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School of Chemistry

The Solar Spark

In this activity you will:

- Use colour wheel and spectroscope to study visible light
- Find out more about research on solar cells and panels

Sunlight

Sunlight is made of the Electromagnetic Spectrum, some parts of which you might have heard of and used:

Microwaves are used in microwave ovens to give energy to the water in your food to warm it up; infra-red radiation in our TV remote controls. Infra-red radiation also interacts with our bodies in a way that we call heat.

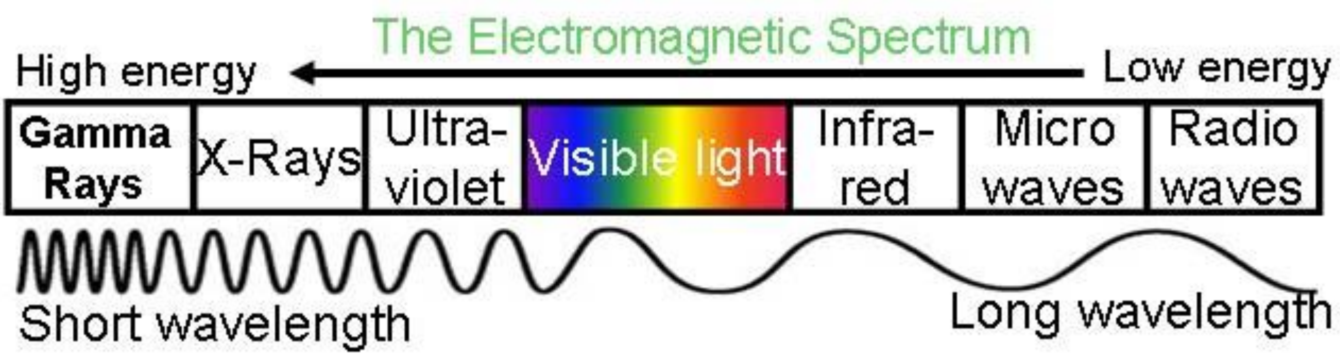

Diagram 1: The sun emits what we call electromagnetic radiation which can be divided up into seven regions: gamma radiation, x-rays, ultra-violet light, visible light, infra-red radiation, microwaves, and radio waves. This is known as the electromagnetic spectrum.

The whole spectrum could be called sunlight, but what you would probably think of sunlight is the <u>visible light</u> region, the part of the spectrum that allows us to <u>see things and gives objects colour</u>.

<u>The most useful part of the spectrum for Solar scientists is visible light</u> as it has enough energy and all of it reaches the Earth's surface.

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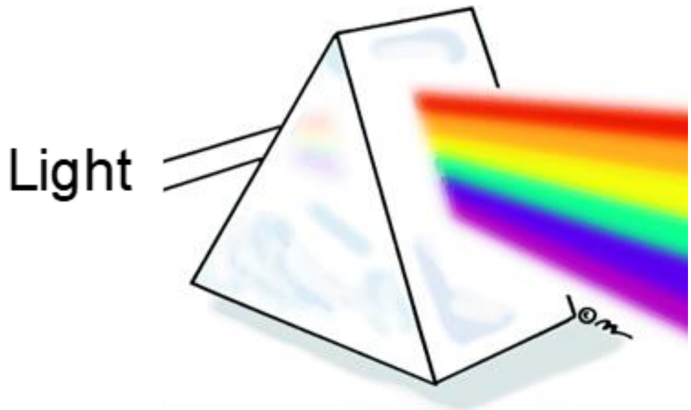
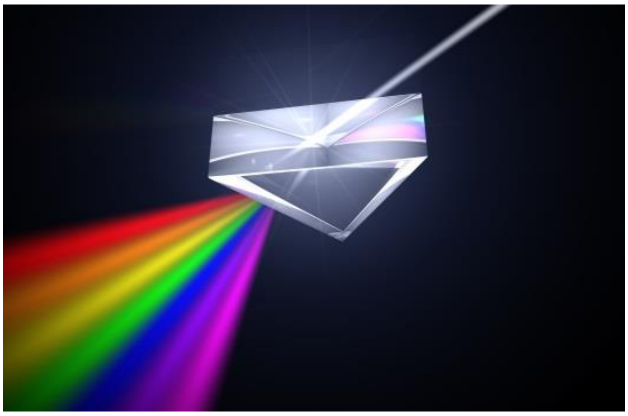
Visible Light

Visible light can be split up into all the colours of the rainbow.

Ever notice that you often see a rainbow when there's sun and water about? That's because the water droplets split the sunlight into its colours.

When you see a rainbow in the sky, the visible light from the sun is split up by the raindrops in the air.





We can also use prisms (wedge-shaped transparent form) to split the light up.

What happens when we mix all the colours of the rainbow?

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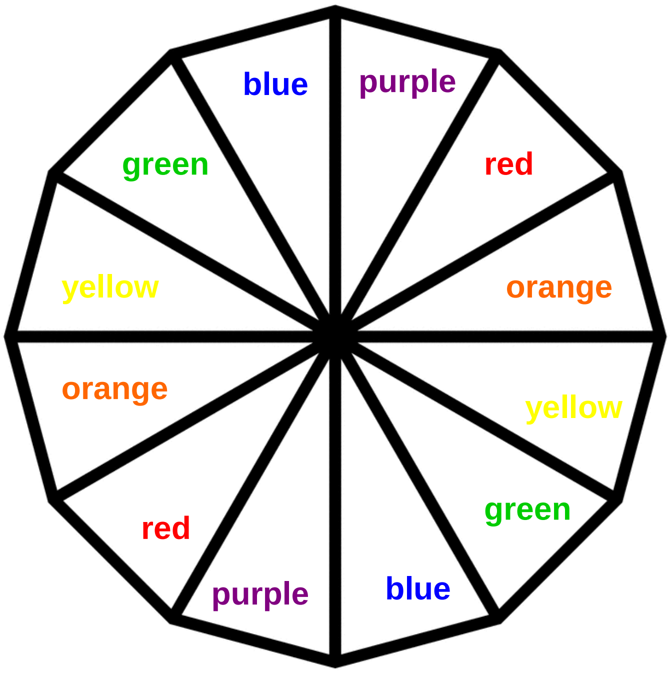
<u>Make Your Own Newton Wheel!</u>

Isaac Newton was the first to discover that visible light is made of seven different colours (red, orange, yellow, green, blue, indigo, purple).

In this activity you will assemble a colour wheel, also known as Newton wheel and see what happens when the individual colours of the rainbow are mixed together.

<u>What you need:</u>
- <u>Scissors</u>
- <u>Colour pens or pencils</u>
- <u>Pencil</u>
- <u>Glue stick</u>

First, make your Newton Wheel
1. Cut out the shape on the right using scissors (optional: you can glue the cut out to thicker card to make it more sturdy)
2. Colour in the segments using colouring pencils
3. Stick the end of a pencil through the middle of the wheel (carefully!)
4. Put a piece of paper on a flat surface and spin the wheel like a spinning top (try to keep it spinning on the paper to avoid pencil marks!).
   See page 12 for complete example.



When the wheel is spinning really fast, all the colours will mix into something new. *What colour do you see when the disc is spinning?**

Your answer:

* White light is made up of lots of different colours and by spinning the colours on the disc, you turn them back into white light!

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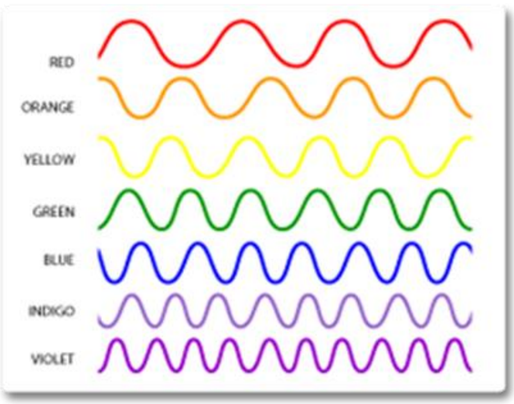
"Newton Wheel of Fortune" Instructions

1. Spin your Newton wheel again
2. Note what colour your wheel stops on and use the table below to find your code

Colour	Code
Red	750nm
Orange	620nm
Yellow	570nm
Green	500nm
Blue	460nm
Purple	380nm



Use of Electromagnetic Spectrum in Science

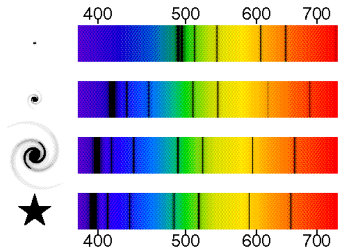
The way that the Electromagnetic Spectrum interacts with matter is called **Spectroscopy**.

Machines used to measure this interaction are called **spectroscopes**. We use the to find out lots of things about everything around us

ASTRONOMY

Astrophysicists use spectroscopy to find out what stars are made of and how galaxies move by studying the light they emit into space.

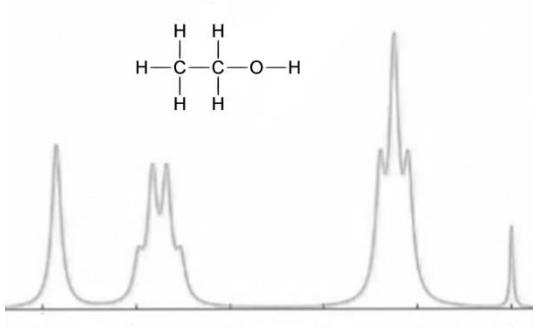
They have to send satellites up into space to get above our absorbing atmosphere. However, some ultra-violet light can get through and causes sunburn if we are in the sun for too long without sun cream.



[1]Image from http://cosmology.com/BigBang4.html

CHEMISTRY

NMR Spectroscopy of ethanol (alcohol)



New chemical compounds are identified using spectroscopy to find out what elements they are made of.

Solar scientists use spectroscopy to explore new dyes and materials for solar cells.

The visible and infra-red regions of the spectrum are what our sun produces the most of. Therefore, it is important for people designing solar cells to try and capture these regions in order to make electricity and usually scientists concentrate on absorbing the visible region.

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Make your own Spectroscope Information

In this activity you will make and use spectroscope to study the colours of different light sources. You will see different 'rainbows' that are produced by various light sources.

You will need:

- The Spectroscope template (at the end of this booklet)
- Scissors
- Glue or sellotape
- Old CD disc.
- Various light sources to look at when you've finished, e.g. a light in your house, a torch, and sunlight.

Using your spectroscope

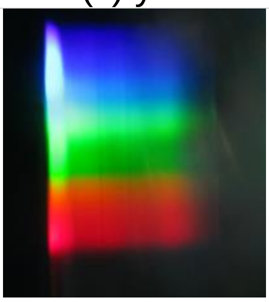
When you've made your spectroscope, hold it under a light (so the light shines through hole b) and put your eye up to the hole. You should be able to see a spectrum of colours. (See page 12 for example).

The CD acts as a diffraction grating to split the light into the colours of the rainbow.

Try looking at different light sources to see what colours of the spectrum they give out or **emit**.

Write in the table below your observations:

Example:

Light Source 1:	Torch
Write below the colour(s) you see:	Colour the colour(s) you see here
Violet Dark blue Light Blue Light green Green Orange Red	

Now, write your own observations:

Light Source 2:	
Write below the colour(s) you see:	Colour in the colour(s) and pattern you see

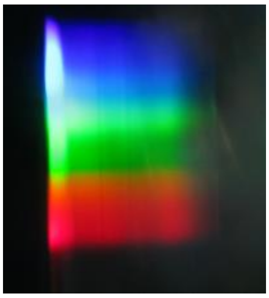
Light Source 3:	
Write below the colour(s) you see:	Colour in the colour(s) and pattern you see

Light Source 4:	
Write below the colour(s) you see:	Colour in the colour(s) and pattern you see

Light Source 5:	
Write below the colour(s) you see:	Colour in the colour(s) and pattern you see

Light Source 6:	
Write below the colour(s) you see:	Colour in the colour(s) and pattern you see

What you will probably notice is…



The sun and many torches emit all the colours of the rainbow and a **continuous** spectrum of all the colours can be seen.

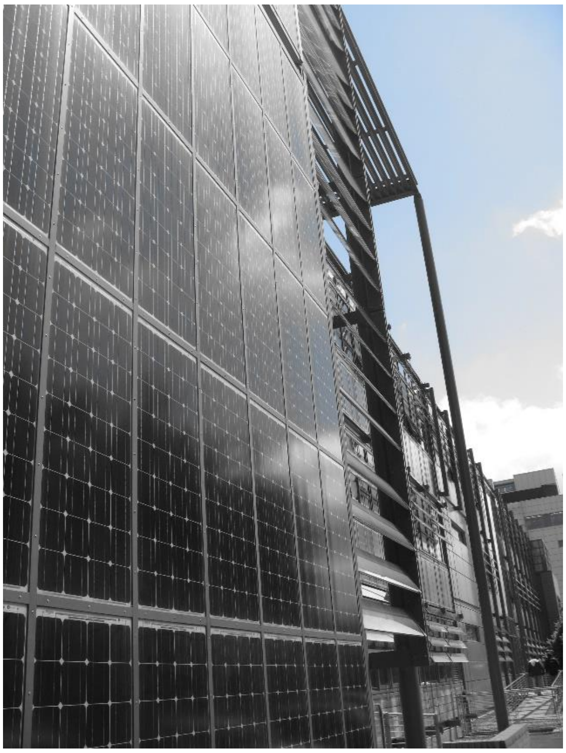
If you look at a TV screen or a fluorescent light you will see **separate lines** of different colours

Some additional exciting information

How can we make electricity out of the sunlight?

Scientists have made use of solar energy over the last 50 years by turning sunlight into electricity using solar cells (picture below).

They were first used in spaceships and satellites up in space, which need a lot of power to run the electrical equipment, but batteries sent up with them run out within days. By using solar cells connected up to make big solar panels they can power the equipment forever.



Solar is considered a source of renewable energy because the sun is expected to exist for millions of years to come. It is also a 'clean' technology in that it doesn't contribute to climate change.

How much energy can we get from the Sun?

The sun is so powerful that if we were able to harness all its energy, it could provide almost 10,000 times as much energy as the whole world needs!

If we didn't have any limitations. i.e. if all energy collected from the sunlight was converted to electricity we would need an equivalent time of a half of football match (45 minutes) to be able to supply human energy demands for an entire year!!

What are the limitations?

Most of solar cells are made from silicon - an element found in sand - which is expensive to purify for use in solar cells; or other elements, which are poisonous or very ineffective in changing sunlight to electricity.

Traditional solar cells are turning about 20 per cent of the solar energy they receive into electricity (the kind of electricity that is produced by batteries).

It also all depends on the amount of sunlight available. You also need a quite large area of solar panels to produce enough electricity to power useful appliances such as light bulbs and computers, or to charge a phone.

Silicon panels are rigid and can be fragile. They are also still rather expensive compared to some of the other options in the solar power market.

Can we make it more efficient?

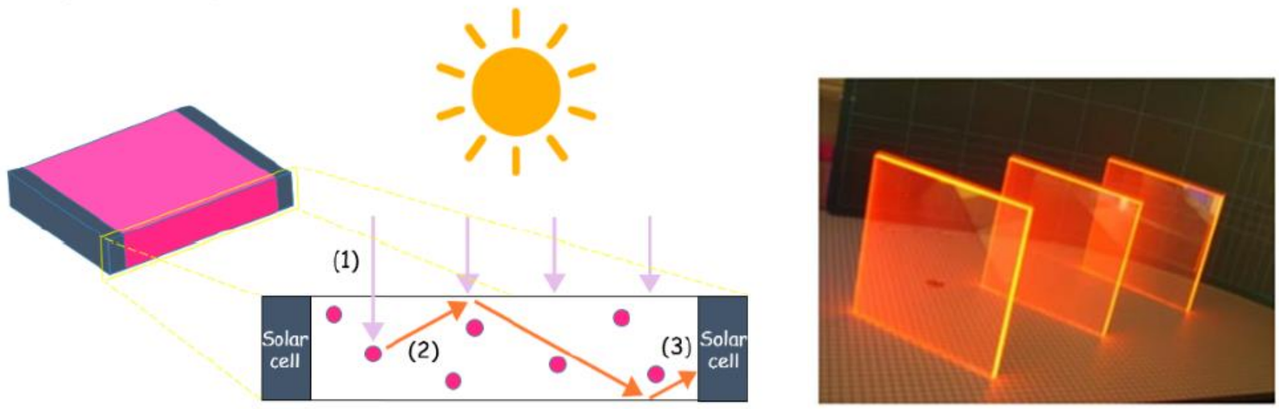
One way of using solar panels more efficiently is to use additional concentrators.

If we can focus sunlight from a wide area on to small and highly efficient cells, we can get more power. We can use coloured materials (like dyes) to absorb the different colours corresponding to the 'code' of the rainbow in order to make electricity from the sun.

Luminescent solar concentrators (LSC) – 'Sunlight Traps'

These are light-concentrating devices – sunlight traps - consisting of a flat see through plastic sheet with shining dyes inside which catches light over a large area and concentrates it to the edge of the sheet, reducing the area and therefore the cost of the solar cell.

Sunlight trap



The dyes in the sheet absorb the incoming light and then re-emit it. The emitted light is trapped in the sheet by something called "total internal reflection" – the same way as light is trapped in fibre-optics – and it is guided to the solar cells at the edge of the sheet, which convert this light energy into electricity.

Completed Newton wheel example:

Completed Spectroscope example:

Hint: Cut out the box from A4 sized paper so that line A is cut as wide as the diameter of CD. Put the CD shiny side facing the cut out square (cut out C), tilt slightly so that the edge of the CD inside of the box touches the same side as the square cut out (cut out C).

1

2

Make your own spectroscope

1. Cut along all the solid black lines with scissors, including line **a**, and cut out the rectangles **b** and **c**.
2. Fold along all the dotted black lines.
3. Make the template into a box by joining the same numbered flaps together, e.g. 1 joins to 1.

3

a

b

2

4. Put a CD into the box through the slot you made at line **a** with the bottom "rainbowy" side of the CD facing upwards.
5. Look into the box through the square hole and you should be able to see light split into a rainbow.
6. Try looking at different types and colours of light and see what changes in your spectroscope.

3

c

1