Science Stage 5

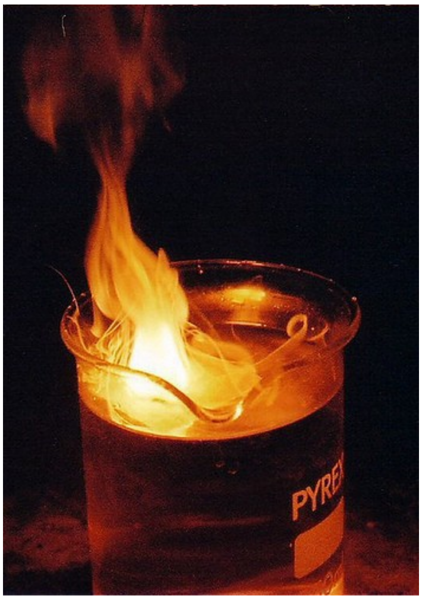
Atomic structure

Part 2

Outcomes

By completing learning you are working towards achieving the following outcomes:

- Produces a plan to investigate identified questions, hypotheses or problems, individually and collaboratively
- Explains how models, theories and laws about matter have been refined as new scientific evidence becomes available



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Atomic Structure 2 Glossary

The following words, listed here with their meaning, are found in the learning material in this unit.

Atom	The smallest part of an element
Boiling point	The temperature at which a liquid boils at a fixed pressure, especially under standard atmospheric conditions
Ductile	A property of metals. It means able to be made into wire.
Electron	A sub-atomic particle with a negative charge. Electrons are found in energy levels around the nucleus
Element	A pure substance which contains only one type of atom
Isotopes	Atoms of the same element that have a different number of neutrons in the nucleus
Malleable	A property of metals. It means able to be shaped without breaking
Melting point	The temperature at which a solid becomes a liquid at standard atmospheric pressure
Model	Something that is used to test scientific ideas and theories
Molecule	The smallest part of an element or compound, consisting of more than one atom of the same kind in an element, or, two or more different atoms in a compound
Neutron	A sub-atomic particle in the nucleus of the atom. It has no charge
Periodic table	Very large table that gives information about all the known elements. It is used throughout the world
Proton	A sub-atomic particle in the nucleus of the atom. It carries a positive charge
Theory	An idea used to explain observations made of the world and universe

Lesson 1: Organising elements

When were elements discovered?

Many substances that we now call 'elements' have been known to humans for many thousands of years, e.g. copper, lead, gold, silver, iron, carbon, tin, sulfur, mercury, zinc, arsenic, antimony and chromium. These substances had many uses, such as for tools, eating and drinking utensils, jewellery, statues, weapons and pigments for painting.

The ancient Greeks were the first to use the term 'elements'. From around 330 BC, they thought that every substance in the world was made up of five elements in differing proportions. These five elements – earth, water, air, fire and aether) – were not the chemical elements of modern science.

These ideas about elements did not change until the 17th century. Following the scientific discovery of the element phosporous by Hennig Brand in 1649, the English chemist Robert Boyle realised that the ancient Greek ideas about elements were wrong.

In 1661, Boyle's scientific observations led him to propose that an element was 'a substance that cannot be broken down into a simpler substance by a chemical reaction'

Figure 1: Robert Boyle

Over the next 200 years, a great deal of knowledge about elements and compounds was gained. By 1869, 63 elements had been identified and named.

Scientists recognise patterns

During the 19th century, as the number of known elements grew, a number of scientists began to recognise patterns in the properties of the elements.

In 1829, Johann Dobereiner (a German chemist) discovered that several groups of three elements (triads) had similar properties.

Figure 2: Johann Dobereiner

In 1864, John Newlands (an English chemist) arranged the known elements into a table in order of their atomic weights. When he did this, he discovered that similar elements tended to fall into the same horizontal rows and each element was similar to the element eight places further on.

Figure 3: John Newlands

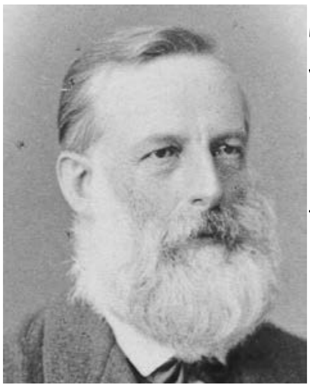


Figure 4: Lothar Meyer

Lothar Meyer, who was working independently to Mendeleev, produced a very similar periodic table in 1864. However, Meyer's table was not published until 1870, a year after Mendeleev's table was published.
By 1882, both Meyer and Mendeleev were acknowledged as the 'fathers of the periodic table'.

The modern periodic table

Figure 5: Henry Moseley

Mendeleev's periodic table has changed over time as scientists have discovered new elements and developed a greater understanding of the atoms that make up elements.

In 1913, Henry Moseley (an English physicist) used X- rays to work out an atomic number for each of the known elements based on their nuclear charge. Moseley realised that, if the elements were arranged in the order of increasing atomic numbers rather than atomic weights, they gave a better fit within the periodic table and overcame some of the discrepancies that Mendeleev had in his table.

In the 1890s, the noble gases were discovered. Mendeleev had not allowed for these and so a new vertical column was placed at the right hand end of the periodic table to include these. You will be learning more about the noble gases later on in these lessons.

Many more elements were discovered in the 20th century. Some new elements have only been discovered in recent years. The periodic table that you will be using in these lessons includes these elements.

Activity 1 – Development of the periodic table

Complete the missing words in the sentences below.

In 1869, D_____________ M____________ produced a _______________ table. He organised the ____________ into rows based on increasing ____________weights, but arranged them so that elements with similar ___________________ appeared _____________ each other in vertical ________________. G____________ were left for elements that were not yet __________________.

The importance of the periodic table

The periodic table shows information about all the known elements – the 90 naturally occurring elements, as well as the man-made elements, (element 43, element 61 and the elements from 93 onwards).

The arrangement of elements shows patterns in the way elements behave in chemical reactions. This gives chemists clues about the way in which different elements will combine.

Activity 2 – True or false? T or F?

1. The ancient Greeks had the same understanding of elements as modern scientists. **T or F**
2. All elements can be placed into the periodic table. **T or F**
3. The arrangement of elements in the periodic table shows patterns in the way elements behave in chemical reactions. **T or F**
4. The modern periodic table only contains the 63 elements known at the time that Mendeleev developed the periodic table in 1869. **T or F**
5. There are 90 naturally occurring elements in the periodic table. **T or F**

Worksheets – Atomic structure

1. State the name of the Russian chemist who produced a periodic table.

   ____

2. In his periodic table he organised the elements based on their atomic weights. Outline how he then arranged the elements in the table.

____

____

____

3. He left gaps in his periodic table – not every space was filled. Why were these gaps left in his table?

____

____

____

4. Complete the missing words in this sentence.

The modern periodic table has the elements arranged in order of increasing a____________ n______________ .

Lesson 2: What's on the periodic table?

Recalling previous work

Remember from previous lessons that each element is shown in a separate box in a periodic table. Each box usually has the name, symbol and atomic number for each element. A more detailed periodic table also includes the atomic weight of each element. For example, the element potassium, with 19 protons, may be written like this:

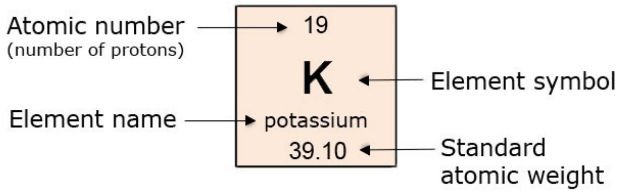


Figure 6: How potassium is shown on the periodic table

The atomic number shows the number of protons in each atom of an element.
The elements are arranged in the periodic table in the order of their atomic number

Activity 3 – Arrangement of protons, electrons and neutrons

Complete the missing words in these sentences to revise sub-atomic particles in an atom.
P___________ and neutrons are in the n_____________ of an atom.

Electrons form a c____________ surrounding the nucleus and are found in different

e_________ levels (or shells).

In an atom, the number of electrons is equal to the number of p____________ .

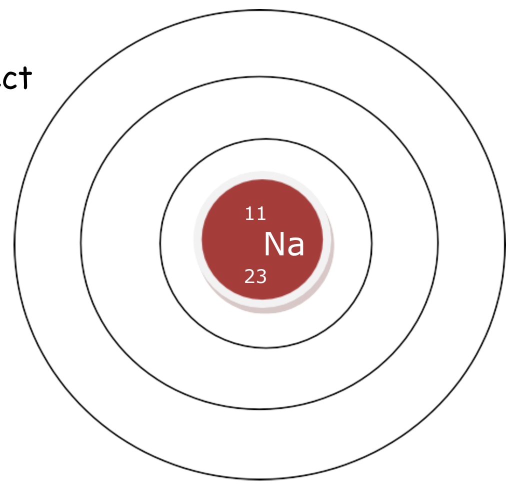
Each energy level (shell) can only hold a maximum n___________ of electrons.

The first energy level holds a maximum of _____ electrons. The second energy level

holds a maximum of _________________ electrons. The third energy level holds a

maximum of _____________ electrons.

Complete the model of sodium below by adding the correct number of electrons to each shell.



How is the periodic table arranged?

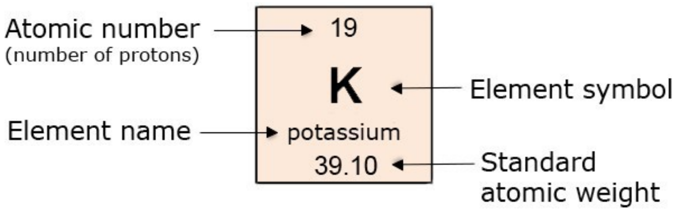
Each box is an element. All the elements are arranged in rows and columns. The horizontal rows are called periods and the vertical columns are called groups.

You read the periodic table from left to right, starting with the first row, then the second row and so on.

The elements are listed in the order of increasing atomic numbers. The table starts with hydrogen, with 1 proton and atomic number = 1. Uranium is near the end with atomic number = 92. It is the heaviest naturally occurring element and has 92 protons.

Look at the periodic table on the next page.

As you learned back in Part 1 of this topic, each box in such a periodic table contains the element's atomic number, symbol and name … plus its atomic weight below the name.



Fortunately, you do not ever have to remember the atomic numbers and atomic weights … as they can always be looked up in a periodic table.

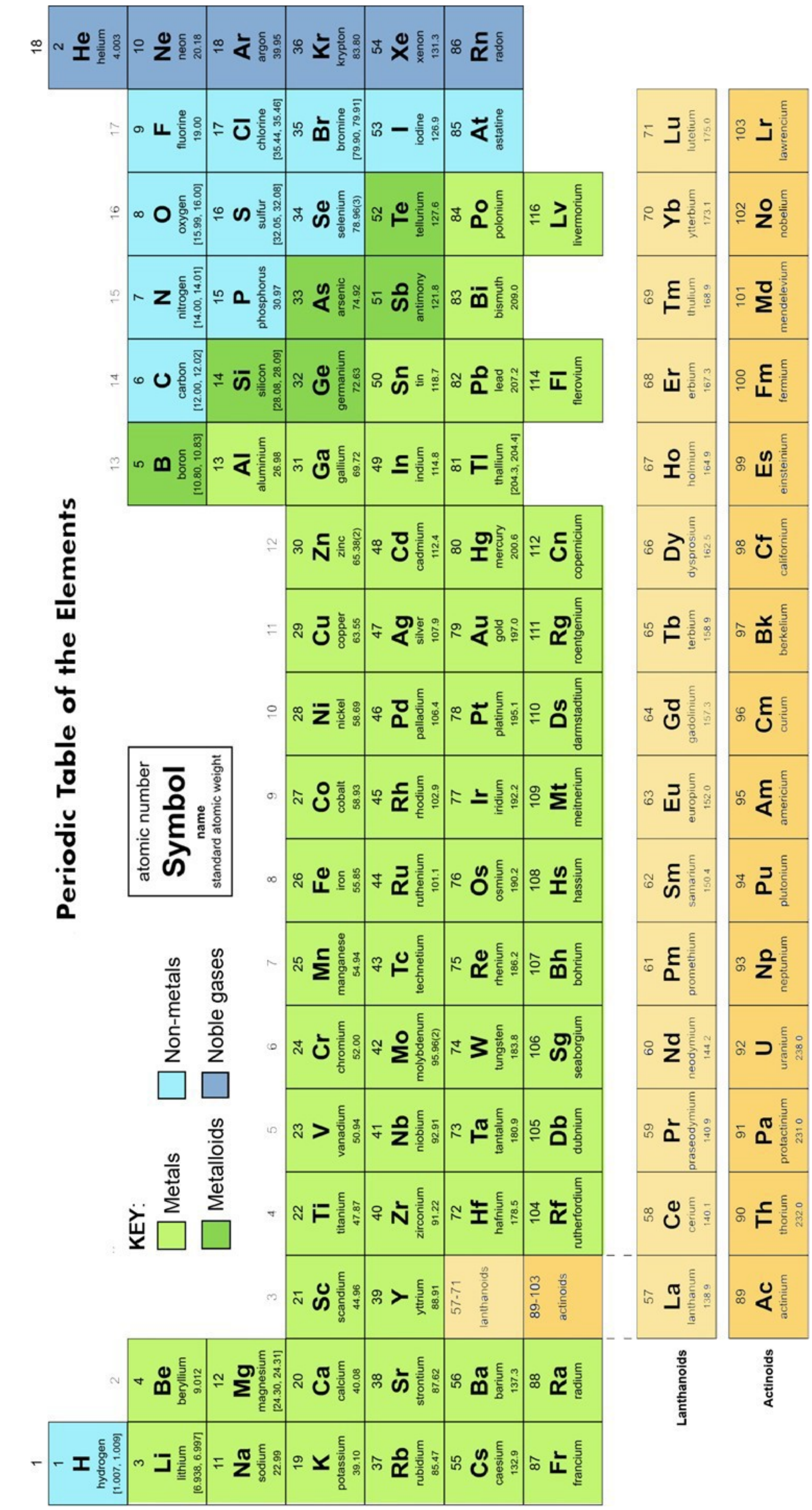


Figure 7: A Periodic Table

Activity 4 – Using the periodic table

It helps in chemistry to be familiar with some of the elements' symbols. Use the periodic table to complete this table. You only need to look at the first 20 elements for this question. Look at the key and you will see that the atomic number is above each element's symbol.

Element	*Symbol*	*Atomic number*
Hydrogen	H	
Helium		2
	Li	3
Magnesium	Mg	
Silicon		14
	C	6
Nitrogen	N	
Fluorine		9
	Ne	10
Oxygen	O	
Sodium		11
	K	19
Calcium	Ca	
Chlorine		17
	Ar	18
Boron	B	
Aluminium		13
	P	15
Sulfur	S	
Beryllium		4

Activity 5 – How do elements get their names?

Elements have been named after people, places and characteristics, such as colour and smell. Use the periodic table to find the names and symbols of the following elements:

What element is named after	*Atomic number*	*Name of element*	*Symbol*
a continent	63		
a country	87		
a state in the USA	98		
a scientist	99		
a planet	93		
the colour indigo	49		

Activity 6 – Can you decipher an elemental message

Look up the chemical symbols for these atomic numbers to see if you can decipher the hidden message:

15 1 39 14 55   53 16   9 92 7

___ ___ ___ ___ ___   ___ ___   ___ ___ ___

The groups in the periodic table

In the periodic table the elements are arranged so that those with similar properties fall into the same vertical column (or group).

e.g. Group 1 – this contains lithium, sodium, potassium, rubidium, caesium and francium. All these elements have similar properties.

Vertical columns = 'groups'

Look at the vertical columns on the periodic table. How many groups are there?
You should have found that there are 18 groups.

Activity 7 – Groups in the periodic table

1. Name the first 4 elements in group 18: ____________________, ______________________, ______________________, ____________________________.

2. What is the group number for the group containing fluorine, chlorine, bromine and iodine? ____________

3. Look at the key on the periodic table, then indicate whether the following groups of elements are metals or non-metals:
   - the group 1 elements: ____________________
   - the group 17 elements: __________________

4. Complete this sentence:

Elements in the same v____________ column (g___________) have s___________ properties.

5. Label the groups in this periodic table with the numbers 1 to18.

Group number

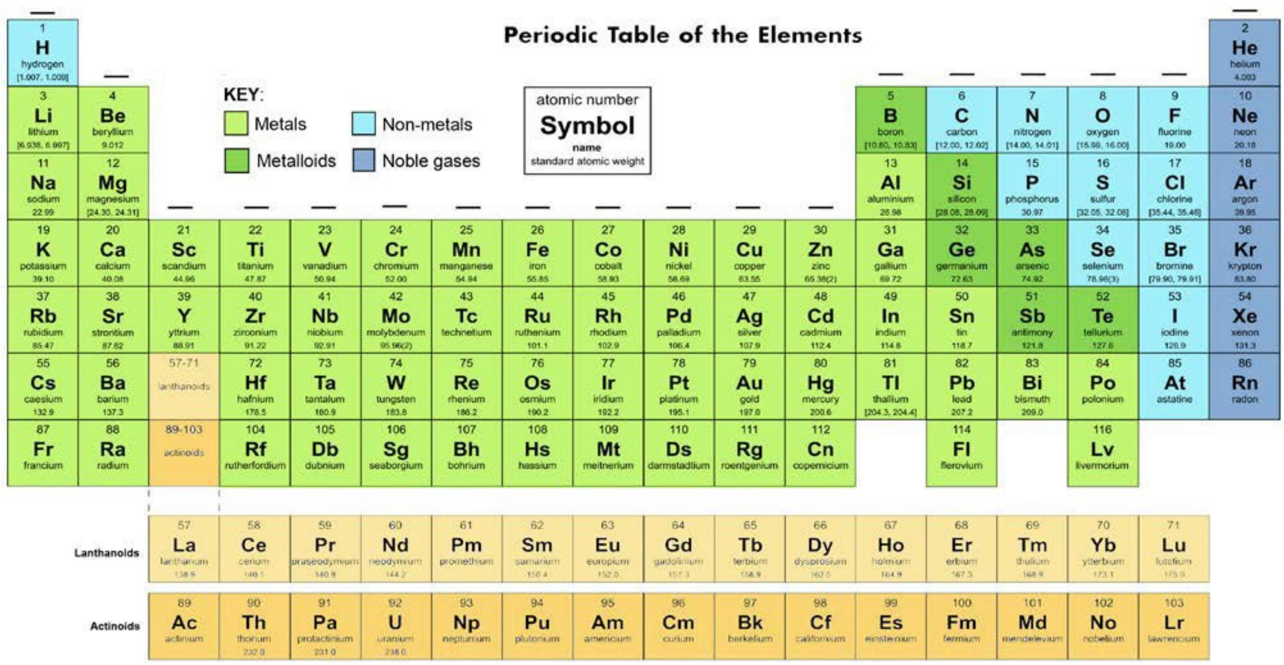


Figure 8: A periodic table

Some of the groups have special names

- Group 17 are known as the halogens – these elements are all coloured, e.g. chlorine is green, bromine is red-brown, iodine is silvery-purple.
- Group 18 are known as noble gases – these gases are very stable and do not readily react with any other substances (i.e. they are very inert).
- The elements in the block from group 3 to group 12 are called transition metals – many of these elements form brightly coloured compounds. Some examples of transition metals that you would probably be familiar with include gold, silver and copper.

Activity 8 – Groups with special names

1. What are the vertical columns on a periodic table called?______________________________
2. Give the names of 2 elements in Group 17. ______________________________
3. State the special name given to the elements in:
   a. groups 3 to 12: ______________________________
   b. group 17: ______________________________
   c. group 18: ______________________________

The periods in the periodic table

The horizontal rows in the periodic table are called periods. They are numbered from 1–7.

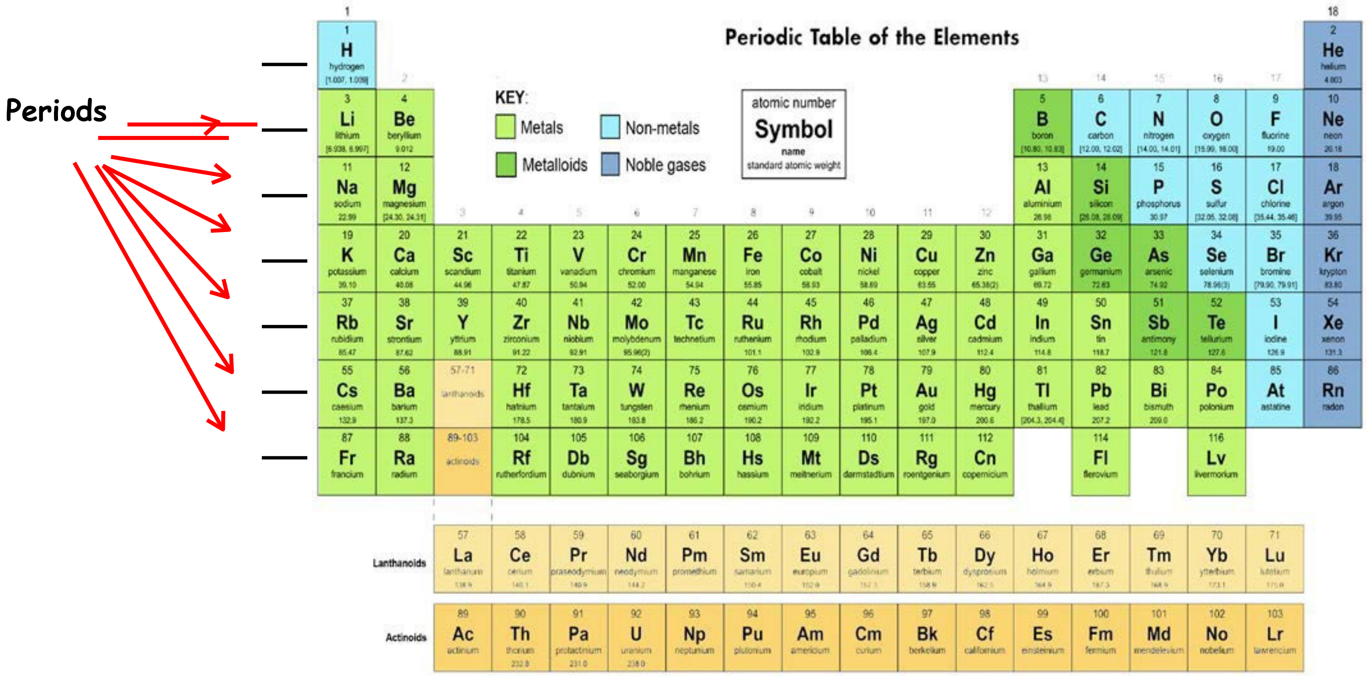
- Period 1 contains two elements – hydrogen and helium.
- Period 2 contains eight elements from lithium to neon.
- Period 3 contains eight elements from sodium to argon.
- Period 4 contains eighteen elements from potassium to krypton.

Horizontal rows = 'periods'

Look at the horizontal rows (periods) on the periodic table. How many periods are there? You should have found that there are 7 periods.

Activity 9 – Periods in the periodic table

Label the periods 1 to 7 on the periodic table below



What trends occur down a group and across a period?
A condensed version of the periodic table is shown on the next page. The transition metals have been taken away because their structure changes in a more complex way that you will learn about if you do senior chemistry.

The remaining 8 groups are shown near each other. Only the first three periods are shown.
Do you remember how electrons surround the nucleus and are found in different energy levels (sometimes shown as shells around the nucleus)?

Look at the diagram below. Can you see how the electrons in an atom of these elements have been drawn in their shells?

How many shells do the period 1 elements have? Can you see 1 shell? How many shells do the period 2 elements have? Can you see 2 shells? How many shells do the period 3 elements have? Can you see 3 shells?

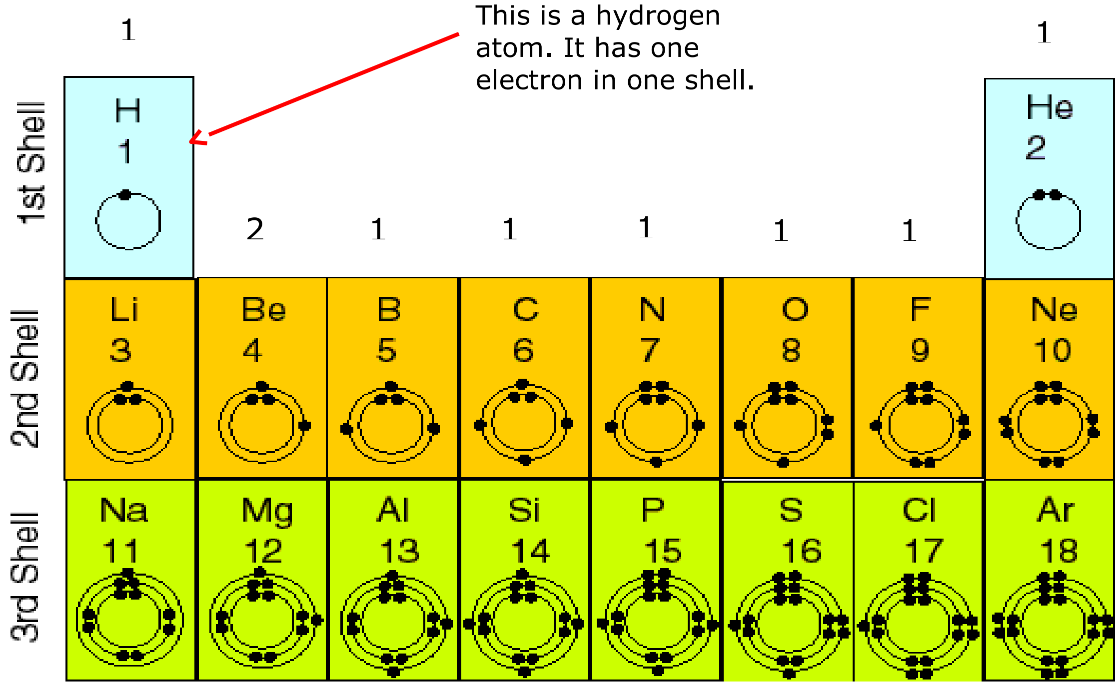


Figure 9: A condensed version of the periodic table

The number of shells increases as you go down the group. This trend (pattern) continues down a whole group. So in periods 4, 5, 6 and 7, the atoms of the elements have 4, 5, 6 and 7 shells respectively.

The period number tells you the number of electron shells

What happens as you go across a period?
Look at the elements in group 1. These are H (hydrogen), Li (lithium) and Na (sodium).
Can you see how many electrons their atoms have in their outermost shell? Did you find 1 electron in each one?

Now look at the elements in group 2. These are Be (beryllium) and Mg (magnesium).
Can you see how many electrons their atoms have in their outermost shell? Did you find 2 electrons in each one?

Keep going from left to right across the table, looking at the number of electrons in the outermost shells of each group in Figure 11 on page 23.
Can you see the trend (pattern) across each period?

- 3rd column (group 13): atoms have 3 electrons in their outer shell.
- 4th column (group 14): atoms have 4 electrons in their outer shell.
- 5th column (group 15): atoms have 5 electrons in their outer shell.

… and so on …

- 8th column (group 18): atoms have 8 electrons in the outer shell.

The group number is related to the number of electrons in the outermost shell.

Activity 10 – Electrons in the outermost shell

Look at the condensed period table and fill in the blanks below.

- All the atoms of the elements in group 13 have __________ electrons in their outer shell.
- All the atoms of the elements in group 16 have __________ electrons in their outer shell.
- All the atoms of the elements in group 17 have __________ electrons in their outer shell.

Using the periodic table to predict properties of elements

A big advantage of the periodic table is that it allows us to infer the properties of elements we may not be familiar with.
For example, let's take a look at the group 1 elements and see how they react with water.

Figure 10: Sodium reacting with water

Lithium floats and gently fizzes on water.

Sodium also floats, but it burns more readily, whizzing about on the water's surface and sometimes explodes … see Figure 10 on the right.
How do you think potassium will react with water? Do you think it will react in a similar way? Will it react more or less vigorously than sodium?

If you thought potassium does react in a similar way and more vigorously than sodium, you were correct!

Potassium reacts much faster than sodium. So much heat is given off that it sets light to the hydrogen gas being produced.
This is because elements in the same group behave similarly in chemical reactions. The elements become more reactive as you go down the group.
So, if we know nothing about caesium, we can predict how it will react with water as it is in the same group as lithium, sodium and potassium.

Activity 11 – Caesium in water

Caesium is a group 1 element on the periodic table just like lithium, sodium, and potassium. Predict whether caesium will react with water. Give a reason for your answer.

____

____

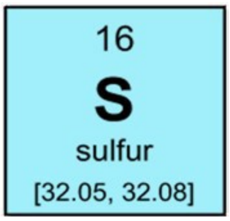
____

____

You can now check your prediction as you watch this video [https://www.sciencealert.com/watch-cooled-down-caesium-in-water-is- the-most-beautiful-explosion](https://www.sciencealert.com/watch-cooled-down-caesium-in-water-is-the-most-beautiful-explosion)

Lesson 2 – What's on the periodic table?

1. Sulfur is an element on the periodic table. It is shown as follows:



   What is the number of the group that sulfur is found in? ______________

2. Look at the periodic table. What is the number of the period that sulfur is found in? ________

3. Complete this sentence:

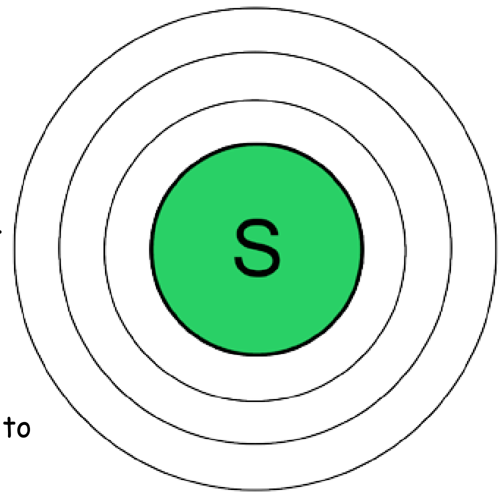
   Sulfur has atomic number _____ and so it has _______ protons ________ electrons.

4. State the number of electrons in each of the following electrons shells of sulfur:

   a. first shell: _____________

   b. second shell: ____________

   c. third shell: ______________



Remember from part 1, that the number of electrons in each energy level (shell) is the electron configuration for an element.

5. Write the electron configuration for sulfur:

6. Complete the model of a sulfur atom on the right, using dots to represent the electrons in each shell.

7. Use the periodic table to complete the following:

   a. Name the element in group 2, period 4. _____________

   b. Name the group that contains helium, neon and argon. _____________

   c. Name the group that contains fluorine, chlorine and bromine. ____________

8. Use the periodic table to complete this table:

Chemical element	*Symbol*	*Atomic number*
potassium		
	Mg	
iron		
copper		
	Zn	
silver		
	Au	
mercury		
	Al	
phosphorus		
	Si	
		17
iodine		
	H	
neon		10
	Ar	

9. Write the correct answer for each question.

   a. Which group number contains the element hydrogen? ___________

   b. Which group number contains the element helium? ___________

   c. Which period number contains the element magnesium? ___________

   d. Which period number contains the element nitrogen? ___________

10. How many electrons are found in the outer shell of the:
    a. group 1 elements? __________
    b. group 2 elements? __________
    c. group 13 elements? __________
    d. group 17 elements? __________

You learnt about some of the trends in the periodic table. Complete these sentences about these trends:

- The number of electron shells i_____________ as you go down a group. The number of electron shells is the s_______ as the p__________ number.
- The number of electrons in the o______________ shell is related to the g___________ number and is the s___________ for all the elements in the same group.
- As you go from left to right across a period, the n______________ of electrons in the outer s_________ of a g___________ increases.

Lesson 3: Classifying the elements

Metals, non-metals and metalloids

The elements in the periodic table can be classified according to their properties as metals, non-metals or metalloids.

Metals are elements which:

- are solids at room temperature (except mercury: this is a liquid)
- are lustrous (able to reflect light well)
- are good conductors of heat and electricity
- are malleable (able to be hammered or shaped without breaking or cracking) and ductile (able to be drawn into a wire)

Figure 11: Mercury, a metal that is liquid at room temperature

Figure 12: Zinc, a solid at room temperature

Some examples of metals are aluminium, cobalt, copper, gold, iron lead, magnesium, nickel, potassium, sodium, silver, tin and zinc.

Most other elements are called non-metals. Some examples of non-metals are bromine, chlorine, hydrogen, iodine, nitrogen, oxygen, phosphorus and sulfur.
Although the elements in group 18 are not metals, it is better to refer to them as noble gases, because they do not readily react with any other substances (i.e. they are inert).

The properties of non-metals are very different from those of metals.

Figure 13: Sulfur

Non-metals are elements which:

- have a dull appearance (except iodine: this is slightly lustrous)
- are poor conductors of heat and electricity
- are brittle (solid non-metals tend to crumble into powders)
- most of them occur naturally as gases in the air
- have relatively low melting points and boiling points

Some elements are more difficult to classify. For example, carbon in the form of graphite is a conductor of electricity and is a solid. Despite this we classify it as a non-metal because, considering all its properties, it resembles a non-metal more closely than the metals.

Figure 14: Carbon

The following elements do not fall clearly into either metals or non-metals. They act like non-metals in most ways, however they have some properties that are more like those of metals:

boron, silicon, germanium, arsenic, antimony and tellurium

They are classified as *metalloids* (and are sometimes called *semi-metals*).

Group	Metal	Metalloids	Non-metals
Appearance	Lustrous	Dull / Lustrous	Dull - except iodine
Electrical conductivity	Good to high	Varies – most are semi-conductors	Poor - except graphite
Malleability and ductility	High	Often brittle	Brittle if solid. Not applicable for gases or liquids.
Density	Usually high	Varies from low to high	Often low
Boiling points	Generally high	Generally high	Usually low
Strength	High	Varies	Low

Activity 12 – Metals, non-metals and metalloids

1. Complete the following sentence:

The e_______________ in the periodic table can be classified according to their properties as either m______________ , n_____-m___________ or m ________________ .

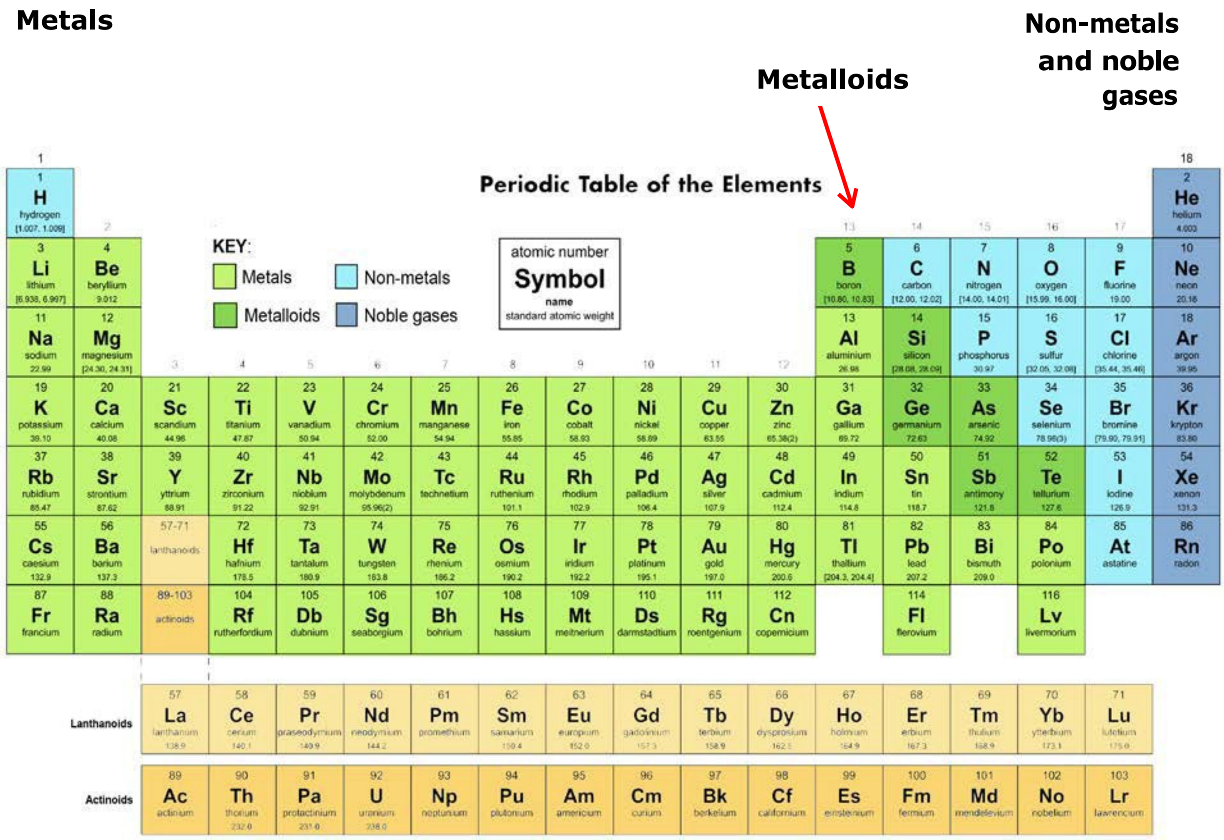
2. Look at these descriptions of some properties of elements. Identify whether they are describing a metal, non-metal or a metalloid:
    - malleable and ductile and a high density: ________________
    - lustrous and a semi-conductor: ________________
    - does not conduct electricity and a low boiling point: ________________

3. Give the name of one element that is a metal. ________________
4. Give the name of one element that is a non-metal. ________________
5. Give the name of one element that is a metalloid. ________________

Where are the metals, non-metals and metalloids on the periodic table?

In the last lesson, you learnt how there are a number of trends (patterns) in the periodic table. Another trend is that the elements found on the left side of the periodic table are metals, while the elements on the right side of the periodic table are non-metals. The metalloids are in-between the metals and non- metals.

Look at the key on the periodic table below. This shows which elements are metals, metalloids, non-metals or noble gases.



Now let's take a look at the period 3 elements.

Going across period 3, sodium, magnesium and aluminium are metals, silicon is a metalloid, and phosphorus, sulphur, chlorine and argon are non-metals.

Figure 15:Elements in period 3 (from left to right): sodium, magnesium, aluminium (metals); silicon (metalloid); phosphorous, sulfur (non-metal powders), chlorine and argon (non-metal gases)

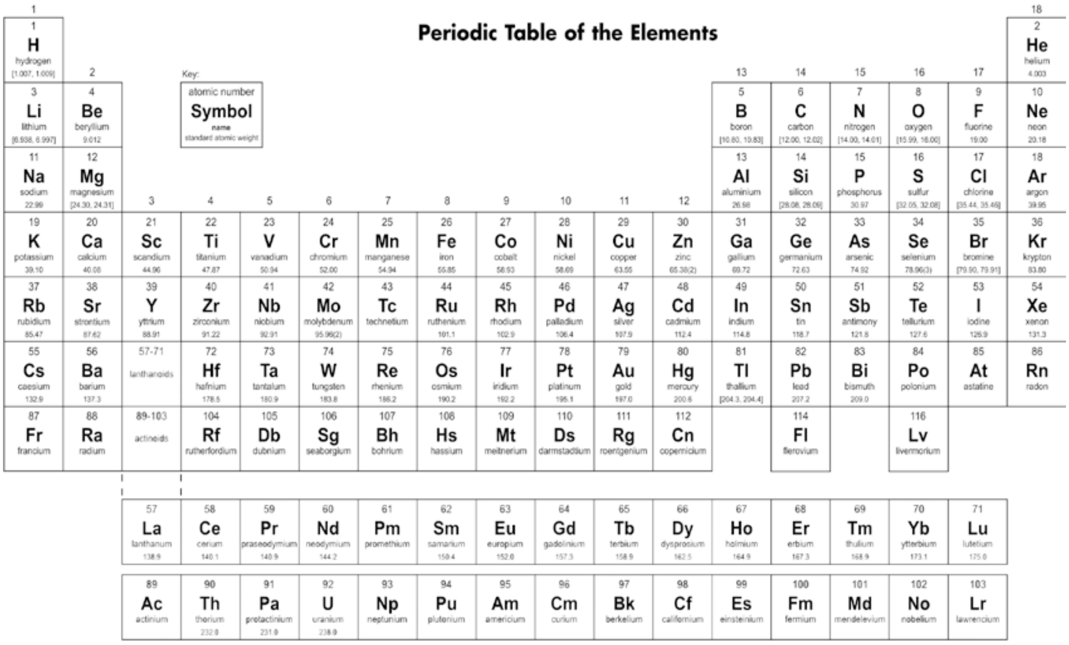
Activity 13 – Location of metals and non-metals

On which side of the periodic table are metals found? ___________________

On which side of the periodic table are non-metals found? ________________

Highlight or colour in the non-metals on the periodic table below. Include a key.

Key:
non- metals



Lesson 3 – Classifying the elements

1. Imagine you are a scientist. You have been given three elements, labelled X, Y and Z. One is magnesium, one is silicon and the other is iodine. You have been asked to look at the results of some tests on them to determine which sample is which element.


Figure 16: Element X


Figure 17: Element Y

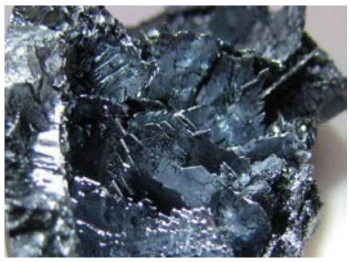


Figure 18: Element Z

The results of the tests on the samples were:

	Element X	Element Y	Element Z
Appearance	lustrous	slightly lustrous	lustrous
Electrical conductivity	semi-conductor	nil	high
Malleability and ductility	brittle	brittle	high
Density	low	low	high
Boiling point	high	low	high

Place a tick (✓) in the table below to correctly indicate which of the elements is magnesium, which is silicon and which one is iodine.

Element	Magnesium	Silicon	Iodine
X			
Y			
Z			

2. Use the periodic table on page 17 to complete this table. Place a tick (✓) in the correct column to indicate whether the elements listed are a metal, non-metal or a metalloid.

Element	*Metal*	*Metalloid*	*Non-metal*
calcium			
chlorine			
sulfur			
germanium			
fluorine			
zinc			
boron			

Lesson 4: Periodic table activities

The elements

Do you think you could either recite or sing a list of all the elements? Listen to one (or more) of the Periodic Table songs below. It is amazing what some people can do!

Activity 14 – Periodic Table Songs

Watch these amazing videos of some Periodic Table songs.
You can look at all of them, or choose to do just one or two of the songs.

1. Daniel Radcliffe (actor for Harry Potter) sings 'The Elements' song.

2. Original version of 'The Elements' song by Tom Lehrer.

3. The New Periodic Table Song

   (by AsapSCIENCE)

TO DO THIS:

1. 'The Elements' song Daniel Radcliffe

   https://www.youtube.com/watch?v=IHzUhytT6zU

2. 'The Elements' Tim Lehrer

   https://www.youtube.com/watch?v=zGM-wSKFBpo

3. 'The New Periodic Table Song

   https://www.youtube.com/watch?v=rz4Dd1I_fX0

Periodic tables

There are a number of different periodic tables available on the internet. When using the internet, you need to be careful that you are using a website that is up-to- date and reliable, e.g. educational, university & government websites. This helps to ensure that the information you are reading is accurate.

Up-to-date periodic tables should include the latest elements that have been discovered. So any new elements from atomic number 112 (copernicium) onwards should be included, such as atomic numbers 114 (flerovium) through to 118 (oganesson). If physicists discover more elements, these new elements will also need to be included in future periodic tables.

Activity 15 – Interactive periodic table

Have a look at this interactive periodic table. It allows you to find out more information about each element, data trends across the periodic table, plus lots more.

https://elements.wlonk.com/ElementsTable.htm

Have a look at this interactive periodic table. It has videos of each element in the periodic table.

http://ed.ted.com/periodic-videos

Each element symbol button goes to a video.

Using the clues below and the information you have learnt in this Atomic Structure topic, to help you complete the crossword puzzle on the next page.

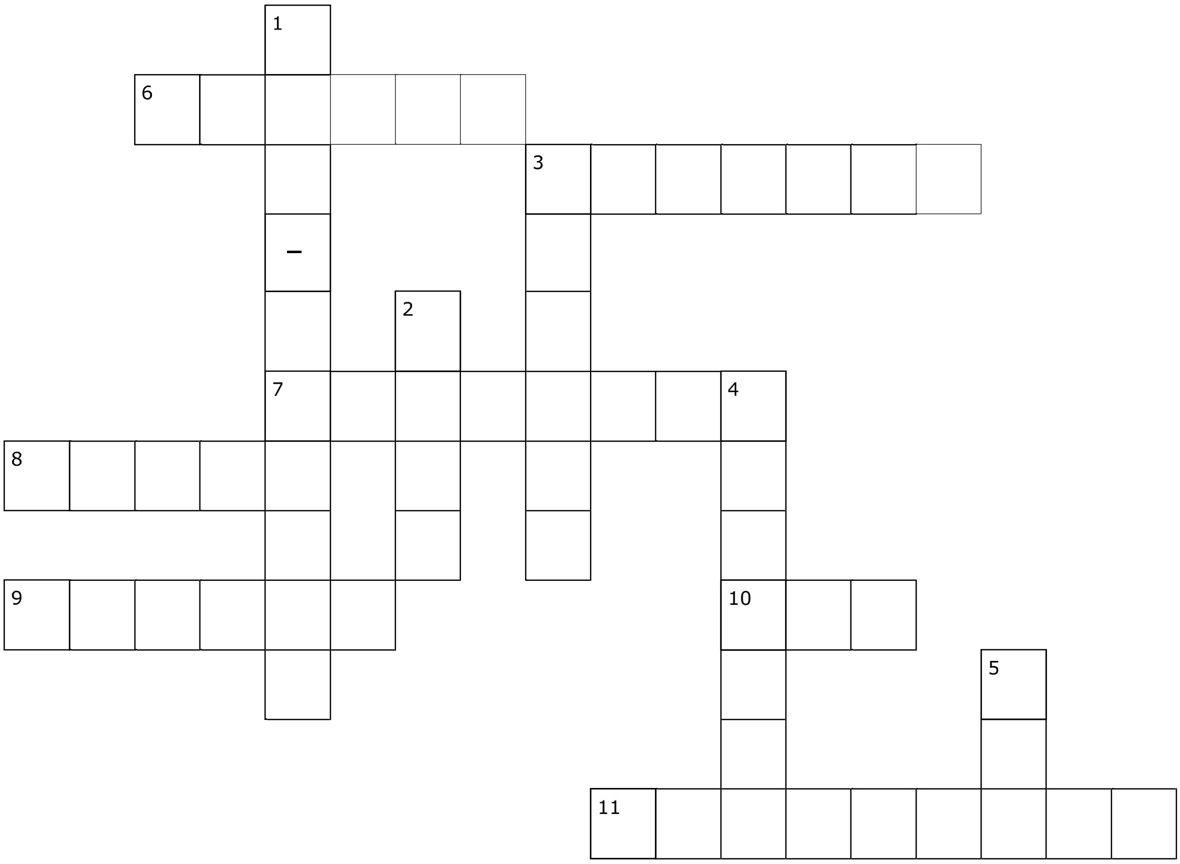
DOWN

1. Gases such as nitrogen, oxygen, sulfur and chlorine are classified as this type of element.
2. Side of the periodic table in which metals are found.
3. Positively charged particle in an atom's nucleus.
4. Neutral subatomic particle in an atom's nucleus.
5. Group 1 has this number of electrons in their outer shell.

ACROSS

3. Horizontal rows on the periodic table are called________________________.
6. Vertical columns on the periodic table are called________________________.
7. Subatomic particle that has a negative charge.
8. Side of the periodic table in which non-metals are found.
9. Elements on the left side of the Periodic Table are called ________________.
10. Maximum number of electrons found in the first electron shell.
11. Dmitri____________________ organised elements into a table based on atomic weights and similar properties.

ATOMIC STRUCTURE CROSSWORD



2. Choose 1 element from the periodic table. Using the information provided by the websites you accessed, construct an A4 Fact sheet on your chosen element. Include history/discovery, uses & properties.

Suggested answers

Activity 1 – Development of the periodic table

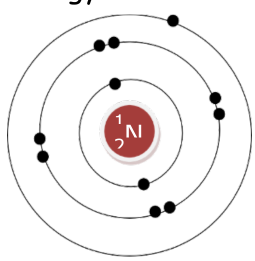
In 1869, D*mitri* M*endeleev* produced a *periodic* table. He organised the *elements* into rows based on increasing *atomic* weight, but arranged them so that elements with similar *properties* appeared *under* each other in *groups*. *Gaps* were left for elements that were not yet *discovered*.

Activity 2 – True or false?

		T or F?
1.	The ancient Greeks had the same understanding of elements	F
2.	All elements can be placed into the periodic table.	T
3.	The arrangement of elements in the periodic table shows patterns in the way elements behave in chemical reactions.	T
4.	The modern periodic table only contains the 63 elements known 1869.	F
5.	There are 90 naturally occurring elements in the periodic table.	T

Activity 3 – Arrangement of protons, electrons and neutrons

1. *Protons* and neutrons are in the *nucleus* of an atom.
2. Electrons form a *cloud* surrounding the nucleus and are found in different*energy* levels (or shells).
3. In an atom the number of electrons is equal to the number of *protons*.
4. (a) Each energy level can only hold a maximum *number* of electrons. The first energy level holds a maximum of *2*electrons.
   The second energy level holds a maximum of *8* electrons. The third energy level holds a maximum of *18* electrons.
   (b) A model of a sodium atom:



Activity 4 – Using the periodic table

Element	Symbol	Atomic number
Hydrogen	H	1
Helium	He	2
Lithium	Li	3
Magnesium	Mg	12
Silicon	Si	14
Carbon	C	6
Nitrogen	N	7
Fluorine	F	9
Neon	Ne	10
Oxygen	O	8
Sodium	Na	11
Potassium	K	19
Calcium	Ca	20
Chlorine	Cl	17
Argon	Ar	18
Boron	B	5
Aluminium	Al	13
Phosphorous	P	15
Sulfur	S	16
Beryllium	Be	4

Activity 5 – How do elements get their names?

What element is named after	*Atomic number*	*Element's name*	*Symbol*
a continent	63	*europium*	*Eu*
a country	87	*francium*	*Fr*
a state in the USA	98	*californium*	*Cf*
a scientist	99	*einsteinium*	*Es*
a planet	93	*neptunium*	*Np*
the colour indigo	49	*indium*	*In*

Activity 6 – Can you decipher an elemental message?

The symbols are: P H Y Si Cs I S F U N So the hidden message is "physics is fun"

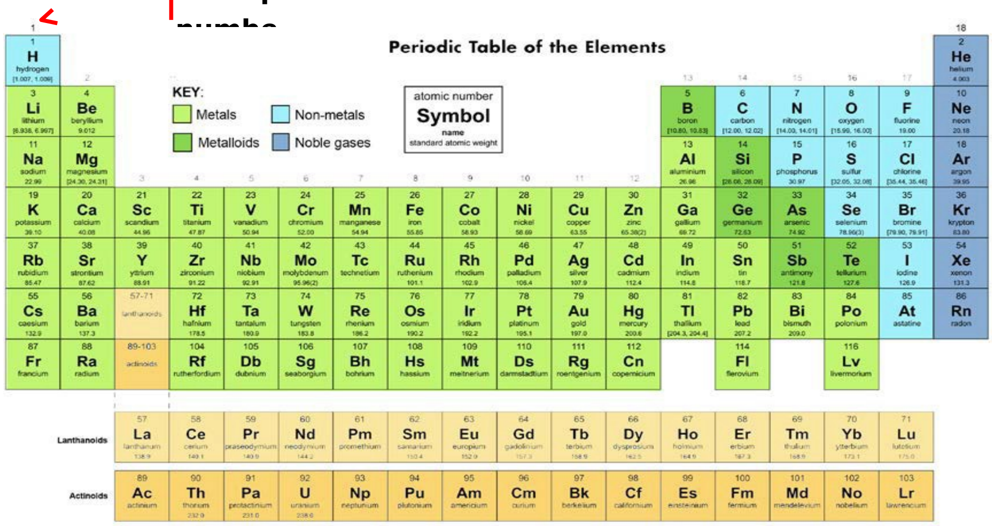
Activity 7 – Groups in the periodic table

1. *Helium, neon, argon, krypton.*
2. *Group 17*
3. (a) Group 1 are *metals.*

(c) Group 17 are *non-metals.*

4. Elements in the same *vertical* column (*group*) have *similar*properties.

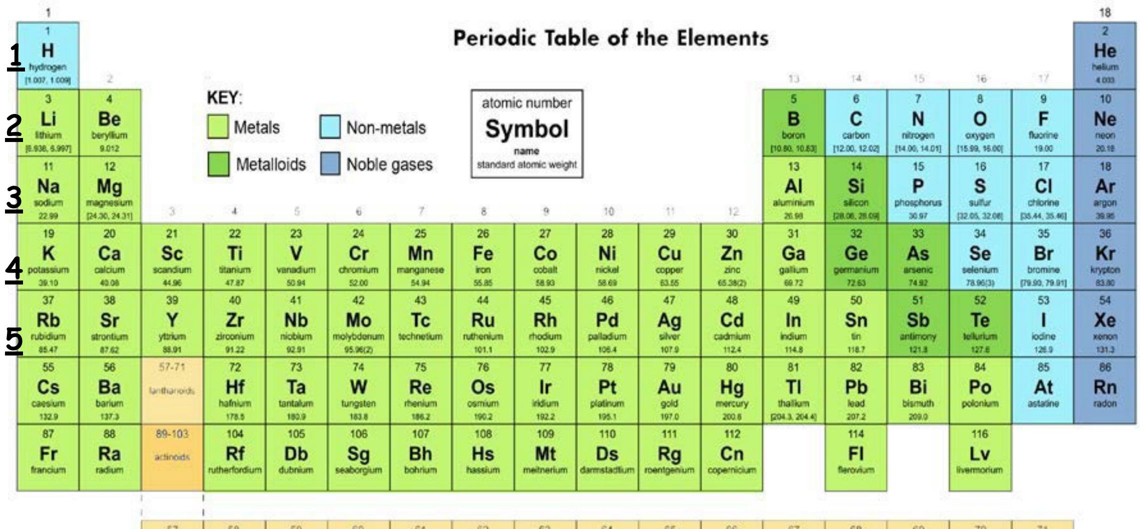
5. Group



Activity 8 – Groups with special names

1. groups
2. Any TWO of these: *fluorine, chlorine, bromine, iodine,astatine*
3. (a) transition metals (b) halogens (c) noble gases

Activity 9 – Periods on the periodic table



Activity 10 – Electrons in the outermost shell

1. All the elements in group 13 have <u>3</u> electrons in their outershell
2. All the elements in group 16 have <u>6</u> electrons in their outershell
3. All the elements in group 17 have <u>7</u> electrons in their outershell

Activity 11 – Caesium in water

Caesium will react very rapidly with water. It will ignite and explode. Caesium is in the same group, so it will have similar properties to the other elements in this group. However, it is lower down the group, so it will react more violently.

Activity 12 – Metals, non-metals and metalloids

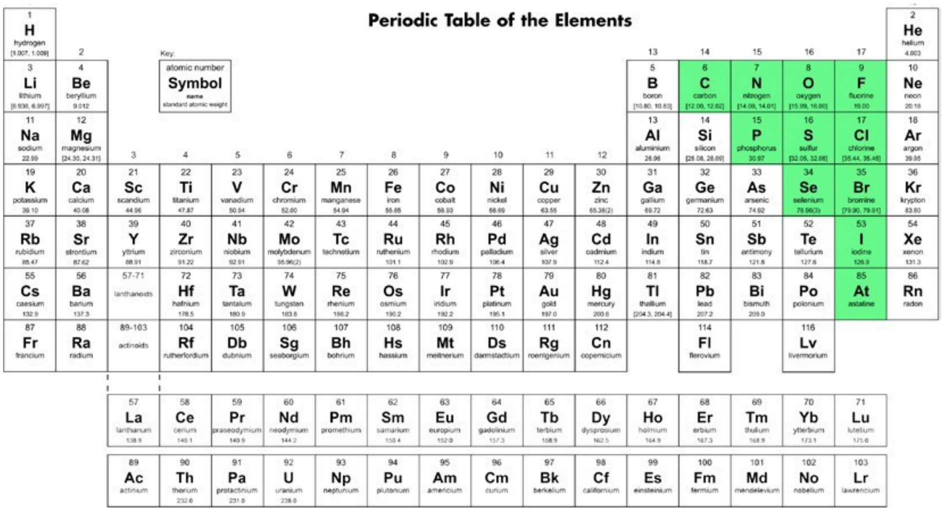
1. The *elements* in the periodic table can be classified according to their properties as either *metals*, *non-metals* or *metalloids*.
2. • malleable and ductile and a high density:<u>metal</u>
- lustrous and a semi-conductor: <u>metalloid</u>
- does not conduct electricity and a low boiling point:<u>non-metal</u>
3. *Answers will vary. Any ONE of:* aluminium, cobalt, copper, gold, iron lead, magnesium, nickel, potassium, sodium, silver, tin, zinc,etc.
4. *Answers will vary. Any ONE of:* argon, bromine, chlorine, hydrogen, iodine,nitrogen, oxygen, phosphorus and sulfur,etc.
5. *Any ONE of:* boron, silicon, germanium, arsenic, antimony andtellurium

Activity 13 – Location of metals and non-metals

1. LEFT
2. RIGHT
3.

Key:

non-metals



Acknowledgments

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Year 9 Atomic Structure

Home Learning Modified by Ms Butler

Please attempt all work and ask questions online, if possible.

The Google Classroom will have quiz questions to assess your understanding of content. Please check Google Classroom frequently for updates or e-mail the following Year 9 Science Co-ordinators.

edwina.butler@det.nsw.edu.au
george.salmon1@det.nsw.edu.au

Science
Stage 5

Atomic structure
Part 3

Lesson 1: Isotopes and their stability

Atomic structure

In previous lessons, you learnt that:

All matter is made up of atoms and atoms are made up of smaller sub-atomic particles.

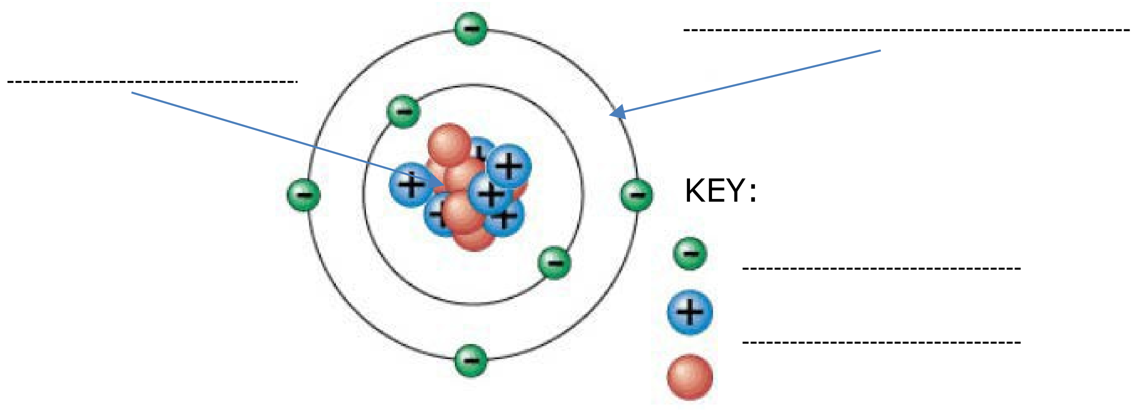
Understanding the structure of atoms led to scientists making sense of radioactivity, which you are going to learn about in this set of lessons.

Here is an activity to help you recall what you know about atomic structure. Please check that all of your answers are correct by going to the Suggested Answers for each activity before you start the next activity.

Activity 1 – What's inside an atom?

1. Use these words to complete the missing labels on the following model of an atom.

electron	proton	electron shell	nucleus	neutron



2. Recall the missing words in the sentences below.
   a. All matter is made up of ________________ .
   b. All atoms contain protons, neutrons and electrons. These are called sub- ______________ particles.
   c. number of protons = number of __________ (in a neutral atom)
   d. The number of protons in the nucleus of an atom of an element is called the ____________ number.

Isotopes

Previously, you also learnt about isotopes. Remember:

Isotopes are atoms of the same element with the same number of protons, but a different number of neutrons.

Let's look at hydrogen again. Hydrogen has three isotopes - each isotope has one proton. However, the different isotopes have 0, 1 or 2 neutrons respectively, as shown below. The name of an isotope includes its mass number. You learnt previously that:

Mass number is the number of protons plus the number of neutrons

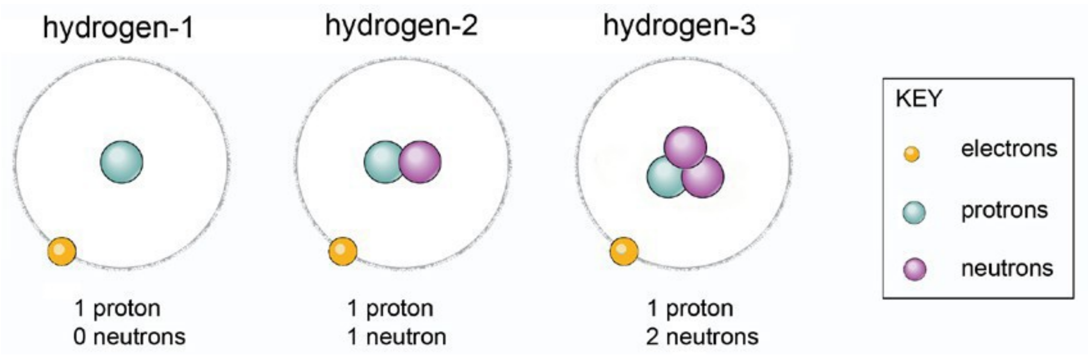


Figure 19: Isotopes of hydrogen

Activity 2 – Isotopes

Use these words to help complete the sentences below about isotopes.

mass	isotopes	protons	atomic
neutrons	number	carbon	

Atoms of the same element that have a different number of neutrons in the nucleus are called i_______________.

All atoms of a particular element have the same number of protons and so they have the same a_____________ number. However, they can have different numbers of n_____________ and so they have different m__________ numbers.

The name of an isotope includes its mass n____________, e.g. carbon- 12 is an isotope of __________ with a mass number of 12.

Mass number = number of ______________ + number of neutrons.

Naming isotopes

> The chemical symbols of isotopes can be written as $^{A}_{Z}E$
> Where:
> A = mass number (number of protons + number of neutrons)
> Z = atomic number (number of protons)
> E = symbol of element

Hence the chemical symbols for hydrogen with a mass number of 3 and an atomic number of 1 is represented as $^{3}_{1}H$ or in words, hydrogen-3. 1

Given that the carbon-14 isotope has 6 protons and a mass number of 14, how would you write the symbols for the carbon-14 isotope?

Did you write $^{14}_{6}C$? If so, well done!

Activity 3 – Describing isotopes

Write the chemical symbols for each of the other isotopes listed in the table below. Two of the chemical symbols have already been done for you.

The periodic table on the following page has the symbols. The data in the table below will help you to work out the mass and atomic numbers.

Remember: mass number (A) = number of protons + number of neutrons atomic number (Z) = number of protons

Isotope	Chemical symbol ($^{A}_{Z}E$)	Number of protons	Number of neutrons
Carbon-12		6	6
Carbon-13	$^{13}_{6}C$	6	7
Carbon-14		6	8
Chlorine-35		17	18
Uranium-235	$^{235}_{92}U$	92	143
Uranium-238		92	146

Periodic Table of the Elements

KEY:
- Metals
- Metalloids
- Non-metals
- Noble gases

atomic number **Symbol** name standard atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 **H** hydrogen [1.007, 1.009]																	2 **He** helium 4.003
3 **Li** lithium [6.938, 6.997]	4 **Be** beryllium 9.012											5 **B** boron [10.80, 10.83]	6 **C** carbon [12.00, 12.02]	7 **N** nitrogen [14.00, 14.01]	8 **O** oxygen [15.99, 16.00]	9 **F** fluorine 19.00	10 **Ne** neon 20.18
11 **Na** sodium 22.99	12 **Mg** magnesium [24.30, 24.31]											13 **Al** aluminium 26.98	14 **Si** silicon [28.08, 28.09]	15 **P** phosphorus 30.97	16 **S** sulfur [32.05, 32.08]	17 **Cl** chlorine [35.44, 35.46]	18 **Ar** argon 39.95
19 **K** potassium 39.10	20 **Ca** calcium 40.08	21 **Sc** scandium 44.96	22 **Ti** titanium 47.87	23 **V** vanadium 50.94	24 **Cr** chromium 52.00	25 **Mn** manganese 54.94	26 **Fe** iron 55.85	27 **Co** cobalt 58.93	28 **Ni** nickel 58.69	29 **Cu** copper 63.55	30 **Zn** zinc 65.38(2)	31 **Ga** gallium 69.72	32 **Ge** germanium 72.63	33 **As** arsenic 74.92	34 **Se** selenium 78.96(3)	35 **Br** bromine [79.90, 79.91]	36 **Kr** krypton 83.80
37 **Rb** rubidium 85.47	38 **Sr** strontium 87.62	39 **Y** yttrium 88.91	40 **Zr** zirconium 91.22	41 **Nb** niobium 92.91	42 **Mo** molybdenum 95.96(2)	43 **Tc** technetium	44 **Ru** ruthenium 101.1	45 **Rh** rhodium 102.9	46 **Pd** palladium 106.4	47 **Ag** silver 107.9	48 **Cd** cadmium 112.4	49 **In** indium 114.8	50 **Sn** tin 118.7	51 **Sb** antimony 121.8	52 **Te** tellurium 127.6	53 **I** iodine 126.9	54 **Xe** xenon 131.3
55 **Cs** caesium 132.9	56 **Ba** barium 137.3	57-71 lanthanoids	72 **Hf** hafnium 178.5	73 **Ta** tantalum 180.9	74 **W** tungsten 183.8	75 **Re** rhenium 186.2	76 **Os** osmium 190.2	77 **Ir** iridium 192.2	78 **Pt** platinum 195.1	79 **Au** gold 197.0	80 **Hg** mercury 200.6	81 **Tl** thallium [204.3, 204.4]	82 **Pb** lead 207.2	83 **Bi** bismuth 209.0	84 **Po** polonium	85 **At** astatine	86 **Rn** radon
87 **Fr** francium	88 **Ra** radium	89-103 actinoids	104 **Rf** rutherfordium	105 **Db** dubnium	106 **Sg** seaborgium	107 **Bh** bohrium	108 **Hs** hassium	109 **Mt** meitnerium	110 **Ds** darmstadtium	111 **Rg** roentgenium	112 **Cn** copernicium		114 **Fl** flerovium		116 **Lv** livermorium		

Lanthanoids	57 **La** lanthanum 138.9	58 **Ce** cerium 140.1	59 **Pr** praseodymium 140.9	60 **Nd** neodymium 144.2	61 **Pm** promethium	62 **Sm** samarium 150.4	63 **Eu** europium 152.0	64 **Gd** gadolinium 157.3	65 **Tb** terbium 158.9	66 **Dy** dysprosium 162.5	67 **Ho** holmium 164.9	68 **Er** erbium 167.3	69 **Tm** thulium 168.9	70 **Yb** ytterbium 173.1	71 **Lu** lutetium 175.0
Actinoids	89 **Ac** actinium	90 **Th** thorium 232.0	91 **Pa** protactinium 231.0	92 **U** uranium 238.0	93 **Np** neptunium	94 **Pu** plutonium	95 **Am** americium	96 **Cm** curium	97 **Bk** berkelium	98 **Cf** californium	99 **Es** einsteinium	100 **Fm** fermium	101 **Md** mendelevium	102 **No** nobelium	103 **Lr** lawrencium

Unstable isotopes are radioactive

Most atoms that make up the world around you are stable. Their nuclei will never change, as the protons and neutrons in the nucleus are held together very strongly.
However, some atoms are unstable. Their nuclei can change over time, as the protons and neutrons in the nucleus are not held together as strongly as in stable atoms. This change can happen quickly, or it might take tens, thousands or even millions of years to occur – it all depends on the type of atom.

So, some isotopes of elements are stable and some are unstable. Unstable isotopes are said to be radioactive because they emit radiation.

Unstable isotopes are called radioactive isotopes, or radioisotopes.

Each element may have several isotopes, but only some isotopes are unstable and therefore radioactive.

Let's look at carbon again.

Carbon has 3 naturally occurring isotopes. Most carbon (98.9%) is carbon-12, some (1.1%) is carbon-13, while a trace only is carbon-14.

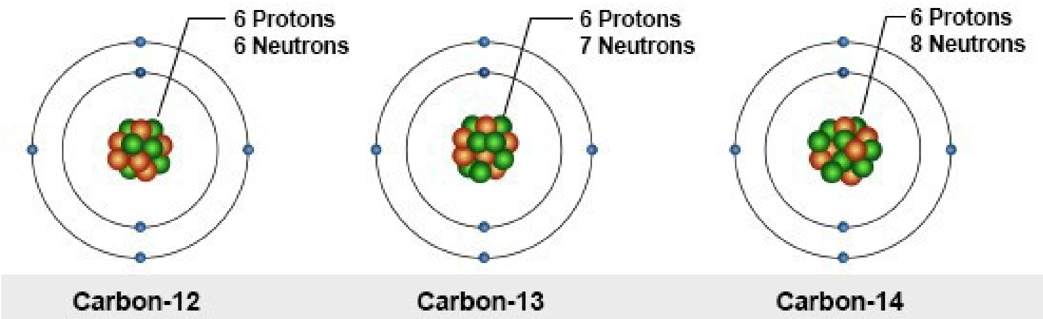


Figure 20: The isotopes of carbon

Each isotope of carbon is a carbon atom with 6 protons in its nucleus. However, each of the nuclei has a different number of neutrons. Only carbon-14 is unstable and therefore radioactive.

Element	Symbol	Number of protons	Number of neutrons	Stable or radioactive?
Carbon-12	${}^{12}_{6}C$	6	6	Stable
Carbon-13	${}^{13}_{6}C$	6	7	Stable
Carbon-14	${}^{14}_{6}C$	6	8	Radioactive

Now let's look at uranium. Uranium is a naturally occurring element. It has no stable isotopes. So all uranium isotopes are radioactive – the most common are uranium- 238, uranium-235 and uranium-234.

Element	Symbol	Number of protons	Number of neutrons	Stable or radioactive?
Uranium-238	$^{238}_{92}U$	92	146	Radioactive
Uranium-235	$^{235}_{92}U$	92	143	Radioactive
Uranium-234	$^{234}_{92}U$	92	142	Radioactive

Did you know? Australia has 23% of the world's known uranium reserves. Uranium is the main fuel used in nuclear power stations. The most common form of uranium is uranium- 238, with more than 99% of natural uranium in the world being this isotope. Most of the rest is uranium-235.

Activity 4 – Unstable isotopes

Answer these questions.

1. What word is used to describe the nucleus of an atom in which the protons and neutrons are held strongly? ______________________________
2. Why are the isotopes of some elements unstable?

   ____

   ____
3. What are unstable isotopes called? ______________________________
4. Complete this sentence.

   When an unstable isotope emits r___________________, it is said to be r__________________.
5. Name an isotope of carbon that is radioactive. ______________________

Lesson 1 – Isotopes and their stability

1. Complete the missing words in the sentences below.

The sub-a____________ particles found in the nucleus of an atom are called p__________ and n__________. E___________ are the sub-atomic particles that orbit the n___________. Isotopes of an element have the same number of p_____________, but a different number of n_____________. Hence they have the same a_________ number, but different m________ numbers.

2. The chemical symbols of isotopes can be written as ${}^{A}_{Z}E$

   a. What is represented by the letter A? _______________________

   b. What is represented by the letter Z? _______________________

3. About 0.01% of the potassium in your body is the radioisotope potassium- 40. Its chemical formula is ${}^{40}_{19}K$
   How many protons and neutrons are in each atom of this radioisotope?

   a. protons _______________________

   b. neutrons _______________________

4. Some isotopes are stable, while some isotopes are unstable. Are the isotopes of uranium stable or unstable? _______________________

5. Why are the isotopes of uranium described as 'radioactive'?

____

____

6. Which isotope of carbon is unstable and radioactive? _______________________

Lesson 2: What is radioactivity?

Recalling information

Last lesson, you learnt that:

- some isotopes are stable and some are unstable
- unstable isotopes are radioactive because they emit radiation
- unstable isotopes are called radioactive isotopes, or radioisotopes.

In this lesson, you are going to learn about radioactivity and the different types of nuclear radiation.

Background radiation

We are all exposed to background radiation every day from a variety of sources. This constant, low-level radiation surrounds us. Background radiation comes from:

- naturally occurring radioactive elements that are in the Earth's atmosphere and crust, as well as in water and living things
- the cosmic radiation that reaches us from the Sun.

Earth's atmosphere protects us from most of the dangers of cosmic radiation. This is because the stratosphere layer in the atmosphere absorbs a lot of this radiation, especially ultraviolet radiation.

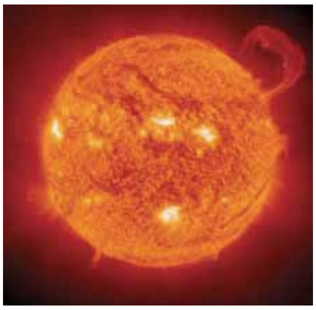


Figure 21: The Sun is a source of cosmic radiation

Did you know that bananas contain the radioisotope potassium-40 (^{40}K). But do not worry – the dose of radiation from eating a few bananas will not harm you. In fact, you would have to eat over 80 million bananas before you would have to worry. The radiation from eating 50 bananas would be equivalent to the radiation from one dental X-ray.

Another source of background radiation is the radiation that people are exposed to from living indoors. The buildings that we live in increase the concentration around us of a radioactive gas called radon, especially when the building does not have plenty of ventilation. This gas is in the air we breathe. It arises naturally from the radioactive decay of uranium and thorium, which are normally present in the rocks, bricks, mortar, tiles and concrete that we use for building materials. These materials also contain small amounts of the radioisotope potassium-40.

There are even small amounts of radioisotopes in the human body, including hydrogen-3 (tritium), carbon-14 and potassium-40.

Figure 22: Some sources of natural radioactivity

Nuclear radiation

Last lesson, you learnt that atoms with unstable nuclei are radioactive because they emit radiation. To become more stable, the nuclei of atoms undergo radioactive decay.

In radioactive decay, the unstable atoms of one element are changed into more stable atoms of a completely different element.

There are two types of radioactive decay: alpha decay and beta decay. In alpha decay, particles called alpha (α) particles are emitted, while in beta decay particles called beta (β) particles are emitted.

Energy is also emitted in both types of radioactive decay in the form of gamma (γ) rays.

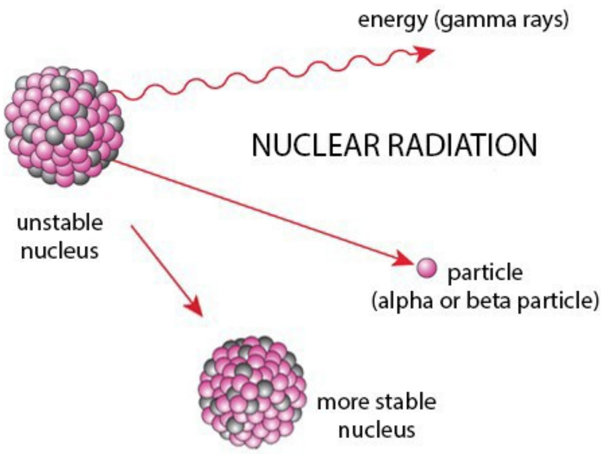


Figure 23: Rodioactive decay occurs in an unstable radioactive nucleus

There are several other types of radioactive emissions emitted by atoms, e.g. positron emission, etc. You will learn more about these other radioactive emissions if you study senior physics.

- **alpha particles (α)**

When a nucleus is too large to be stable, it may release an alpha particle and energy, and a different element is formed. Alpha decay usually only occurs in atoms with a very large mass number, e.g. greater than 90.

An alpha particle has the symbol α. It consists of two protons and two neutrons (so it is the same as a helium-4 nucleus, $^{4}_{2}He$).

For example, when uranium-238 undergoes alpha decay, it emits an α particle and thorium-234 is formed.

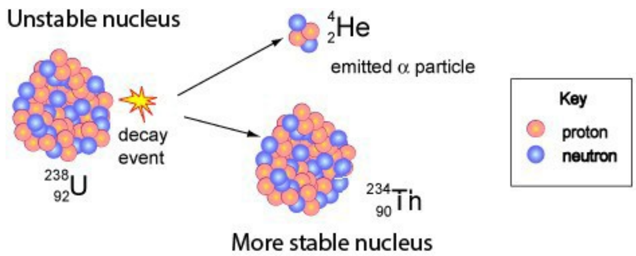


Figure 24: U-238 forms Th-243 and releases an alpha particle

- **beta particles (β)**

When the number of protons compared to the number of neutrons in a nucleus is too high or too low, a nucleus releases a beta particle and energy, and a different element is formed. A beta particle has the symbol β and can be either an electron (a negative particle) or a positron (a positive particle). For example, when carbon-14 undergoes beta decay, it emits a β particle (an electron) and changes to nitrogen-14.

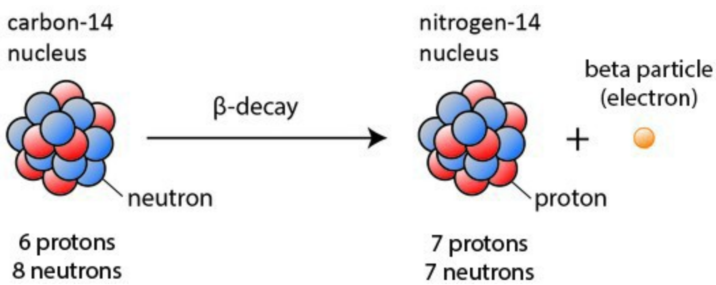


Figure 25: C-14 changes to N-14 and releases a beta particle

- **gamma rays (γ)**

Gamma rays are not particles, but bursts of energy that travel at the speed of light. A gamma ray has the symbol γ. They are a type of electromagnetic wave that is emitted in both alpha decay and beta decay.

How far can radiation penetrate?

Alpha (α) particles cannot travel easily through materials and can be stopped by a few centimetres of air, a sheet of paper or human skin. Alpha particles can harm the surface layers of living things, and cause serious damage if breathed in, eaten or injected.

Beta (β) particles may travel metres in air and several centimetres into living things, but cannot penetrate more than a few centimetres into materials such as aluminium, wood, glass or plastic. So beta particles cause damage to living tissue.

Gamma (γ) rays are far more penetrating than alpha or beta particles. They can only be stopped by a thick shield of lead, steel, concrete or several metres of water. Gamma rays may cause serious or permanent damage to living tissue.

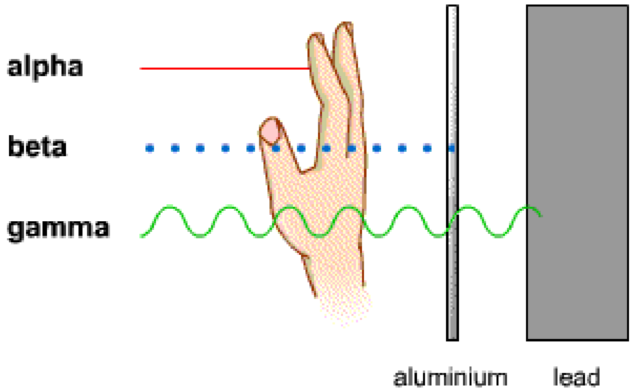


Figure 26: The penetration of different types of radiation

The radiation that is released from an object can be detected using equipment such as a Geiger counter.

Figure 27: A geiger counter

Activity 5 – Penetration and detection of radiation

A scientist wanted to determine what type of nuclear radiation was being emitted by a radioisotope. The following experiment was conducted.

Three different materials (paper, glass and lead) were placed separately over an object that was emitting nuclear radiation. The radiation that passed through each material was measured.
The results obtained in this experiment are shown in the table below.

Material used	*Radiation readings*
Paper	No effect on readings
Glass	Readings fell by over one half
Lead	Big fall in readings

Answer the following questions.

(a) What type of nuclear radiation does this radioisotope emit?

(b) Explain your answer.

(c) What instrument could have been used to detect and measure the nuclear radiation being emitted by the object?

Half-life of radioactive isotopes

We refer to how stable a radioactive isotope (radioisotope) is in terms of its half-life. The half-life of a radioisotope is the time it takes for half of its atoms to undergo radioactive decay. Different radioactive isotopes decay at different rates.

Radioisotope	Half-life
Gold-200	48 minutes
Radon-222	4 days
Iodine-131	8 days
Cobalt-60	5.3 years
Americium-241	460 years
Carbon-14	5730 years
Plutonium-239	24,000 years
Uranium-238	4.5 million years

For example, radon-222 decays into polonium-218 with a half-life of 4 days. This means that 100 atoms of radon-222 decay to 50 atoms of radon-222 over 4 days, then to 25 atoms of radon-222 over the next 4 days, and so on. Understanding the half-life of radioisotopes helps scientists to work out the age of fossils, e.g. in carbon dating.

Carbon dating relies on the fact that all living things contain a small amount of carbon-14. When an organism dies, the carbon-14 begins to decay into nitrogen-14. It has a half-life of 5730 years.

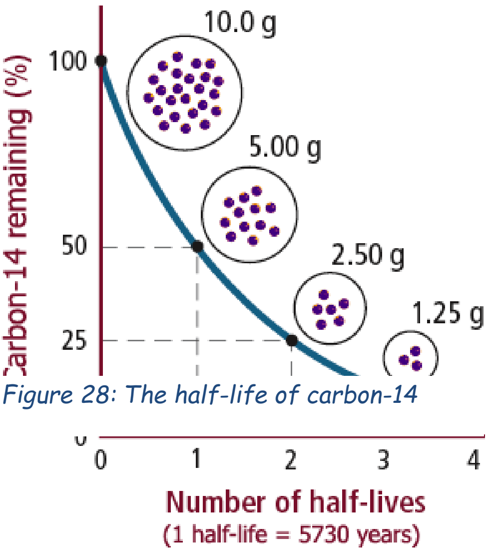


Figure 28: The half-life of carbon-14

So a plant that died 5730 years ago will have half the amount of carbon-14 as a plant living today. In 11,460 years there will be 25% of the original carbon-14 left, and so on. This also means that scientists can calculate the age of wooden tools, paper and fabrics that are made from plants.

Carbon dating cannot be done on things that were not once part of a living organism, as these have never contained any carbon-14. So carbon dating cannot be used to date rocks.

Activity 6 – Background radiation and nuclear radiation

1. State 3 causes of background radiation.

    a. ________________________

    b. ________________________

    c. ________________________

2. How are we protected from most of the dangers from cosmic radiation from outer space?

    ____

    ____

3. Explain why it is safe to eat bananas, even though they contain the radioactive isotope, potassium-40?

    ____

    ____

    ____

    ____

4. Use these words to complete the sentences below.

stable	alpha	gamma	decay	beta	nucleus

When an unstable _________________ undergoes radioactive __________________ , such as alpha decay or beta decay, it becomes more _________________. The particles emitted in radioactive decay are either ______________ particles or _____________ particles. Energy is also emitted in the form of ____________ rays.

5. Explain why carbon dating cannot be used to determine the age of a rock?

    ____

    ____

    ____

    ____

Lesson 2 – What is radioactivity?

1. Complete the missing words in the sentences below.

Every day, we are all surrounded by low levels of radiation called b_____________________ r__________________. This radiation comes from ______________ elements in Earth's crust, ____________ radiation from the Sun and even the ______________ that we live in.

2. What happens to the stability of the nucleus of an element after it has undergone radioactive decay?

____

____

3. Name 3 things that can be released from a nucleus during radioactive decay:

____

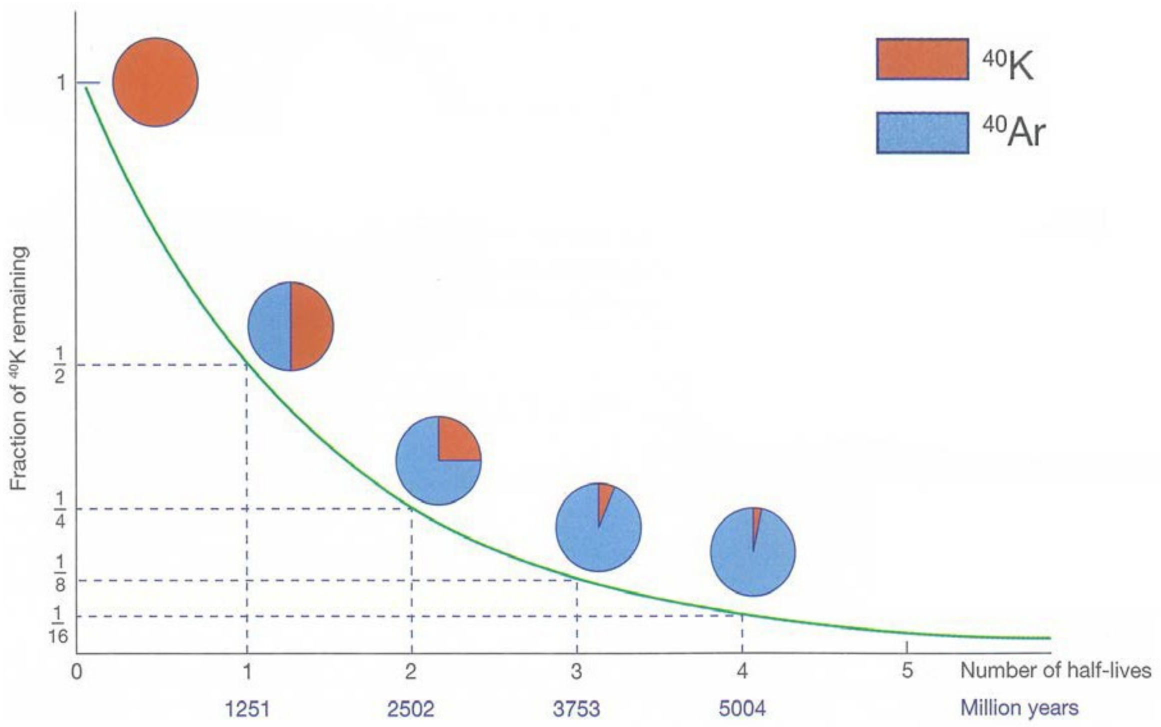
____

4. Complete this table to indicate which types of radiation (alpha particles, beta particles, gamma rays) is stopped by the materials listed.

Material	*Type of radiation that is stopped by this material*
Sheet of paper	
Concrete	
Glass	
Human skin	
Plastic	
Lead	

5. Scientists can use the radioisotope potassium-40 to determine the age of a rock containing a fossil and so determine the fossil's age. Potassium-40 decays to argon-40 (plus radiation), as shown below.

Note: Each half-life is 1251 million years (=1.251 x 109 years).



Use the graph above to answer these questions.

a. The fraction of potassium-40 in a sample of rock containing a fossil was found to be $\frac{3}{4}$. What is the age of the fossil?

[Hint: Run a horizontal line across from where $\frac{3}{4}$ would be on the vertical axis. Then, where it meets the plotted line of the graph, draw a vertical line down to the horizontal axis. This will give you the age of the fossil.]

____

____

b. What is the age of a fossil if the fraction of potassium-40 left in the rock is $\frac{1}{4}$?

____

Practical: Simulating Radioactive Decay

Aim: To simulate the process of radioactive decay.

Equipment:

- 50 pieces of paper (approx. 2 cm square) with one dot on one side (or you could use coins or M&M's or Skittles)
- cup

Method:

1. Place the pieces of paper in the cup
2. Shake the cup
3. Empty out the pieces of paper. Remove all the pieces that have the dot side up. Count how many pieces were removed. Return the rest to the cup. Record the number of pieces removed in the table below.
4. Repeat steps 2–4, removing the dot side up pieces each time, until no pieces of paper are left in the cup.
5. Calculate the number of pieces remaining and record this in the second column.

Results:

Trial	Number of remaining pieces	Number of pieces removed
1		
2		
3		
4		
5		
6		
7		

Draw two graphs on the same piece of paper.

Put the trial number on the horizontal axis and the number of pieces of paper on the vertical axis.

Draw one graph using the number of pieces remaining and another using the number of pieces removed.

Discussion:

1. What do the pieces of paper represent?

2. What do the two different sides of the paper represent?

3. What does shaking the cup represent?

4. What is the relationship between the lines on your graph(s)?

5. In what ways does this activity simulate radioactive decay?

6. Would there ever be no radioactivity left?

Conclusion:

Write a conclusion for this activity.

Lesson 3: Effects of nuclear radiation

Radiation can be harmful

The energy from radiation harms living things, as it can cause changes within their cells. As a result, their cells may be damaged or killed.

The amount of radiation that harms a person depends on the size of the dose received, as well as the length of time they are exposed to it. A short exposure to a very large amount of nuclear radiation can cause radiation burns and radiation sickness. A lower amount of radiation over a longer period of time can still result in radiation sickness.

Radiation burns damage the cells on the surface of the skin or other organs. It may take 1 or 2 days for itching and redness to appear and 1 to 3 weeks before the appearance of burns and blisters.

Figure 30: Radiation burns - these can be as severe as other burns from fire or sunburn

Figure 29: This person was burned by radiation from the atomic bomb dropped on Hiroshima

Radiation sickness may result in symptoms such as nausea, vomiting, fever, hair loss and diarrhoea.

Effect of radiation on cells

High radiation doses tend to kill cells, while lower doses damage the structure of the DNA within the cells. When radiation damages the DNA in cells, it causes mutations (changes) to the genes and/or chromosomes.

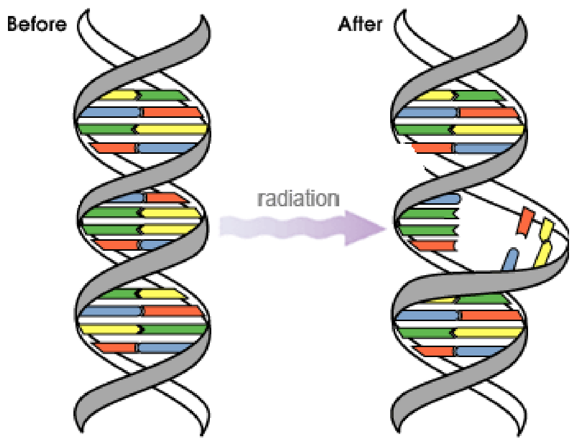


Figure 31: Radiation can damage the structure of DNA molecules

As a result, the genetic instructions in the DNA will no longer be correct and so metabolic processes in the body will not function correctly. This can lead to a person becoming sick and developing diseases such as leukaemia and cancers.

Figure 32: Radiation can damage the DNA in cells, and cause them to become cancers.

The reproductive cells (egg and sperm) are particularly at risk from exposure to radiation. This can lead to the affected organism becoming infertile, or having offspring with birth defects, e.g. physical deformities, intellectual disability or genetic diseases.

All living things are affected by radiation – so plants are affected by radiation, as well as animals.

Figure 33: The forests around Chernobyl are still heavily contaminated with radiation from the nuclear power plant disaster there in 1986

People who work with radiation must take precautions to ensure their cells are not harmed. For example, radiographers who take X-rays and other scans that involve radiation, operate the machinery from a protection booth. This booth is made using thick concrete or lead shielding to block the radiation. They also often wear a protective lead apron.

These signs use the international symbol for radioactivity and are displayed to stop people entering an area that would expose them to harmful radiation.

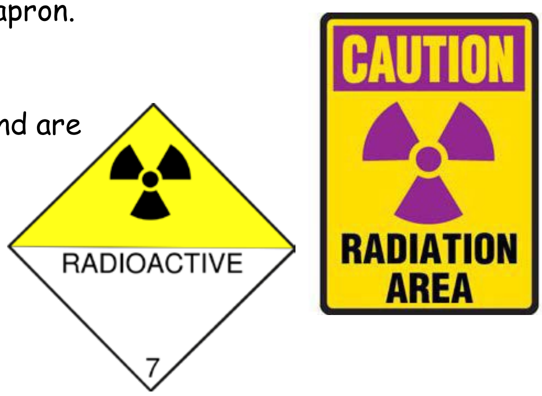


Figure 34: Some typical radiation warning signs

Discovery of radioactivity

The discovery of radioactivity was made accidentally by the French physicist Henri Becquerel back in 1896, when he was investigating the fluorescence of uranium salts.

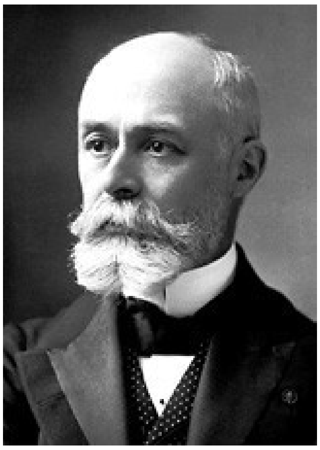


Figure 35: Henri Becquerel

Becquerel was the first scientist to report the effects of radioactivity on living tissue. This is because he suffered burns on his skin from carrying a small amount of the element radium
in his pocket.

Becquerel also discovered that photographic film was 'fogged up' (darkened) by radiation from uranium salts. This discovery led to the dosimeter badges that are still worn today by people who work with radiation. Dosimeter badges measure a person's exposure to background radiation – the darker the film gets, the more radiation exposure they have had.

The term 'radioactivity' was coined by Marie Curie, a student under Becquerel.
She conducted much research into radioactivity, together with her husband Pierre.
The unit used today for measuring radioactivity is the becquerel (Bq), named after Becquerel.

All three scientists, Pierre and Marie Curie and Becquerel, were awarded the Nobel Prize in Physics in 1903 for their discoveries about radioactivity.

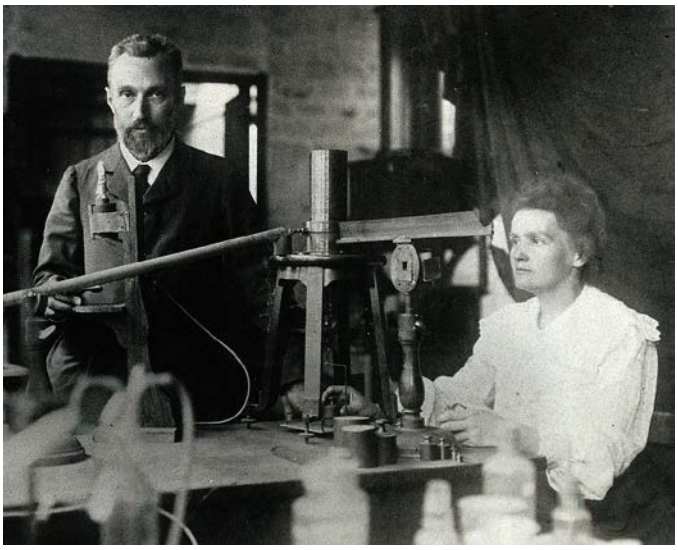


Figure 36: Marie and Pierre Curie in their lab

The risks of radioactivity were not realised at first

The dangers of radiation were not understood at first.

In the early 1900s, scientists took no precautions. Becquerel died only 12 years after his discovery of radiation, at age 54 – most probably from radiation effects. Marie Curie died from a fatal form of anaemia (a disease involving blood cell deficiencies), brought on by her exposure to radiation over years in the laboratory.

Shortly after the discovery of the radioactive metal radium, doctors discovered that radium salts were able to shrink the size of a cancerous tumour. As a result, 'radium therapy' was introduced into hospitals around the early 1900s because of its so-called 'miraculous healing effects'. However, in many cases, the use of radium caused more harm than good.

People soaked themselves in baths of hot radioactive spring water, little realising the dangers of doing so. Radioactive water from hot springs was bottled and sold for around 10 years as a tonic for 'medicinal purposes' – as it was falsely thought to have 'healing properties'. This radioactive water, known as radithor, contained radium, and so people taking it became very ill and many died of cancer.

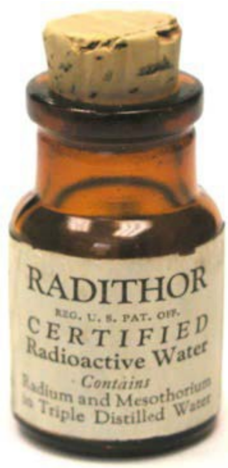


Figure 37: Radioactive water, known as Radithor, was bottled and sold in stores.

The story of the 'radium girls'

Back in the 1920s, the US Radium Corporation employed hundreds of young women in their factory in New Jersey, to paint 'glow in the dark' paint onto watch dials.

These women had been told the paint was harmless. They were expected to lick the fine-tipped brushes they used to assist in the painting of the tiny numbers and hands onto the watch dials. As a result, they ingested deadly amounts of radium.

Many years later, these same women began to suffer due to radiation poisoning. Many died of cancer before the company revealed that the paint actually contained radioactive radium salt. Hundreds of these 'Radium Girls', as the newspapers of the day called them, died as a result of repeated exposure to radiation.

Figure 38: Females workers painting 'glow in the dark' dials in watches

A video clip about the use of radium

- **The Mystery of Matter: The Radium Craze**

  After the discovery of radium, there was a worldwide craze to use it – from lipstick to curing hair loss, etc. Few people realised the great harm this radioactive element could do.- https://www.youtube.com/watch?v=ym2WXJKHuP8

Activity 6 – Nuclear radiation can cause problems

Answer these questions.

1. Use these words to complete the sentences below.

cells	damage	mutations	kill	sick	DNA

Nuclear radiation can either _________ cells, or _____________ the structure of ______ within cells. When DNA is damaged, changes (________________) in its genetic instructions result in the _________ not functioning correctly. This leads to a person becoming _________.

2. Name two (2) diseases that people can develop as a result of being exposed to nuclear radiation.

 ____

 ____

3. What is indicated by this international symbol?

____

4. Name the first radioactive element to be discovered. ____________________________

5. What are the symptoms of radiation sickness?

____

____

6. When radiographers take scans involving nuclear radiation they stand behind protective booths. Why are these booths made from thick concrete or lead shielding? [Hint: Look back at both Lessons 2 and 3.]

____

____

____

7. How are radiation burns and/or radiation sickness caused?

____

____

8. Why are plants affected by radiation, as well as animals?

____

____

9. When an organism has been exposed to radiation, their reproductive cells can be affected. This can make the organism infertile, or can affect their future offspring. What does 'infertile' mean?

____

____

10. Complete the missing words below, to indicate three (3) possible types of birth defects that might occur in their future offspring as a result of exposure to radiation.

Physical d______________________

____

____

Intellectual d____________________

____

____

G________________ diseases.

____

____

VIDEOS FOR E-LEARNING SITE

Nuclear tests at Maralinga (May 2010)

http://splash.abc.net.au/home#!/media/105376/nuclear-tests-at-maralinga

Between 1952 and 1963, the Australian Government led by Robert Menzies allowed Britain to test nuclear bombs in the open air at sites in Australia. These sites included Maralinga in South Australia. It was the land of the Maralinga Tjarutja people who, along with many Australian soldiers working on the nuclear project, suffered terrible consequences.

OR Backs to the Blast, an Australian Nuclear Story

http://aso.gov.au/titles/documentaries/backs-blast/clip3/

This clip shows black-and-white newsreel footage of a nuclear test at Maralinga, South Australia, in the 1950s, and includes comments from people exposed to radioactive fallout from the test.

Public Enemy Number One

http://australianscreen.com.au/titles/public-enemy-number-one/clip1/

This clip shows black-and-white scenes of the Japanese city of Hiroshima in 1945, shortly after the atomic bomb was dropped. These are intercut with a 1981 interview with Wilfred Burchett, a war correspondent and witness to the destruction. The devastated city and some survivors are seen, both in aerial shots and from ground level. Doctors at a hospital are shown treating patients, whose radiation injuries are graphically depicted.

Wilfred Burchett was the first journalist to report from the site of atomic devastation at Hiroshima, Japan, in 1945. He labelled the effect on human beings as 'atomic plague'. Archival footage shows victims being treated in hospital and flattened landscape.

The Mystery of Matter: The Radium Craze

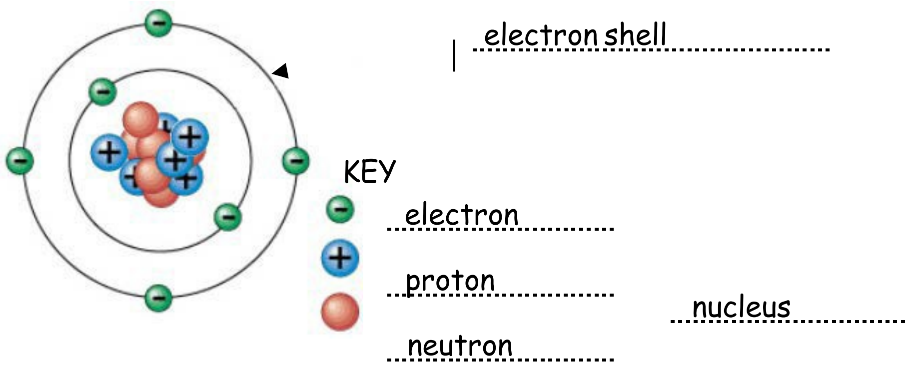
https://www.youtube.com/watch?v=ym2WXJKHuP8

After Marie and Pierre Curie's discovery of radium, the new element's wondrous ability to glow in the dark inspired a worldwide craze – a rush of radium-laced products that promised to cure everything from impotence to hair loss. What few people realized – and the Curies were reluctant to admit – was the great harm this radioactive element could do.

Suggested answers

Activity 1 – Isotopes are not always stable

1.



2. (a) All matter is made up of *atoms*.

   (b) All atoms contain protons, neutrons and electrons. These are called *sub-atomic* particles.
   (c) number of protons = number of *electrons* (in a neutral atom)
   (d) The number of protons in the nucleus of an atom of an element is called the *atomic* number.

Activity 2 – Isotopes

1. Atoms of the same element that have a different number of neutrons in the nucleus are called *isotopes*.
2. All atoms of a particular element have the same number of protons and so they have the same *atomic* number. However, they can have different numbers of *neutrons* and so they have different *mass* numbers.
3. The name of an isotope includes its mass *number*, e.g. carbon-12 is an isotope of *carbon* with a mass number of 12.
4. Mass number = number of *protons* + number of neutrons.

Activity 3 – Describing isotopes

Isotope	Chemical symbol ($^{A}_{Z}E$)	Number of protons	Number of neutrons
Carbon-12	$^{12}_{6}C$	6	6
Carbon-13	$^{13}_{6}C$	6	7
Carbon-14	$^{14}_{6}C$	6	8
Chlorine-35	$^{35}_{17}Cl$	17	18
Uranium-235	$^{235}_{92}U$	92	143
Uranium-238	$^{238}_{92}U$	92	146

Activity 4 – Unstable isotopes

1. What word is used to describe the nucleus of an atom in which the protons and neutrons are held strongly? *stable*
2. Why are the isotopes of some elements unstable?
   The protons and neutrons in their nucleus are not held together as strongly as in stable atoms.
3. What are unstable isotopes called? *isotopes*
4. When an unstable isotope emits *radiation* it is said to be *radioactive*.
5. Name an isotope of carbon that is radioactive. Carbon-14

Acknowledgments

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Year 9 Atomic Structure | Home Learning

Modified by Ms Butler

Please attempt all work and ask questions online, if possible.

The Google Classroom will have quiz questions to assess your understanding of content. Please check Google Classroom frequently for updates or e-mail the following Year 9 Science Co-ordinators.

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Science
Stage 5

Atomic structure

Part 4

Lesson 1: Uses of nuclear energy

In this lesson, you will learn about how nuclear energy can be beneficial if used correctly and so has many uses in medical treatments and diagnosis of diseases, as well as in industrial applications and scientific research.

However, nuclear energy has a 'dark side'. So some people do not want nuclear energy to be used. They worry about the possibility of nuclear power plant disasters, or the use of atomic weapons and all the problems these can cause.

Some medical uses of nuclear energy

- **Diagnosing diseases**

Radioisotopes with short half-lives can be given to a person by injection, inhalation or can be swallowed. Some of the radioisotopes this way include cobalt-60, fluorine-18, iodine-131 and iridium-192.

The gamma rays emitted by a radioisotope inside a person's body can be detected outside the body, e.g. by a PET scanner. This can show whether an organ is working properly or not, and if the person has a cancer or not.

Figure 40: A patient undergoing a PET scan of his brain

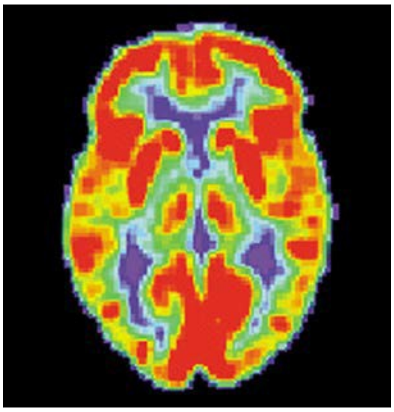


Figure 39: PET scan of a normal human brain

- **Treatment of cancers**

Although radiation can cause cancers, it can also be used to kill the cells in a cancerous growth. This type of treatment is called radiotherapy.

The radiation can come from a machine outside the body, or it can come from a radioisotope placed inside the body.

The problem with radiotherapy is that healthy cells are also be damaged and so this can cause side effects such as skin irritation, swelling, hair loss, ulcers, nausea, constipation, heart disease and secondary cancers.

Some industrial uses of nuclear energy

Radiation has many uses in industry. Some examples are:

- **Sterilisation of medical equipment**

Radiation, e.g. gamma rays, is used in sterilisation to kill bacteria in medical equipment, e.g. bandages, needles, scalpels, syringes, etc.

- **Treating food**

Exposure to gamma rays helps to keep foods much longer as it stops them from spoiling. Radiation will kill pests and microorganisms that would otherwise make the food go bad – the food is just as good for you after it has been irradiated

Figure 42: Gamma radiation can be used to sterilise medical equipment

Figure 41: Radiation can make foods last longer

- **Finding leaks and following the movement of substances**

Radioisotopes, e.g. sodium-24, can be used to investigate for leaks inside objects, e.g. pipes for water, oil, gas, sewage.

They can also monitor the movement of water in rivers, lakes and oceans.

- **Measuring the thickness of substances**

Engineers can accurately measure the thickness of materials, e.g. steel sheets, paper, aluminium foil and plastic film, by measuring how much nuclear radiation can pass through them.

- **Controlling insect pests**

Insect populations can be reduced using radiation rather than poisons. Scientists can use gamma rays to kill the sex cells in an insect and so make them infertile. When sterile male insects are released and mate with a normal female, no offspring will be produced. For example, this method was used to eradication Screwworm blowflies from areas in North America, Mexico and Libya.

Figure 43: A Screwworm blowfly

- **Nuclear power is used in the generation of electricity**

Some countries have nuclear power stations to produce electricity. For example, France generates around 78% of its electricity from nuclear power, the highest percentage in the world.
In a nuclear reactor, uranium undergoes a fission reaction. In fission, a uranium nucleus splits into two new smaller elements and also releases neutrons, radiation and heat in the process. The heat energy is used to heat water to produce steam. The steam drives a turbine that drives the electricity generators that produce electricity.

Figure 44: A nuclear power plant in Belgium. This produces nearly 3000 MW (megawatts) of power.It has 3 nuclear reactors (in the domed buildings) and 3 cooling towers

Nuclear power is also used to provide electricity on many submarines and large naval ships, such as aircraft carriers, that need to be at sea for long periods of time.

- **Domestic smoke detectors**

Smoke detectors can detect particles in air. Those used in houses and apartments contain a small amount of radioactive americium-241.

This has a half-life of 432 years and produces alpha (α) particles. If there are smoke particles in the air, the alpha particles are blocked and the alarm sounds.

Did you know?

'No butts' technology

Some smoke detectors can detect different types of smoke, including cigarette and cigar smoke, as the different particle sizes absorb different amounts of radiation.

Smoke alarms are used in places where smoking is discouraged, such as in airplane toilets (see above). Some smoke alarms are even programmed with a voice message warning smokers that it is about to sound the alarm!

How are radioactive isotopes made?

There are only about 50 isotopes of elements that emit radioactivity naturally. Most radioactive isotopes (radioisotopes) are made radioactive artificially (about 2000 in total).

Radioisotopes can be made either by neutron bombardment in a nuclear reactor, or by bombarding their atoms with sub-atomic particles such as protons and neutrons in a particle accelerator, such as a cyclotron or a synchrotron.

Australia has a nuclear reactor

There are no nuclear power stations producing electricity in Australia, even though Australia has 31% of the world's uranium supplies. Uranium therefore is a valuable export for Australia.

Figure 45: Uranium ore is obtained from rocks, such as this chalcopyrite rock found at Olympic Dam, in South Australia. [The 20 cent coin in the photo is being used as a scale.]

However, Australia has a nuclear reactor, called OPAL, at Lucas Heights in the southern area of Sydney. OPAL is used for research and to produce radioisotopes for medicine and industry. OPAL is run by a government organisation called ANSTO (Australian Nuclear Science & Technology Organisation). This reactor replaced the previous HIFAR nuclear reactor back in 2006.

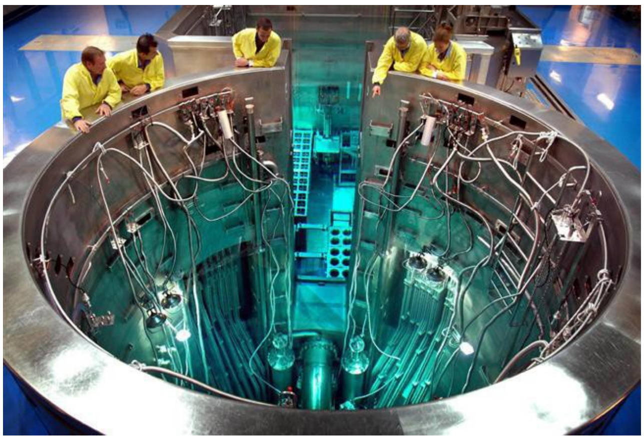


Figure 46: Workers looking down into the 5-metre wide OPAL reactor vessel at ANSTO

OPAL is a 20 MW (megawatt) reactor. Although you cannot see the water, this 13 metre-deep vessel is filled with water for cooling purposes. This water is effective at blocking the radiation and so it is safe for these workers to be so close to the reactor.

Activity 1 – Using nuclear energy

Answer these questions.

1. Why must radioisotopes used in medicine have a short half-life?

____

____

2. Explain why nuclear radiation can cause cancers, but can also be used to treat cancer?

____

____

____

____

3. Use these words to complete the sentences below.

nuclear   steam   generators   fission   electricity   heat

Nuclear power can be used in the production of _________________. To do this, a controlled _________________ reaction involving uranium occurs in a ___________________ reactor. This reaction results in the release of neutrons, radiation and ______________________. The heat energy is used to heat water to produce _________________. The steam drives a turbine that drives the electricity ______________________ that produce electricity.

4. Give ONE medical use of nuclear energy, then complete the table.

Medical use of nuclear energy: ____

Benefits (Why is this good?)	**Problems** (How could this be bad?)

5. Give ONE industrial use of nuclear energy, then complete the table.

Industrial use of nuclear energy: ____

Benefits (Why is this good?)	**Problems** (How could this be bad?)

6. Imagine you are on a Bioethics Committee at a children's hospital.

An oncologist (a doctor who treats cancer patients) presents a case in which the parents of Mary, a child diagnosed with cancer, want Mary to be treated with radiotherapy without telling her she has cancer.

a. Think about the rights of each person, then complete the following table by listing as many ethical issues as you can for each person.
Remember, 'ethics' is about what is considered 'right' or 'wrong'.

Person	*Ethical issues*
Child	
Parents	
Doctor	

b. Do you think the age of the child is relevant or not? Explain.

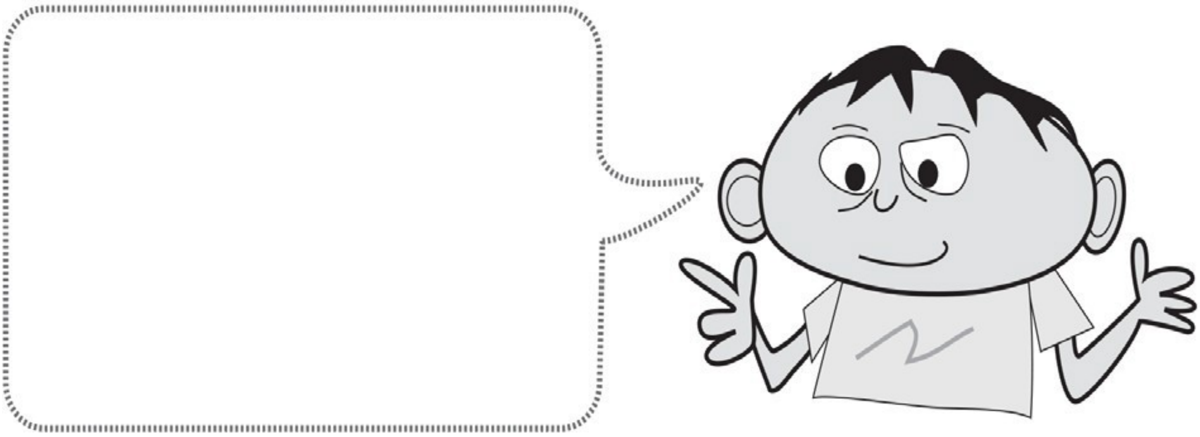
____

____

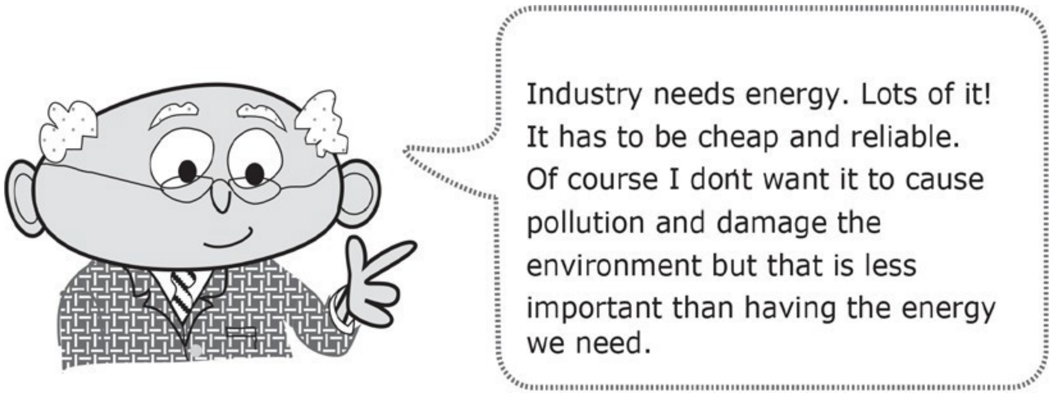
____

____

7. This person is very concerned about protecting the environment. Write an opinion that he might have.



8. Read the opinion of the businessman below.



Why do you think he has this viewpoint?

____

____

____

____

Lesson 2: Arguments for and against nuclear energy

FOR NUCLEAR ENERGY

Australia has a plentiful supply of uranium ore. Uranium can be used in nuclear reactors and produces much more energy than coal or oil.

Fuel source	Energy produced (MJ/kg)
Coal	9-30
Wood	14-16
Crude oil	45-46
Diesel oil	38-48
Uranium (in a light water reactor)	500,000

Table 4 Energy from some fuel sources

[Note: 1 MJ = 1 million Joules]

- Nuclear power stations release only water vapour into the air, and so do not pollute the air with large amounts of greenhouse gases such as carbon dioxide, as occurs from coal-fired power stations.
- Radioisotopes have many uses in both medicine and industry.

AGAINST NUCLEAR ENERGY

- It costs much more to build a nuclear power station than a coal-fired power station.
- The risk of a nuclear disaster is a great concern, especially after the mishaps at Three Mile Island (US)
- in 1979, Chernobyl (Russia) in 1986 and Fukushima (Japan) in 2011.
- The disposal of radioactive wastes is a problem, as they can remain radioactive for thousands of years and contaminate the environment.
- What about nations that might use nuclear energy in a war? Or what if terrorists were to use nuclear weapons?

What is done with nuclear wastes?

Wastes from nuclear reactors are radioactive and most wastes have very long half- lives of thousands of years. Nuclear wastes can be sealed in steel or concrete containers, or mixed into glass blocks and stored in power stations, or buried under the seafloor or underground, well away from any groundwater. However, there is no satisfactory or permanent solution yet to the problem of disposing of nuclear wastes.

Activity 2 – For or against the use of nuclear energy?

What do you think? Answer these questions.

1. Do you think nuclear energy is a suitable alternative to fossil fuels for electricity production? Give at least two points to support your opinion.

2. Do you think there is a place for nuclear energy to be used, even if you oppose its use for electricity production? Give at least two points to support your opinion.

Lesson 3: The 'dark side' of radioactivity

Despite the benefits of using radioisotopes in medicine and industry and in using nuclear power to produce electricity, there are also problems.

When nuclear reactors go wrong

Radioactive materials cause contamination problems if released into the environment.

This can happen unintentionally, e.g. due to human error, accidental leaks, or a natural disaster such as an earthquake.
Two recent catastrophic nuclear power plant disasters that have resulted in radioactive contamination of the environment are:

Chernobyl disaster in the Ukraine in 1986
Due to design flaws and poor procedures at Chernobyl's nuclear power plant, a reactor explosion occurred. This explosion and subsequent fires led to the release of radioactive materials into the atmosphere. These were spread by wind, rain and waterways, resulting in high levels of radiation in food chains, not only in the area, but also over much of nearby Europe. While 55 people died at the time, over 600,000 were contaminated by radiation. Over 4000 have died from cancers and many more deaths are expected. It is thought that around 3 million children will have been affected.

Fukushima disaster in Japan in 2011
This was due to an earthquake occurring off the coast of Japan that resulted in a huge tsunami. The tsunami flooded the reactors at the Fukushima Daiichi nuclear power plant. This led to the accidental release of radioactive materials from the power plant.

Nuclear weapons involve fission or fusion reactions

There are over 30,000 nuclear weapons in the world today, enough to destroy our planet many times over and wipe out all life on Earth.

FISSION BOMBS (also called atomic bombs or A bombs)

You have just learnt how uranium undergoes a fission reaction in nuclear reactors to produce energy. If this reaction is controlled, the rate at which energy is produced is controlled. However, if a fission reaction is not controlled, as in nuclear weapons, massive amounts of energy and radioactivity are released into the environment. The material usually used is uranium or plutonium.

The atomic bombs that were deliberately dropped in 1945 on Japan to help end World War II were devastating. They caused widespread destruction in both Nagasaki and Hiroshima – around

90% of the buildings were destroyed, over 70,000 people died instantly, and tens of thousands more died in the aftermath. Their exposure to large amounts of radiation damaged the DNA in their bodies leading to cancers and leukaemia. It also damaged their sex cells. So many children of survivors were born with physical / mental defects.

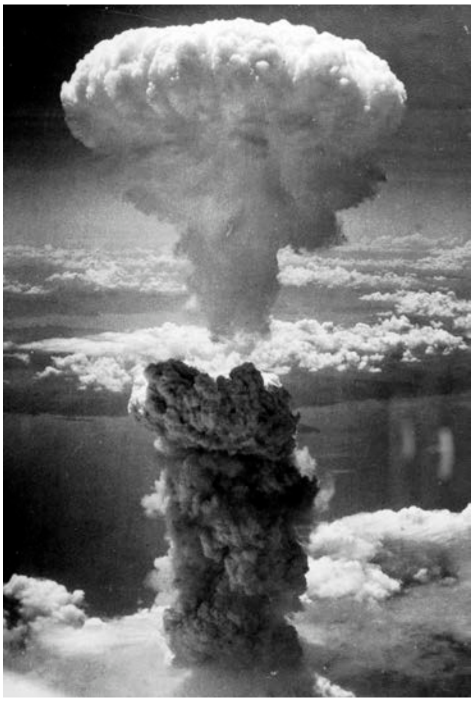


Figure 47: The mushroom cloud from the atomic bomb exploded over Nagasaki in 1945. The cloud extended over 18 km into the air.

> **DID YOU KNOW?** Contamination from the nuclear accident at the Chernobyl reactor in 1986 is around 100 times the combined contamination of the bombs dropped on Hiroshima and Nagasaki.

FUSION BOMBS (also called hydrogen bombs or H bombs)

Fusion bombs have also been developed. These use a fusion reaction in which two small nuclei (e.g. hydrogen-2) come together to form a larger nucleus (e.g. helium-4).

A large number of fusion (hydrogen) bombs have been tested by various countries, since the first one was dropped by the USA in 1956 on an uninhabited island in the Bikini Atoll in the Pacific Ocean. Some other test sites include: Marshall Islands, Monte Bello Islands, Christmas Island, as well as Emu Field and Maralinga, both in remote areas of South Australia.

Unfortunately, these bombs have left large amounts of radioactive contamination in the environment wherever they were tested.

Some video clips about the 'dark side' of nuclear energy

- **Public Enemy Number One**

  A report by Wilfred Burchett, the first journalist to report from the site of the atomic devastation in 1945 at Hiroshima, Japan.

  http://australianscreen.com.au/titles/public-enemy-number-one/clip1/

- **Nuclear tests at Maralinga in South Australia**

  Between 1953-1963 the Australian Government allowed the British to test nuclear bombs at sites in Australia.

  http://splash.abc.net.au/home#!/media/105376/nuclear-tests-at-maralinga

Now complete the cloze passage below using these words:

Blood fallout sore eyes skin vomiting diarrhoea

Nuclear ________________ is tiny particles of radioactive dust that can spread for kilometres. The affects of radioactivity from these nuclear tests included ________________ , _________________ and ___________________. There were also reports of cancer, _____________ disease and _______________conditions - all symptoms of radiation poisoning.

INQUIRY 7 Fukushima disaster

There have been various accidents in nuclear power stations, but a recent one was at Fukushima in Japan in 2011. There was a meltdown in three reactors and radioactive material was released into the environment.

Use the internet and other resources to find out as much as you can about the Fukushima disaster. Write a report. In your report you should answer these questions:

- What caused the accident?
- What is a meltdown in a nuclear reactor?
- What radioisotopes were released into the environment? What were their half-lives?
- What was done to reduce the loss of life and to clean up the disaster area?
- What short-term and long-term effects did the radiation have on people in the Fukushima area?

When writing your report use several different sources, not just one. Use your own words rather than copying material. And make the report interesting by using photos, maps and diagrams where possible.

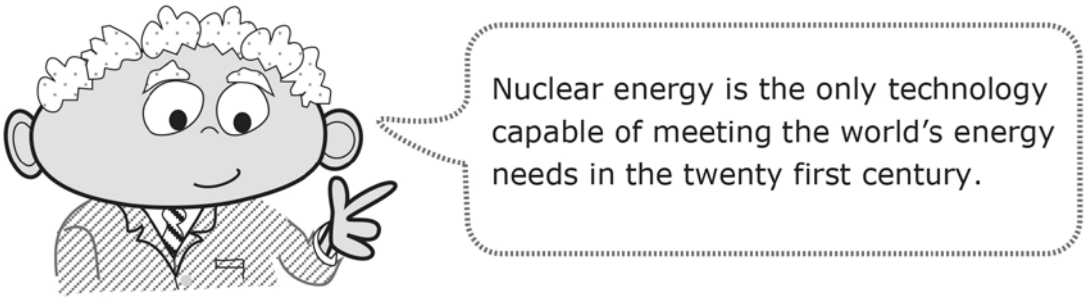
Source: Science Essentials

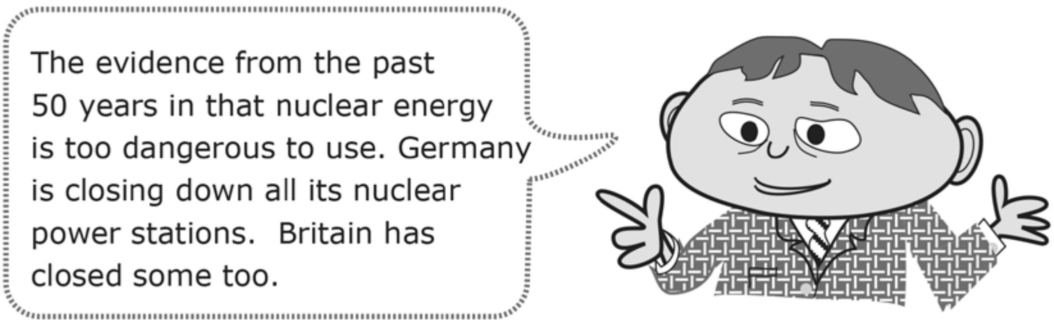
Activity 3 – Concerns about nuclear energy

Answer these questions.

1. Some people have concerns about the use of nuclear radiation because of its 'dark side'. List two things that these people worry about.

2. Here are the opinions of two scientists.





How can these scientists have such different viewpoints about nuclear energy?

VIDEOS FOR ELEARNING SITE

Nuclear tests at Maralinga (May 2010)

http://splash.abc.net.au/home#!/media/105376/nuclear-tests-at-maralinga

Between 1952 and 1963, the Australian Government led by Robert Menzies allowed Britain to test nuclear bombs in the open air at sites in Australia. These sites included Maralinga in South Australia. It was the land of the Maralinga Tjarutja people who, along with many Australian soldiers working on the nuclear project, suffered terrible consequences.

OR Backs to the Blast, an Australian Nuclear Story

http://aso.gov.au/titles/documentaries/backs-blast/clip3/

This clip shows black-and-white newsreel footage of a nuclear test at Maralinga, South Australia, in the 1950s, and includes comments from people exposed to radioactive fallout from the test.

Public Enemy Number One

http://australianscreen.com.au/titles/public-enemy-number-one/clip1/

This clip shows black-and-white scenes of the Japanese city of Hiroshima in 1945, shortly after the atomic bomb was dropped. These are intercut with a 1981 interview with Wilfred Burchett, a war correspondent and witness to the destruction. The devastated city and some survivors are seen, both in aerial shots and from ground level. Doctors at a hospital are shown treating patients, whose radiation injuries are graphically depicted.

Wilfred Burchett was the first journalist to report from the site of atomic devastation at Hiroshima, Japan, in 1945. He labelled the effect on human beings as 'atomic plague'. Archival footage shows victims being treated in hospital and flattened landscape.

The Mystery of Matter: The Radium Craze

https://www.youtube.com/watch?v=ym2WXJKHuP8

After Marie and Pierre Curie's discovery of radium, the new element's wondrous ability to glow in the dark inspired a worldwide craze – a rush of radium-laced products that promised to cure everything from impotence to hair loss. What few people realized – and the Curies were reluctant to admit – was the great harm this radioactive element could do.

Suggested answers

Activity 1 – Use of nuclear energy

1. Radioisotopes need to be in a patient's body for as short a time aspossible.
2. Nuclear radiation can cause cancer as it damages healthy cells. However, it can treat cancer as it also destroys harmful cells such as cancerous cells at thesame time.
3. Nuclear power can be used in the production of electricity. To do this, a controlled fission reaction involving uranium occurs in a nuclear reactor. This reaction results in the release of neutrons, radiation and heat. The heat energy is used to heat water to produce steam. The steam drives a turbine that drives the electricity turbine that produce electricity.

Activity 2 – For or against the use of nuclear energy

1. If you answered 'yes': you should have highlighted 2 benefits of using nuclear energy. (1 mark)

   If you answered 'no': you should have highlighted t 2 problems with nuclear energy. (1 mark)

2. If you answer 'yes' and you don't oppose its use for electricity production - you would highlight the advantages of nuclear energy over the use of fossil fuelsetc.

   If you answer 'yes' and you do oppose its use for electricity production - you would perhaps attach conditions on to it like more research being needed and better methods being needed for disposing nuclear waste.

   If you answer 'no' - you might argue for the continued use of fossil fuels or renewable energy such as solar or wind energy.

Activity 3 – Concerns about nuclear energy

1. Concerns might include:
- It costs much more to build a nuclear power station than a coal-fired power station.
- The risk of a nuclear disaster is a great concern, especially after the mishaps at Three Mile Island (US) in 1979, Chernobyl (Russia) in 1986 and Fukushima (Japan) in 2011.
- The disposal of radioactive wastes is a problem, as they can remain radioactive for thousands of years and contaminate theenvironment.
- What about nations that might use nuclear energy in a war? Or what if terrorists were to use nuclear weapons?

2. These scientists probably come from different backgrounds and so have different perspectives about what is important or not. The first person is ignoring the problems and just thinking about how much more energy can be made nuclear energy. While the second person is worried about the problems that nuclear energy may cause for the environment.

Acknowledgments

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