil a liter of water. Compare this to the volume of lava produced during the eruption of Mauna Ulu (which covered an area of 44 km^2) and the energy that must have been required to produce that amount of lava. What does this tell you about the energy stored in the Earth?

EXPLORE: Energy

- Energy is a property that allows an object to do work. It may be transferred between objects and systems and transformed into different forms but it can not be created or destroyed. The amount of energy in a closed system is the same before and after a transformation. Energy is measured in joules (J).
- One simple way of measuring the energy in a system or transfer between objects is to measure the heat in the system or object, which is done using a thermometer. A thermometer measures the average energy of molecular motion in an object or system. The amount of substance in an object is also important in determining the amount of heat (energy) in the object.
- For example 100 liters of water at 30°C has much more energy stored in it than 1 liter of water at 30°C, even though their temperatures are the same.

3. To develop an understanding of energy and, in particular, how much energy is used or stored by certain objects or systems, research the equivalent use of 10,000 J by the following five objects or substances:

   (a) How long it takes a 100 W light bulb to use 10,000 J of electrical energy: ______

   (b) How much 10,000 J will raise the temperature of 1 liter of water by in °C: ______

   (c) What volume of gasoline stores 10,000 J of energy: ______

   (d) What mass of table sugar (sucrose) stores 10,000 J of energy: ______

   (e) The speed in meters per second (ms^{-1}) of a 145 g baseball that has 10,000 J of kinetic energy ______

4. List five different "types" of energy that are commonly used in everyday language: ______

5. A cup of hot water cools down over time. Where do you think the energy that was in the water went? ______

PS3.A PS3.B EM

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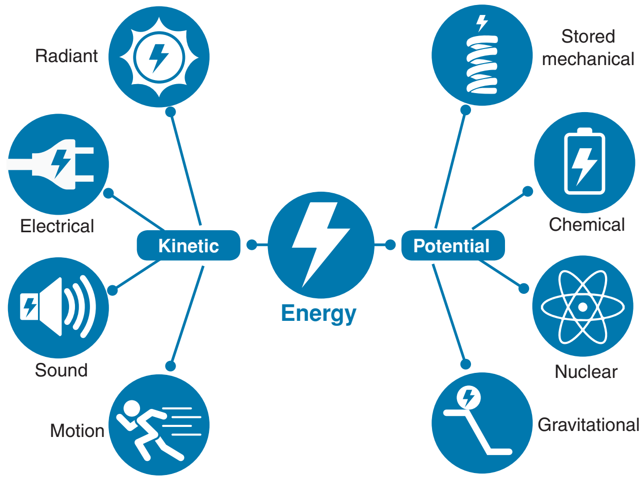
EXPLORE: Forms of energy

- As you would have found in your research in question 5 on the previous page, energy takes many different "forms". These forms are really just convenient ways for us to categorize and think about energy and how it's being used. If we say "electrical energy" we know that the energy is in the form of charged particles moving around a circuit of wires.
- The diagram on the right shows how energy can be categorized as potential or kinetic. These terms basically translate as "energy that is able to do work at some point in the future" and "the energy possessed by an object due to its movement" respectively.



6. Study the photographs below. Write whether they show potential or kinetic energy and what "form" that energy is in (e.g. chemical).

A


Ball moving through air

B

Single cell battery

C

Lightning

D

Compressed spring

E

Flame from a candle

F

Water falling over a cliff

(a) ____________________

(b) ____________________

(c) ____________________

(d) ____________________

(e) ____________________

(f) ____________________

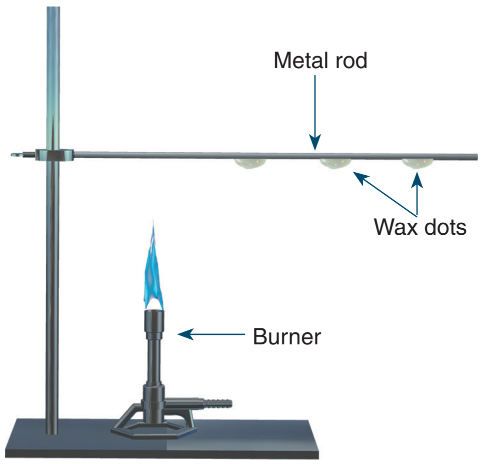
EXPLORE: Moving energy

Conduction

- The particles in a substance are constantly moving (kinetic energy). In a solid object, the particles vibrate about a fixed position. The more energy a substance contains, the faster and larger the movements of its particles.
- Energy is able to move from place to place (it can be transferred). For example, light energy released from nuclear reactions in the Sun travels across space to Earth. Plants use some of that energy to carry out photosynthesis and produce sugars, sustaining life on Earth.
- There are three main ways in which energy is transferred: by convection, conduction, and radiation.

- **Set up the following equipment**

i. Place wax dots along the metal wire at 2 cm intervals.
ii. Set the Bunsen flame to blue and start a timer.
iii. Observe the effect on the wax dots. Record the time for each dot to start melting.
iv. Let the metal wire cool down the 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		

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

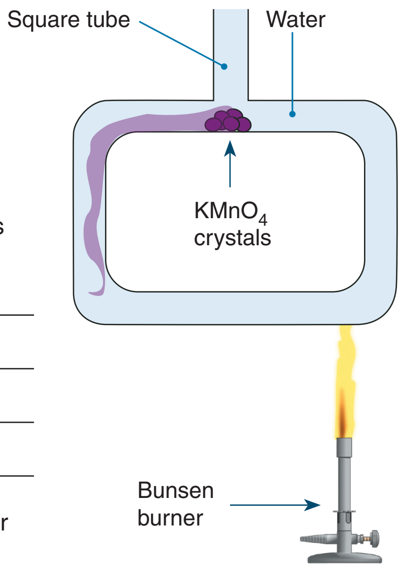
(b) Was there a time difference for each wax dot to start melting when the yellow flame was applied? What was it?

(c) Can you explain why there was a difference in time between the first dot melting when a blue flame was applied and when a yellow flame was applied?

(d) Using circles to represent the particles in the metal wire, draw a diagram to represent how you think the energy of the flame is melting the wax dots:

Convection

- The diagram on the right shows a square tube with $KMnO_4$ crystals dissolving at the top and heat from a Bunsen burner being applied at the lower right corner.
- Note how the color produced by the dissolving $KMnO_4$ crystals has moved from the top of the tube towards the left hand side and down the to the left hand bottom corner.



8. (a) Why do you think the purple color has moved in the direction it has? What has caused this moment?

(b) Predict what would happen if the experiment was reset and the Bunsen burner moved to the left hand side of the tube:

(c) Predict what might happen if the Bunsen burner was moved to the middle of the tube and give a reason for your prediction:

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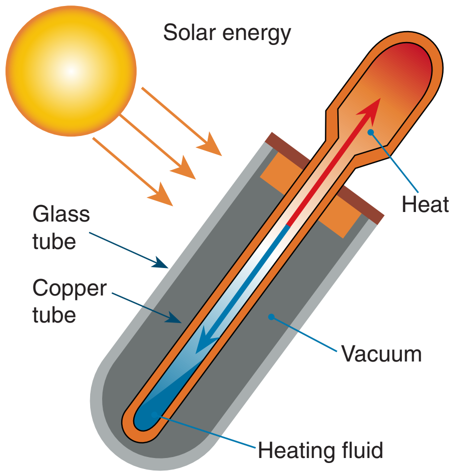
Radiation

- All objects above 0 Kelvin (-273° C) radiate thermal energy. Radiation (light energy) is produced by the acceleration (a vibrating particle is constantly accelerating) of electric charge and requires no medium to move through. Radiation in the infrared band of the electromagnetic spectrum is felt as heat.
- When a photon of infrared light hits an object, energy is transferred, which makes the particles in the object vibrate. The more photons hitting the object, the more energy is transferred and the more the particles vibrate.
- These vibrations can be measured by a thermometer as a rise in temperature.

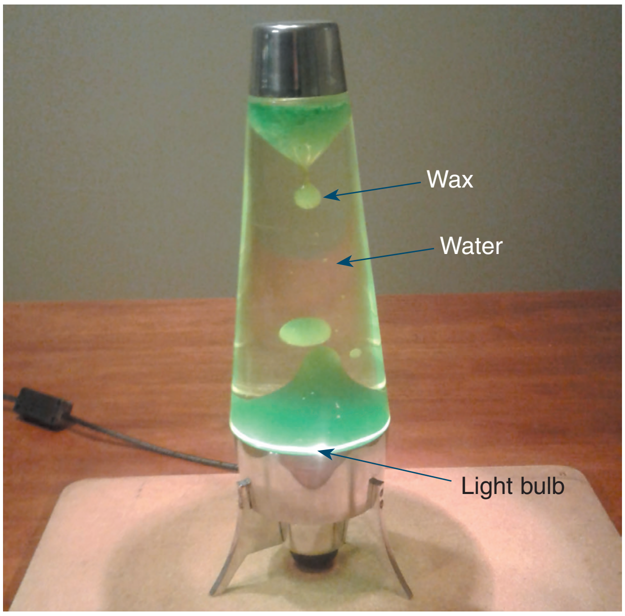
9. The diagram on the right shows the internal structure of an evacuated solar tube used in solar water heating. The tube is made up of an outer tube and a smaller inner tube containing heating fluid. The heating fluid transfers heat to the water cycled past the top of the tube. Between the outer and inner tubes there is a vacuum.

   Explain how the energy from the sun is able to heat the heating fluid in the inner tube. What is the significance of the vacuum between the two tubes?



EXPLAIN: Lava lamp

10. By now you should have an understanding of what energy is and how it is transferred. Use your understanding to explain the behavior and features of the lava lamp shown below in terms of energy and movement of particles. Use diagrams to help with your explanation.



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13 Order and Disorder

ENGAGE: A campfire

The photo shows a log of wood burning in a campfire. The wood represents a concentration of energy. The energy is stored in the chemical bonds within the wood (e.g. between the bonds holding carbon atoms together to form cellulose). By burning the wood, the energy is released and becomes spread out, heating the air molecules around it and causing them to move faster.

This is an example of increasing entropy. Entropy is a measure of the amount of energy dispersal in a system or the unavailability of energy to do work. Entropy in the universe never decreases and will eventually increase to a point where all energy is evenly dispersed (maximum entropy). In the case of the burning wood, the ordered, concentrated energy has low entropy. Burning it increases entropy as the energy in the wood becomes dispersed.

Entropy can be reduced in a closed system, but always by increasing entropy in the wider universe. The energy in the wood was stored as a product of photosynthesis, which is powered by the Sun, which itself is releasing vast amounts of energy every second and thus rapidly increasing the entropy the universe.

1. Entropy never decreases unless it increases somewhere else by at least an equal amount. Name two everyday devices that reduce entropy somewhere while increasing it somewhere else:

2. The second law of thermodynamics states that entropy always increases over time. It is sometimes colloquially expressed as "order tends to disorder".

   As a class or group discuss what this means and why you think the entropy of the universe will always increase (to a maximum). Summarize your ideas below:

EXPLORE: Flow of energy

Place a cup of water at 80°C on a bench where the air temperature is 20°C. Does the cup get hotter or colder over time? Why? The activity below will help illustrate how energy flows.

▸ Set up the following investigation on heat

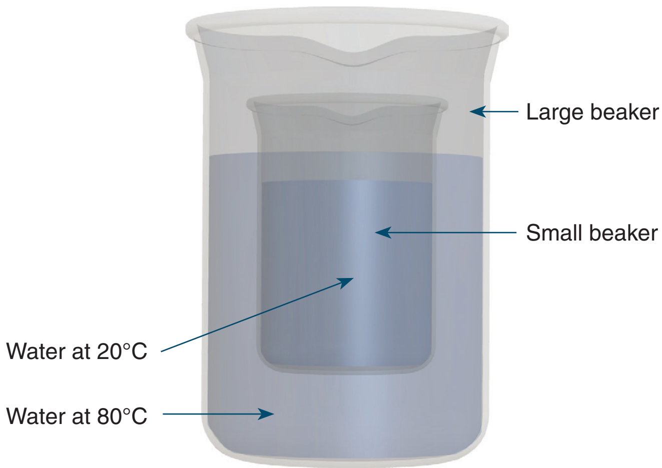
i. Fill a large beaker (or other large vessel) with hot water around 80°C (measure the temperature to be precise).

ii. Into the large beaker, place a small beaker filled with water at room temperature (again measure the temperature to be precise).

iii. Place the set up in an insulated box or wrap insulation around the larger beaker to reduce the heat loss out of the system.

iv. Measure at two minute intervals and record the temperatures of the water in the large and small beaker in the table provided.

v. Do this until the temperatures becomes steady. Graph your result on the grid provided opposite.



PS3.A PS3.B EM

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Time (minute)	Temperature in large beaker	Temperature in small beaker
0 (initial)		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		

3. (a) Describe the shape of the lines for both the temperature in the large beaker and small beaker:

(b) Why do you think the lines have this shape? (Hint: what is happening to the energy in each beaker?)

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EXPLORE: Mixing temperatures

Set up two 500 mL beakers both containing 200 mL of water

i. In one beaker set the water temperature to around 80°C (measure to be precise). In the second beaker, set the temperature to about 20°C (again, measure to be precise). Record the temperatures in the spaces below.

ii. Predict what will happen when the contents of the two beakers are mixed. Try to predict a precise temperature that the water will have after mixing based on your initial measurements. Write your prediction in the space below:

iii. Mix the water in the two beakers together and measure the temperature. How close was your prediction?

4. (a) i. Initial temperature in beaker one: ______

   ii. Initial temperature in beaker two: ______

   (b) Prediction of temperature after mixing: ______

   (c) Final temperature after mixing: ______

   (d) How close was your prediction? In terms of the energy in the system, explain why the temperature changed and what has happened to the overall energy in the system:

EXPLAIN: Rate of diffusion

i. Fill two 250 mL beakers with 200 mL of water. In one beaker set the water temperature to around 80° C. In the second beaker set the temperature to about 20°C. In this case the temperatures do no need to be precise.

ii. To the 80°C beaker add a few crystals of potassium permanganate ($KMnO_4$). A few drops of food coloring will also work, as will an M&M (red or blue are easier to see). Observe any changes over the next minute.

iii. Repeat the process for the 20° C beaker.

Caution is required when handling $KMnO_4$ as it is a strong oxidizer. Wear protective eyewear and gloves. Contact with the skin leaves a long lasting purple to brown stain.

$KMnO_4$ crystals

5. (a) What did you notice about how the $KMnO_4$ diffused in the 80°C water and the 20°C water?

   (b) In terms of the heat energy in each beaker, explain why the $KMnO_4$ diffused like this:

6. Describe the concept of heat and which direction heat flows. Explain why heat behaves like this:

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