The Periodic Table

home

Outcomes

Chemical science

6.2

Describe the similar characteristics of groups of elements in the Periodic Table.

6.3

Specify the characteristics, chemical reactions and usefulness to society of groups of similar substances.

Stimulus questions

1. Identify the metals around you right now.
2. Draw what you think an atom looks like.
3. Why do scientists often use symbols instead of names for elements?
4. Why do some elements have apparently illogical symbols such as Fe for iron and W for tungsten?
5. Do fish swim in H_2O or H_2O_2 and what's the difference anyway?

Unit 1.1 What's the matter?

All around us is **matter**: we breathe it, we drink it and we sit on it. But what is matter made from?

Atomos: Greek for indivisible

Last year you found that **atoms** were smaller-than-microscopic particles that make up all matter. Atoms are made up from even smaller particles called **protons** (often shown as p^+), **neutrons** (n) and **electrons** (e^-). Protons and neutrons are roughly 1800 times more massive than electrons and are located in the **nucleus**, at the centre of the atom. Electrons spin fast around the nucleus in a region of empty space.

Neutrons are **neutral**, having no charge. Protons are **positive** and electrons are **negative**. Opposite charges attract each other and this keeps the electrons from spinning out from the atom.

Atomic and mass numbers

The number of protons in an atom is called its **atomic number**. Atoms are electrically neutral and must have the same number of electrons as protons.

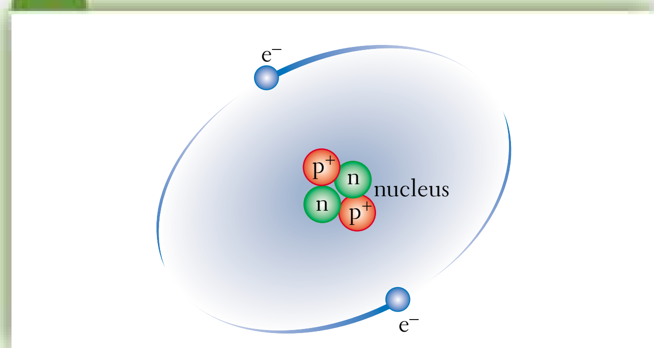

Fig 1.1.1 A simple model of a helium atom

Science snippet

Spacious!

If an atom were the size of the Melbourne Cricket Ground, the nucleus would be about the size of a pea sitting in the centre square. The electrons would be specks of dust floating around the stands.

Fig 1.1.2

In an atom:

atomic number = number of protons

= number of electrons

The total number of particles in the nucleus (protons + neutrons together) is called the **mass number**. Neutrons do not add any charge to an atom, so there is no rule connecting them with protons or electrons.

mass number =

number of protons + number of neutrons

These numbers can be shown as:

Mass number → 238

Symbol of the element that this atom belongs to → U

Atomic number → 92

$$^{238}_{92}U$$

This indicates that the atom is uranium and has:

- 92 protons and 92 electrons
- 146 neutrons (238 — 92 = 146)

home

Elements

Elements are the basic building blocks of all matter and each element has only one type of atom making it up: gold contains only gold atoms, and oxygen contains only oxygen atoms. If atoms belong to the same element then they have the same number of protons and the same atomic number. There are roughly 100 different types of basic atoms so there can only be 100 different elements.

Each element is given its own symbol. Those known in ancient times often have symbols derived from their Latin or Greek names. The rest are more logical.

Molecules and lattices

Atoms do not normally exist by themselves but exist in molecules or lattices. A **molecule** is a group of atoms **bonded** (joined) together. In a **lattice**, atoms keep bonding together until something stops them. Molecules and lattices have a **chemical formula** that tells us what type of atoms they contain and the proportion of atoms in them.

Compounds

Compounds are formed when different elements chemically combine. Compounds can be either many identical molecules or a lattice: a drop of water contains millions of H_2O molecules and a grain of salt has millions of NaCl units.

Prac 1
p. 6

Mixtures

A **mixture** can be separated by techniques such as filtration or evaporation since it is made of different elements or compounds simply thrown together. No formula can be written for a mixture. Examples of mixtures include salt water, a cup of coffee, soil, air and blood (see Fig 1.1.6).

Prac 2
p. 6

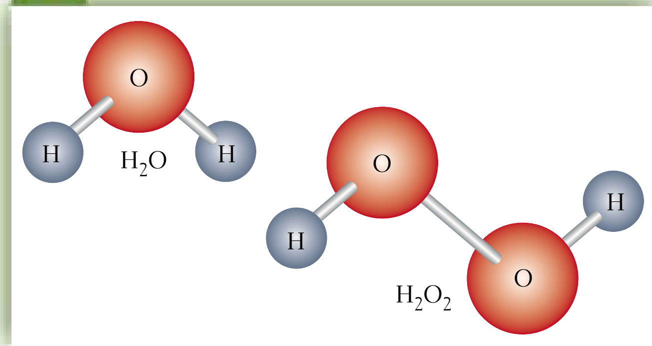

Fig 1.1.3 Molecules of water and the bleach hydrogen peroxide are both made from hydrogen and oxygen atoms. What a difference a single oxygen atom makes!

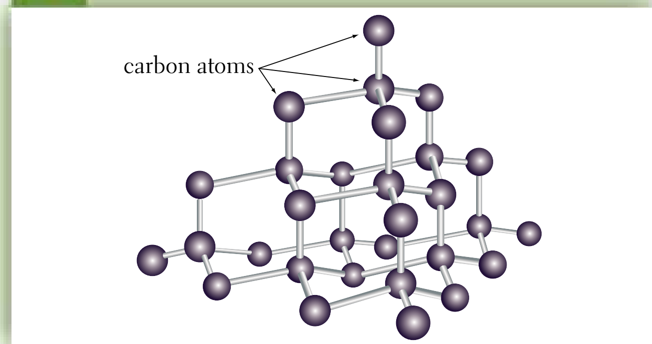

Fig 1.1.4 An example of a lattice—this one is diamond

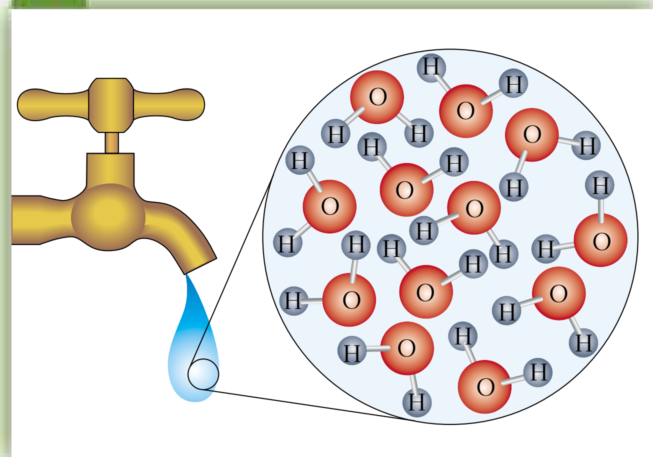

Fig 1.1.5 A compound is made up of many identical molecules or units.

Science snippet

Get it right!

There is a correct way of writing symbols for elements, e.g. calcium is Ca, not CA or ca.

home

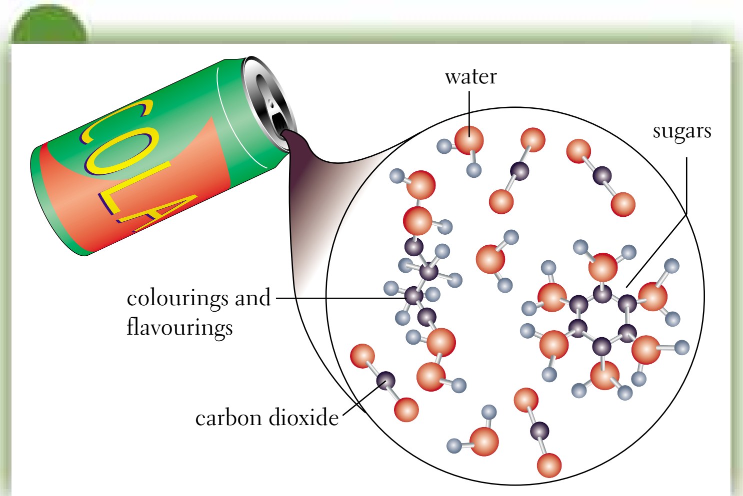

Fig 1.1.6 Soft drinks are mixtures of many compounds.

Unit 1.1 Questions

1 What can be said about the number of protons and electrons in an atom? Why?

2 What do these expressions mean?
- a Atomic number
- b Mass number
- c Nucleus

3 Use the symbols of the elements to determine those that have been known the longest.

4 Which of the three subatomic particles:
- a is the smallest?
- b is the heaviest?
- c is positive?
- d is negative?
- e is neutral?
- f spins around the nucleus?
- g are in the nucleus?

5 Copy the following, correcting any incorrect statements so they become true:
- a The mass number is usually bigger than the atomic number of an atom.
- b The chemical symbol for iron is FE.
- c Salt is the compound NaCl.
- d Most of the atom is empty space.
- e A molecule is the same as a lattice.

6 What is the difference between:
- a an element and a compound?
- b the element iron and an atom of iron?
- c the compound water and a molecule of water?
- d a compound and a mixture?
- e an atom and a molecule?

7 Identify as either element, compound or mixture:
- a Lead Pb
- b Nitric HNO_3
- c Sea water
- d Ammonia NH_3
- e Peanut butter

8 Copy each of the following diagrams into your workbook. Under each, label as either:
- a atom
- b molecule
- c compound
- d lattice
- e mixture

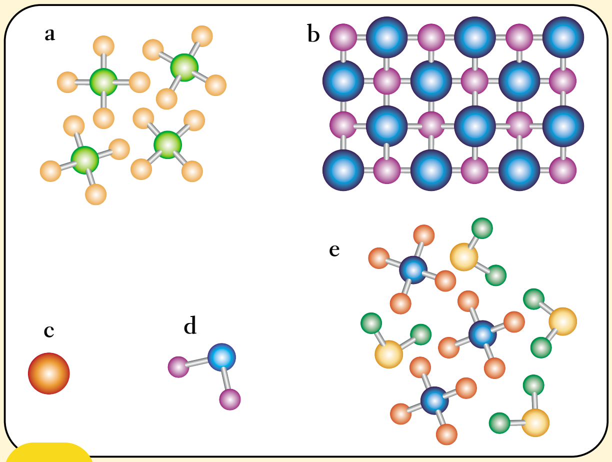

Fig 1.1.7

9 What type of atoms, and how many, are in a single molecule of:
- a SO_2?
- b H_2S?
- c $C_{12}H_{22}O_{11}$?
- d H_2SO_4?
- e CH_3COOH? (Take care!)

10 Draw a diagram to represent:
- a a molecule of water
- b the lattice of sodium chloride

11 Explain why a chemical formula could never be written for a glass of cordial.

home

12 How many protons, neutrons and electrons would be in each of these atoms?
$^{56}_{26}Fe$, $^{59}_{28}Ni$, $^{64}_{29}Cu$, $^{197}_{79}Au$

13 Copy and complete the following table:

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Symbol for the atom
Carbon	6			6	6	$^{12}_{6}C$
Sulfur		32		16		
Sodium	11			12		
Oxygen				8	8	
Fluorine	9	19				
Iodine		127		74		

CREATIVE WRITING
Journey to the centre of the atom

You board your spacecraft-like machine and ready yourself for subatomic miniaturisation. Your mission: to explore the atomic world of atom $^{40}_{19}K$. Describe what you see, particle size, distances travelled and the problems you encounter.

PROJECT
Making models

Construct models of:

- the molecules H_2O, H_2O_2 and other molecules found in this unit
- the lattice of diamond and sodium chloride
- a mixture that could represent a soft drink

Unit 1.1 Research / Extension

1 Elements in comics? Explore http://www.uky.edu/Projects/Chemcomics/
2 Find out what an isotope is. Give examples.
3 Find what foodstuffs are rich in these elements: Na, Ca, Fe, Mg, Zn, I.
4 Check the nutrition information on the labels of:
   - a canned food
   - a breakfast cereal
   - a milk drink
   - a soft drink

   List the ingredients under the headings: element, compound, mixture.

Fig 1.1.8

home

Unit 1.1 Practical activities

Unit 1.1 Prac 1
Making the compound CO_2

You will need

2 test tubes, test-tube rack, drinking straw, 1-hole rubber stopper with glass tubing, limewater, marble chips, 2 M hydrochloric acid, safety glasses

What to do

Part A

1 Place 5 mL of the limewater in a test tube. Place a fresh straw in the test tube and gently blow bubbles through the limewater. Record your observations.

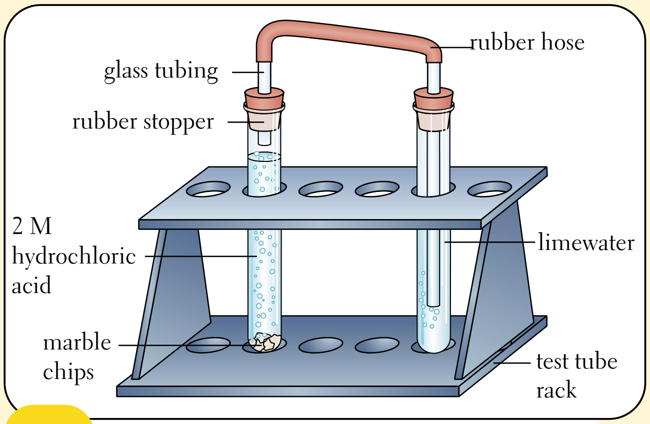

Fig 1.1.9 Preparing CO_2

Part B

1 Add a couple of marble chips to another test tube. Cover with 2 cm of hydrochloric acid.
2 Stopper immediately and pass the rubber tubing into a test tube filled with limewater.
3 Record what you see happening in both test tubes.

Questions

1 What gas do humans breathe out?
2 What evidence is there that the gases made in parts A and B are the same?
3 Is carbon dioxide an element, compound or mixture? Explain.

Unit 1.1 Prac 2
Compounds in soft drinks

The bubbles in soft drink are carbon dioxide (CO_2). Which drink has the most bubbles?

You will need

Access to an electronic balance (accuracy 0.01 g), 500 mL measuring cylinder, large beaker (over 400 mL), stirring rod, a selection of 375 mL cans of soft drinks, including 'lite' drinks

What to do

1 Copy the following table into your workbook:
2 Record the mass of a full, unopened can.
3 Find the mass of the empty beaker.
4 Pour the entire can into a measuring cylinder. Record the actual volume.
5 Empty the drink into the beaker and stir until it is 'flat'.
6 Find the mass of the beaker and flat drink.
7 Also record the mass of the empty can.
8 Repeat for other drinks or share your results with other groups.

Questions

1 Did all the cans contain their advertised volume?
2 Calculate the mass of CO_2 in each drink.
3 Which drink would you expect to go 'flat' first? Which would stay 'fizzy' for longest? Explain.
4 Are 'lite' soft drinks really lighter than normal?
5 What does 'lite' refer to?

Drink	Ingredients	Mass of full can (g)	Mass of empty can (g)	Mass of empty beaker (g)	Volume of drink (mL)	Mass of beaker and flat drink (g)	Mass of CO_2 (g)

home

Unit 1.2 Development of a table

It has long been known that some groups of elements act remarkably similar to each other, as if they belong to the same 'family': their **physical properties** (colour, melting and boiling points, density, hardness and so on) and **chemical properties** (the way they react with other chemicals) are alike.

Mendeleev and Meyer

In 1869 Russian **Dmitri Ivanovich Mendeleev** arranged the known elements in order of atomic number, putting the known 'families' into vertical columns. To do this he needed to insert gaps in the table, predicting the gaps were elements not yet discovered. Using family resemblances, Mendeleev predicted what properties could be expected of them. When eventually these elements were discovered, their properties closely matched his predictions. It is an expanded version of this table that we still use in chemistry today: we call it the **Periodic Table**.

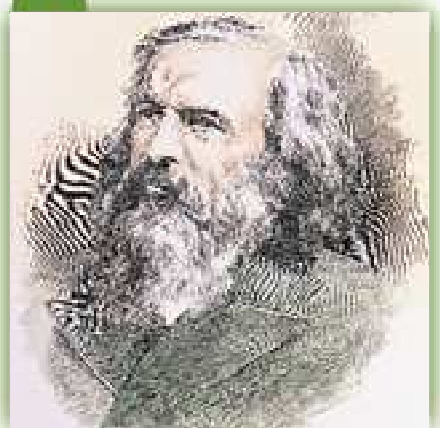

Fig 1.2.1 Mendeleev was so important to early chemistry that stamps had his portrait on them!

Prac 1 p. 9

Science snippet

A little late!

German chemist **Lothar Meyer** devised a table similar to that of Mendeleev in 1868–69. He did not get into print however until 1870, 1 year after Mendele[ev]. Despite losing the race to first, Meyer is acknowledg[ed] as a joint 'father' of the Periodic Table.

home

Features of the Periodic Table

About 80% of the elements in the Periodic Table are **metals**. Another smaller set of elements are classified as **non-metals**. Separating the metals and non-metals is a set of elements that act a little like both—the **metalloids**.

The most reactive metals (for example Fr) are in the bottom left of the table and the most reactive non-metals are in the upper right (F).

Prac 2 p. 10

Horizontal rows in this table are called **periods** and are numbered 1 to 7. Vertical columns are given the Roman numerals I to VIII and are called **groups**.

There are blocks of elements without normal group numbers: the **transition elements**, the **lanthanides** and **actinides**.

There are at least fifteen **synthetic** elements, made solely in the laboratory. All of these decay quickly into other elements. Some decay so quickly that few experiments have been able to be performed on or with them. Atoms with atomic numbers 116 (ununhexium Uuh) and 118 (ununoctium Uuo) have been detected recently.

Science snippet

Warning, warning!

Pure fluorine is an extremely dangerous gas that will react violently with just about anything. It was not successfully prepared until 1886 and only after several scientists died.

	Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group VIII
		II											III	IV	V	VI	VII	
Period 1	H Hydrogen 1																	He Helium 2
Period 2	Li Lithium 3	Be Beryllium 4											B Boron 5	C Carbon 6	N Nitrogen 7	O Oxygen 8	F Fluorine 9	Ne Neon 10
Period 3	Na Sodium 11	Mg Magnesium 12											Al Aluminium 13	Si Silicon 14	P Phosphorus 15	S Sulfur 16	Cl Chlorine 17	Ar Argon 18
Period 4	K Potassium 19	Ca Calcium 20	Sc Scandium 21	Ti Titanium 22	V Vanadium 23	Cr Chromium 24	Mn Manganese 25	Fe Iron 26	Co Cobalt 27	Ni Nickel 28	Cu Copper 29	Zn Zinc 30	Ga Gallium 31	Ge Germanium 32	As Arsenic 33	Se Selenium 34	Br Bromine 35	Kr Krypton 36
Period 5	Rb Rubidium 37	Sr Strontium 38	Y Yttrium 39	Zr Zirconium 40	Nb Niobium 41	Mo Molybdenum 42	Tc Technetium 43	Ru Ruthenium 44	Rh Rhodium 45	Pd Palladium 46	Ag Silver 47	Cd Cadmium 48	In Indium 49	Sn Tin 50	Sb Antimony 51	Te Tellurium 52	I Iodine 53	Xe Xenon 54
Period 6	Cs Cesium 55	Ba Barium 56	La* Lanthanum 57	Hf Hafnium 72	Ta Tantalum 73	W Tungsten 74	Re Rhenium 75	Os Osmium 76	Ir Iridium 77	Pt Platinum 78	Au Gold 79	Hg Mercury 80	Tl Thallium 81	Pb Lead 82	Bi Bismuth 83	Po Polonium 84	At Astatine 85	Rn Radon 86
Period 7	Fr Francium 87	Ra Radium 88	Ac Actinium** 89	Rf Rutherfordium 104	Ha Hahnium 105	Sg Seaborgium 106	Ns Nielsbohrium 107	Hs Haffium 108	Mt Meitnerium 109	Uun Ununnilium 110	Uuu Unununium 111	Uub Ununbium 112						

*Lanthanides 58–71	Ce Cerium 58	Pr Praseodymium 59	Nd Neodymium 60	Pm Promethium 61	Sm Samarium 62	Eu Europium 63	Gd Gadolinium 64	Tb Terbium 65	Dy Dysprosium 66	Ho Holmium 67	Er Ersium 68	Tm Thulium 69	Yb Ytterbium 70	Lu Lutetium 71
**Actinides 90–103	Th Thorium 90	Pa Protactinium 91	U Uranium 92	Np Neptunium 93	Pu Plutonium 94	Am Americium 95	Cm Curium 96	Bk Berkelium 97	Cf Californium 98	Es Einsteinium 99	Fm Fermium 100	Md Mendelevium 101	No Nobelium 102	Lr Lawrencium 103

Legend
- liquid at room temperature
- gas at room temperature
- metals
- metalloids
- non-metals

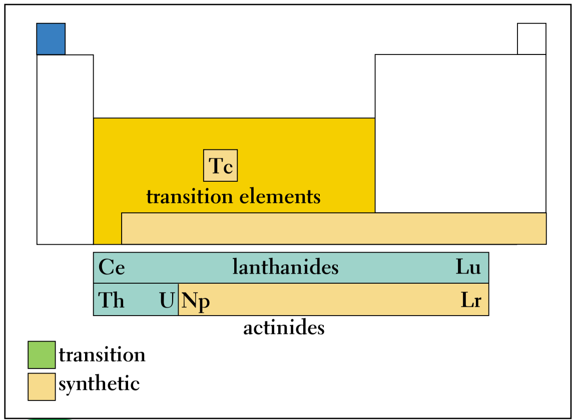

Fig 1.2.3 Special blocks

Fig 1.2.2 The Periodic Table

Unit 1.2 Questions

1 The symbols of some elements come from their Greek or Latin names. Use the Periodic Table to discover what these names describe:
- **a** Cuprum
- **b** Aurum
- **c** Plumbum
- **d** Wolfram
- **e** Bromos

2 What is the Roman numeral for these numbers?
- **a** 5
- **b** 4
- **c** 7
- **d** 2

3 Why did Mendeleev leave some gaps in his original table?

4 Copy the following, correcting any incorrect statements so they become true:
- **a** Horizontal rows in the Periodic Table are transition metals.
- **b** Vertical columns are called 'periods'.
- **c** The most reactive metallic atom would be lithium Li.
- **d** The most reactive non-metallic atom would be fluorine F.
- **e** The transition elements are all metals.

5 Name these elements and classify them as metal, non-metal or metalloid: Cl, Na, Ar, Si, Cu, Ge

6 List the names of the metalloids.

7 List the symbols of the non-metals.

8 List five common transition elements.

9 Which groups are most metals and non-metals found in?

10 What are five physical properties?

11 Name three elements that:
- **a** are in Group VI
- **b** are in Period 3
- **c** would be in the same 'family' but not in Group VI
- **d** would show similar chemical properties but are not in a, b or c above
- **e** are noble gases

12 The word **ferrous** means 'containing iron'. Suggest why.

13 Plumbing pipes were once made of lead. Suggest where the words 'plumber' and 'plumbing' came from.

14 Use the Periodic Table to predict the mass number of a:
- **a** hydrogen atom with three neutrons
- **b** chlorine atom with twenty neutrons
- **c** nickel atom that has thirty neutrons

Unit 1.2 Research / Extension

1 What important work did these scientists do and what elements are named after them?
Curie, Mendeleev, Einstein, Nobel, Lawrence

2 Compare Mendeleev's original Periodic Table with the one we use today. What differences and similarities are there? This website may be useful:
http://chemlab.pc.maricopa.edu/periodic/foldedtable.html

3 Find alternative versions of displaying the Periodic Table. http://chem.pc.maricopa.edu/periodic/periodic.html is useful.

home

Unit 1.2 Practical activities

Unit 1.2 Prac 1
Investigating a physical property

Density measures the amount of material that fits into a certain volume. It is a far better way of comparing the 'heaviness' of a material than using mass alone.

$$\textbf{Density} = \frac{\textbf{mass of the material}}{\textbf{volume of the material}}$$

You will need

Cubes or cylinders of aluminium, brass, lead, wood, ice; a collection of small items such as pebbles, candles, chunks of concrete or cement, copper wire; access to electronic balance, rulers, beakers and measuring cylinders

What to do

1 For each sample of material you need to measure its mass in grams.

2 You must also find the volume. Use a mathematical formula for samples with a regular shape such as a cube. You need to develop a way of measuring volume accurately for strange shapes, however. Volume must be measured in 'centimetres cubed' or cm^3. You can measure in mL, but will need to convert your measurement into cm^3 (1 mL = 1 cm^3).
3 Draw a series of cartoon sketches showing how you intend to measure the volume of the irregular shapes.
4 Collect all the necessary measurements for each sample you have.
5 Test if each sample floats on water.
6 Place your results in a table like this:

Sample	Mass (g)	Dimensions (cm)	Volume (mL)	Volume (cm^3)	Density (g/cm^3)	Float/sink

7 Take measurements to find the density of a sample of water.

Questions

1 Make a rule about densities and floating.
2 What is the conversion between mL and cm^3?
3 The density of water is 1.0 g/cm^3. How does your answer compare to this? What errors may have caused your answer to be different?
4 What is heavier, a tonne of lead or a tonne of feathers? Give detailed reasons for your answer.

Science snippet

You gotta be dense!

Depleted uranium (DU) and tungsten are twice as dense as lead, so ammunition shells made from them can penetrate even the heaviest of armour on tanks. The tips of tungsten shells become 'rounded' on impact but DU burns at the edges on impact, making it thinner, sharper and even more penetrating. DU shells were widely used by NATO in the conflict in Kosovo in the late 1990s. Several Italian troops have since developed leukaemia—a possible side effect of exposure to the burnt shells?

Unit 1.2 Prac 2
Comparing elements

You will need

Samples of sulfur, aluminium, carbon, iodine, silicon, tin, zinc, lead, magnesium, calcium, iron; steel wool; 3 to 4 test tubes and rack; power pack about 2 V or battery; wires with alligator clips; light globe; safety glasses

What to do

1 Construct a table in your workbook like the one below:

Element	Metal or non-metal	Appearance	Shiny or dull when polished	Floats/sinks	Action with water	Electrical conductivity

2 Describe the appearance of each sample.
3 'Shine' the sample with the steel wool. Record its appearance now.
4 Try to bend the sample. Does it bend or crumble?
5 Place some of the sample in water: does it float? Watch for any reaction.
6 Test if the sample conducts electricity.

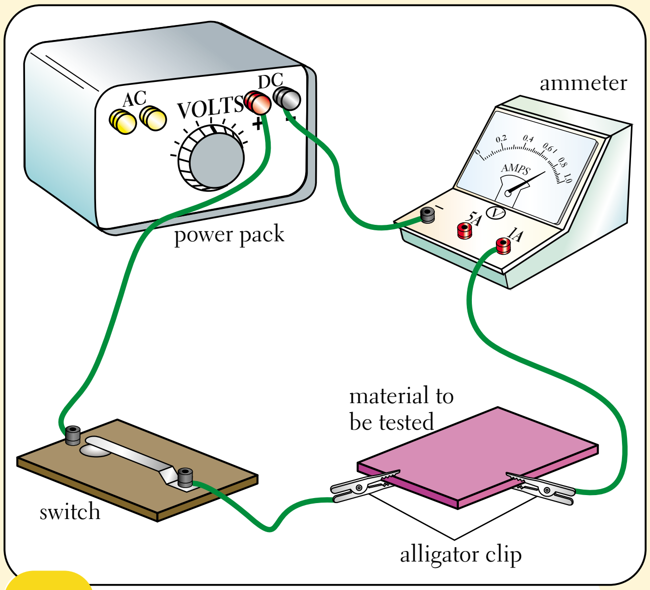

Fig 1.2.4 Does it conduct?

Questions

1 What similar properties did each of the metals have?
2 How was each of the non-metals similar?

home

Unit 1.3 The role of electrons

The way an atom behaves depends on what it does with its outer electrons. Other atoms that come into the vicinity can grab them easily. Meanwhile the protons and neutrons are relatively safe, being at the centre of the atom. Electrons determine all the chemical reactions that an atom takes part in and the numbers of each atom in any compound formed.

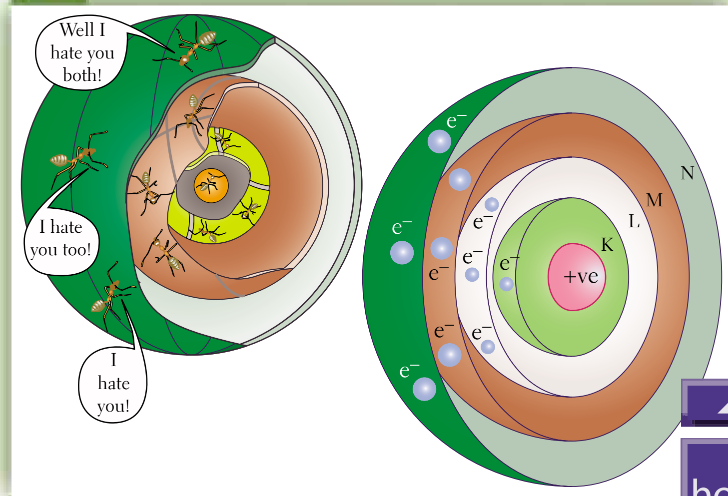

Fig 1.3.1 Ants and electrons

Electron shells

Electrons do not spin just anywhere around the atom, but in **shells** or **energy levels**, which are numbered 1, 2, 3 and 4 or named **K**, **L**, **M** and **N**.

It is easy to picture these shells if we imagine a pea as the nucleus of our atom. The pea sits in the middle of a table tennis ball (our first shell, K). All this sits inside a tennis ball (L shell), which sits inside a basketball (M shell), which sits inside a beach ball (N shell). Ants are running fast across the surface of the balls (these are our electrons) but stay as far away as possible from the others (electrons repel each other because of their negative charges). Only two ants fit on the K ball (otherwise they'll be too close) but more ant-electrons can fit on the L, M, and N balls since they are bigger.

Science snippet

Heavy fleas!

Imagine if all the empty space from every atom in our body was removed. The electrons are now stuck to the nucleus and we are the size of a flea! We still have the same weight as before though!

The number of electrons that can actually fit in each shell is:

K shell	L shell	M shell	N shell
Maximum of 2 e^-	Maximum of 8 e^-	Maximum of 18 e^- but happy if it holds only 8	Maximum of 32 e^- but happy if it holds only 8

Electronic configuration

The arrangement of electrons in shells is called the atom's **electronic configuration**.

Silicon has fourteen electrons. Two go into K, eight into L and the remaining four go into M: its electronic configuration is 2,8,4.
↑↑↑
K L M

The electronic configurations of the first twenty elements are shown on the next page.

home

	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
Period 1	H 1							He 2
Period 2	Li 2,1	Be 2,2	B 2,3	C 2,4	N 2,5	O 2,6	F 2,7	Ne 2,8
Period 3	Na 2,8,1	Mg 2,8,2	Al 2,8,3	Si 2,8,4	P 2,8,5	S 2,8,6	Cl 2,8,7	Ar 2,8,8
Period 4	K 2,8,8,1	Ca 2,8,8,2						

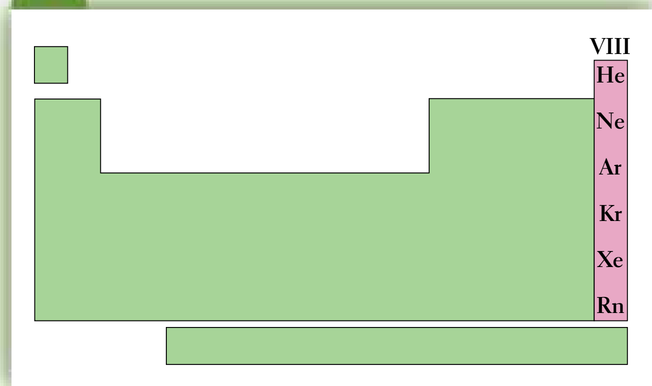

Fig 1.3.2 The noble gases: they don't want to react.

Periods, groups and electrons

Notice that:

- the number of shells used by an atom is the same as the period number
- the group number is the same as the number of outer shell electrons (Helium, He, is an exception.)

For example, F has the configuration 2,7. It has two shells in use, so is placed in Period 2. It has seven electrons in its outer shell and so is placed in Group VII.

If two atoms are in the same group then they have the same number of outer shell electrons and will have the same basic properties. As we move down a group, more shells are used. The atoms get bigger and slight differences in properties can be expected.

Prac 1 p. 14

Ions

If the number of electrons changes in an atom, it becomes charged and we call it an **ion**. If an atom loses electrons, it becomes a **positive ion**. If it gains electrons then the ion is **negative**.

If a sodium atom meets a chlorine atom, the sodium loses its outer shell electron to form the sodium ion Na^+. Chlorine takes on another electron to become the ion Cl^-. It now carries a new name: chloride. Both ions are stable and happily exist as Na^+Cl^- … sodium chloride (common salt). The attraction between the positive and negative ions holds the salt crystal together.

Prac 2 p. 15

Atoms that react and atoms that don't

Group VIII (sometimes also called Group 0) contains the **noble** or **inert** gases. Unlike other elements, the noble gases rarely react and are **stable**. This is because He and Ne atoms have their outer shells filled and Ar, Kr, Xe, and Rn have eight electrons in their outer shell.

All other atoms react so that they can be as stable as the noble gases: they also want a filled outer shell, or eight electrons in it. To do this, atoms gain electrons, lose electrons or sometimes even share electrons. We can now start to predict what atoms will do in a chemical reaction! Very useful!

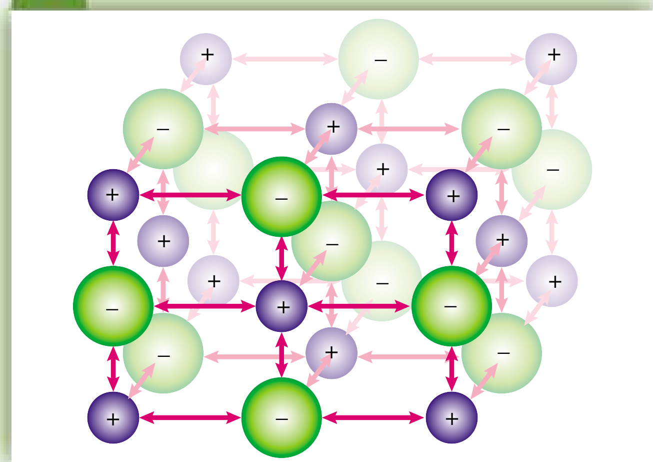

Fig 1.3.3 The sodium chloride lattice: positive and negative attract.

home

	Sodium		Chlorine		
	Before	After		Before	After
p^+	11	11	p^+	17	17
e^-	11	10	e^-	17	18
Charge	Neutral	+1	Charge	Neutral	–1

	Atomic number	Number of electrons	Electronic configura-tion	The atom could lose	Or it could gain	Most likely scenario	Most likely ion formed
H	1	1	1	$1e^-$	1e	Uncertain	H^+ or H^-
He	2	2	2	Unreactive		No ion formed	
Li	3	3	2,1	$1e^-$	$7e^-$	Lose 1 e^-	Li^+
Be	4	4	2,2	$2e^-$	$6e^-$	Lose 2 e^-	Be^{2+}
B	5	5	2,3	$3e^-$	$5e^-$	Lose 3 e^-	B^{3+}
C	6	6	2,4	$4e^-$	$4e^-$	Uncertain	
N	7	7	2,5	$5e^-$	$3e^-$	Gain 3 e^-	N^{3-}
O	8	8	2,6	$6e^-$	$2e^-$	Gain 2 e^-	O^{2-}
F	9	9	2,7	$7e^-$	$1e^-$	Gain 1 e^-	F^-
Ne	10	10	2,8	Unreactive		No ion formed	

Unit 1.3 Questions

1 What are energy levels?

2 What does the electronic configuration of an atom show?

3 How many electrons does each shell normally hold?

4 What is the same about atoms in:

a the same group?

b the same period?

5 What are three other family names for the noble gases?

6 What is the difference between an atom and an ion?

7 Why don't we worry about the number of neutrons when calculating the charge of an ion?

8 Explain why noble gases do not form ions.

9 How does a sodium ion form?

10 Sodium chloride has charges but no overall charge. Explain.

11 Copy out the table of ionic charges. Extend and complete it to include all the elements to calcium Ca.

12 How many electrons do each of these have?

a An atom with eight protons

b An atom with eighteen protons

c An atom with an atomic number of 3

d An atom with an atomic number of 19

e An atom in Period 2, Group VII

f An atom in Period 3, Group II

g An atom of phosphorus

h An atom of aluminium

13 Write the electronic configuration for each of the atoms in question 12 then predict their likely ionic charges.

14 What period and group would these atoms belong to?

a An atom with configuration 2,4

b An atom with configuration 2,8,6

c An atom with seven electrons

d An atom with fifteen electrons

e Ca

f Ne

15 What would be the electronic configuration of these atoms?

a An atom in Period 2, Group VI

b An atom in Period 3, Group VIII

c An atom of Period 1, Group VIII (be careful)

d An atom of Mg

e An atom of S

16 Copy and complete the following table into your workbook:

Number of protons	Number of neutrons	Number of electrons	Overall charge	Is it an atom or ion?	Symbol
8	6	8			
10	10	10			
11	10	10			
17	16	18			
15	15	18			
19	18		+1		K^+
20	19		+2		
8	7	10	–2		

home

Unit 1.3 Research / Extension

1 Something strange happens with the electron configuration of the transition elements. Find what it is.
2 Find out about the subshells s, p d and f and their weird shapes.

Unit 1.3 Practical activities

Unit 1.3 Prac 1
Firework colours

The original Chinese fireworks burned yellow/white only. Today fireworks include metal salts to colour them. The colours come from electrons jumping back and forth from shell to shell, emitting energy as they do so.

Fig 1.3.4 Metal salts give colour to fireworks

You will need

Bunsen burner, bench mat and matches, tongs, safety glasses, wooden icy-pole sticks soaked overnight in distilled water and solutions of barium chloride, copper chloride, potassium chloride, sodium chloride and strontium chloride, spectroscope (optional)

What to do

1 Copy the following table into your workbook. List all the solutions.

Solution	Compound formula	Colour of flame	Metallic element in solution	Non-metallic element in solution
Distilled water	H_2O			
Barium chloride	$BaCl_2$		Ba	Cl

2 Place the stick soaked in water in a blue Bunsen flame, then remove it. Record any colour that it gave the flame.

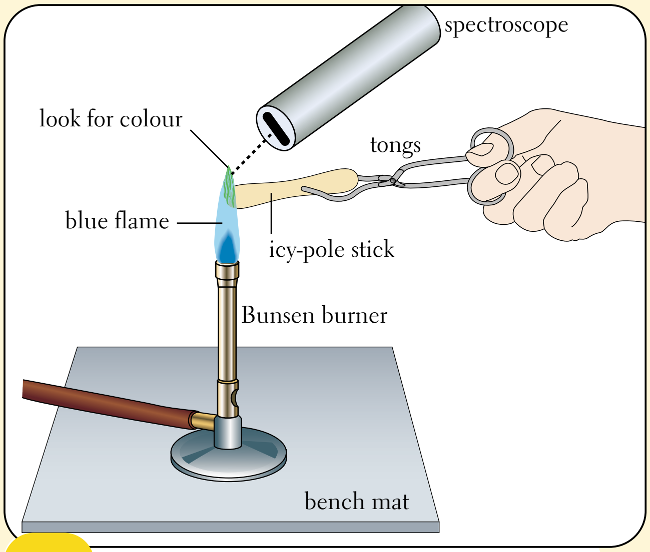

Fig 1.3.5 What colour is produced?

3 Place each of the other sticks in the flame and record the colour you see.
4 *Optional*: Point a spectroscope towards a bright portion of the sky (not the Sun). Draw the spectrum you see. Observe each of the coloured flames through the spectroscope, recording what you see.

Questions

1 What was the purpose of the stick soaked in water only?
2 Why did the water need to be distilled and not from the tap?
3 The non-metallic element did not add colour to the flame. What proof do you have?

4 Which of the solutions tested would you choose to make a firework:
  a red?
  b green?
  c blue/green?

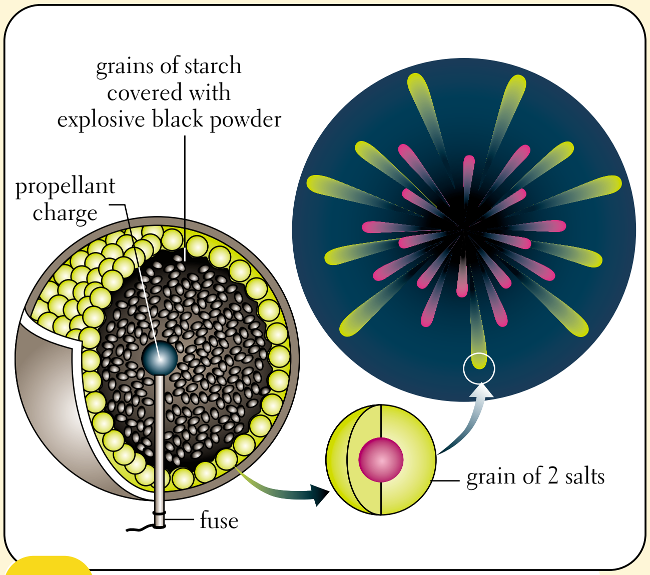

Fig 1.3.6 A firework 'grain'

5 The grains that spray out and give colour are made of starch soaked in the appropriate salt. Draw a grain that would burn and give the colours:
  a blue/green, then purple
  b red, then green
6 Where did the electrons get the energy to jump shells?

Unit 1.3 Prac 2
Ions get together!

WS 1.2

You will need

'Jigsaw' sheet of ions

What to do

1 Carefully cut around the jigsaw pieces on the sheet provided by your teacher.
2 Copy the following table into your workbook.

Compound name	Positive ion used	Negative ion used	Compound formula	Total positive charge	Total negative charge	Overall charge of compound

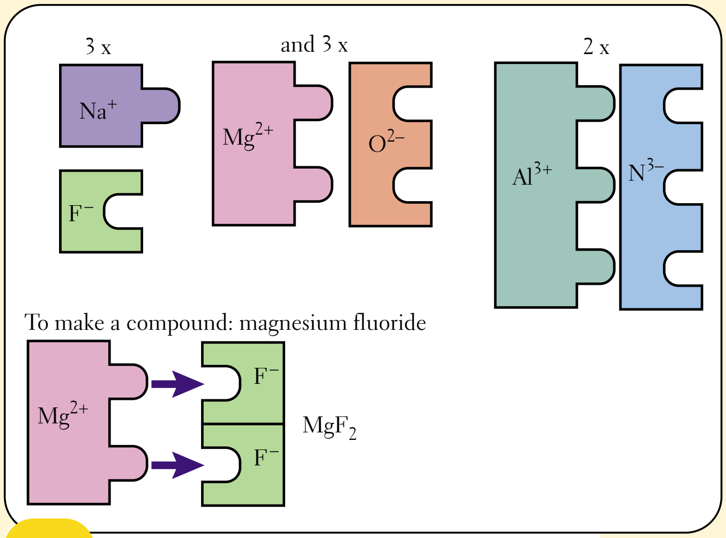

Fig 1.3.7 You need these jigsaw pieces.

3 Use the jigsaw pieces to 'create' the following compounds:
  sodium fluoride, sodium oxide, sodium nitride, magnesium fluoride, magnesium oxide, magnesium nitride, aluminium fluoride, aluminium oxide, aluminium nitride
4 Put all the relevant information about each compound in the table.
5 Re-label some of the pieces to create:
  lithium chloride, calcium bromide, barium sulfide, strontium phosphide

Questions

1 What was the overall charge of each compound 'created'?
2 Make up a rule that allows you to predict the formula of a compound.

Unit 1.4 Metals, non-metals and metalloids

Metallic elements outnumber the non-metallic elements four to one in the Periodic Table. What's the difference between them and where do the metalloids fit in?

Prac 1 p. 18

What is a metal?

Metals:

- allow heat and electricity to pass easily through them. Metals are excellent **conductors of heat and electricity**.
- shine when polished or freshly cut. We describe metals as **lustrous**.
- can be hammered into new shapes. Scientists call this **malleable**.
- are **ductile**. This means that metals can be stretched and drawn into long thin wires.

Densities are high: most metals sink in water. All but mercury are solid at normal room temperatures. Atoms of metals cannot exist by themselves but form lattices instead.

DYO Prac 2 p. 19
Prac 3 p. 19

About non-metals

All non-metals share these properties:

- They are all either poor conductors of electricity or do not conduct at all (insulators).
- Their melting and boiling points are so low that they are usually liquids or gases at normal room temperatures.
- They are brittle and tend to crumble into powders.
- They are dull, having little or no shine.

Group VIII atoms are the only ones that exist by themselves. Most other non-metallic atoms form molecules that contain two atoms. Some have more. A few form lattices.

Prac 4 p. 20

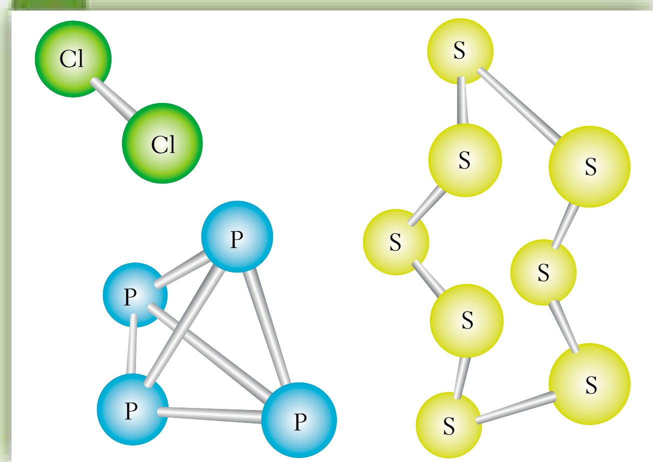

Fig 1.4.1 Non-metals generally form molecules.

Those electrons again!

The strength with which an atom holds its electrons is called its **electronegativity**. Metal atoms have a low electronegativity and non-metals have a high electronegativity. Metals have little control over their outer electrons while non-metals have tight control over theirs and are greedy for more. In a fight (or chemical reaction) non-metals try to rob metals of their outer-shell electrons: they each end up with eight electrons in their outer shells. The metal forms a positive ion and the non-metal forms a negative ion. The name of the non-metal often changes too.

home

Non-metallic atom	Name of atom	Ion formed	Name of ion
F	Fluorine	F^-	Fluoride
Cl	Chlorine	Cl^-	Chloride
Br	Bromine	Br^-	Bromide
O	Oxygen	O^{2-}	Oxide
N	Nitrogen	N^{3-}	Nitride

The special case of H and He

Hydrogen has only one electron. It can lose it to become the hydrogen ion H^+, or it can gain another one to become the hydride ion H^-: it can act like a Group I *or* Group VII element, depending on what it comes into contact with.

Because its two electrons fill its outer shell, helium acts very similar to the noble gases of Group VIII. It could be placed in Group II but is usually placed in Group VIII because of family resemblances.

Science snippet

Helios, the Sun

Helium was discovered on the Sun before it was discovered on Earth. How? The Sun emits electromagnetic radiation (light) and one particular frequency could not be explained. It was coming from a new element that was given the name helium, after the Greek word for the Sun, **helios**.

Metalloids

The **metalloids** act like non-metals in most ways. They do however have some properties that are metallic: most importantly they can conduct electricity.

Science snippet

Don't breathe: it's dangerous!

Each year the burning of coal around the world releases 26 000 tonnes of the metalloid arsenic into the air! Coal also contains about 1.3 parts per million of uranium. It is estimated that in 1991 alone, 6630 tonnes of uranium were belched into the sky. Of this 47 tonnes were weapons-grade U-235, sufficient to make 1700 atom bombs!

Unit 1.4 Questions

1 Separate these properties into those that belong to metals and those that belong to non-metals: ductile, normally gas or liquid, dense, malleable, brittle, lustrous, excellent conductors, dull, poor conductors, normally solid.

2 What do these words mean?
- **a** Lustrous
- **b** Malleable
- **c** Ductile
- **d** Brittle
- **e** Electronegativity
- **f** Metalloid

3 Do metal atoms form molecules or lattices?

4 List three non-metallic elements that:
- **a** are gases at room temperatures
- **b** are liquids at room temperatures
- **c** are in Group V
- **d** are in Period 2
- **e** would be related to chlorine
- **f** would have larger atoms than those of oxygen

5 Draw an example of a molecule that has:
- **a** two atoms
- **b** four atoms
- **c** eight atoms

6 Which has a higher electronegativity: a metal or non-metal?

7 What are the likely charges of the ions that belong in the Groups I, II, III, V, VI, VII and VIII?

8 What ions would these atoms form?
- **a** Na
- **b** S
- **c** I
- **d** P
- **e** Al

9 What metal or metals:
- **a** is the only metal that is a liquid at 25°C?
- **b** are in Period 3?
- **c** are in Group IV?
- **d** would form +2 ions?

10 At normal room temperatures how many non-metals exist as:
- **a** solids?
- **b** liquids?
- **c** gases?

home

11 Explain why H could be placed:
  a in Group I
  b in Group VII
  c by itself
12 Helium could be placed in Group II. Why?
13 Why is helium normally placed in Group VIII?

Unit 1.4 Research / Extension

1 Lead and mercury are cumulative poisons. What does this mean? What are the main sources of these metals? How do they affect us?
2 Find out how 'liquid gases' like liquid oxygen and liquid nitrogen are made.
3 The Iron Age represented a massive advance in the technology of food collection and warfare. Find when this was and explain how iron (and its alloy steel) changed the lives of people at that time.

CREATIVE WRITING

War of the electrons

Atom meets atom. They both want electrons. They fight for control. They form an alliance of atoms, where they join in relative peace. You are a submicroscopic war correspondent reporting on the battle taking place in a chemical reaction. Write a short history of the war. Your report must identify:

- the atoms taking part
- their relative strengths
- what electrons are affected
- the fate of the electrons
- what the atoms look like after the war

Suitable choices could be:

- the Monarchy Al galily (say, Na, K) and the Republic of Halo Genes (F, Cl, etc.)
- the Empire of the Alkaline Earths (Mg, Ca, etc.) and the Halo Genes

For researching correspondents:

- Bromos and his evil smelling twin brother Br
- Magnesium and her brightly burning twin sister Mg

Unit 1.4 Practical activities

Unit 1.4 Prac 1
Metal crystals

WARNING: Silver nitrate stains skin badly. Lead nitrate is very poisonous and reactive. Wear safety glasses and gloves at all times when dealing with them.

You will need

Sterilised Petri dish, 250 mL beaker, Bunsen burner, tripod, gauze mat, bench mat, 1 cm x 4 cm strip clean zinc sheet, one 0.3 g sample of silver nitrate, lead nitrate, copper sulfate or tin chloride, 0.5 g agar powder, 40 mL distilled water, stirring rod, stereo microscope (optional)

What to do

1 Place 40 mL of distilled water in the beaker and sprinkle 0.5 g of agar into it. Warm gently over the Bunsen burner, stirring until dissolved.
2 Remove the beaker and add one 0.3 g sample to it. Stir until dissolved.

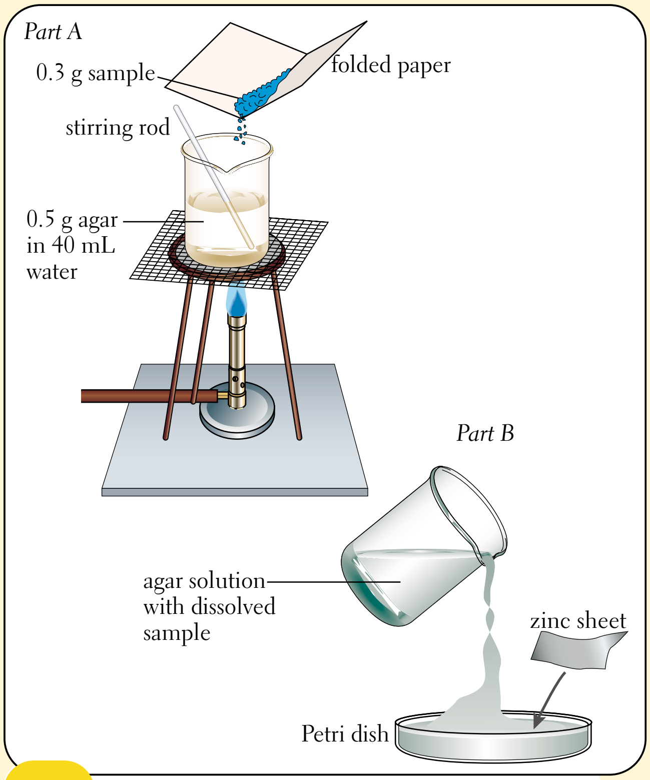

Fig 1.4.2 Making an agar plate

3 Pour the agar solution into a Petri dish and gently place the zinc strip in the centre.
4 Allow the agar to cool and set into a jelly.
5 Place the lid on top.
6 Inspect the metal crystals that form over the next few days. If available, use a stereo microscope for a better view.
7 Draw the shape of the crystals you see in each group's Petri dish. Describe any colour changes.

Questions

1 Why were the crystals grown in agar and not a liquid?
2 Would crystals be molecules or a lattice? Why?
3 What happened to the agar with dissolved silver nitrate? This is also what happens if silver nitrate comes into contact with your skin.
4 Petri dishes and agar are often used in pathology. Find why.
5 How does the agar in a Petri dish go 'bad'?

DYO

Unit 1.4 Prac 2 More crystals

You will need

100 mL conical flask, cork or rubber stopper, silver nitrate solution, 10 to 15 cm length of copper wire and/or strip of copper foil

What to do

1 Use this diagram to write a method for another way to prepare silver crystals.

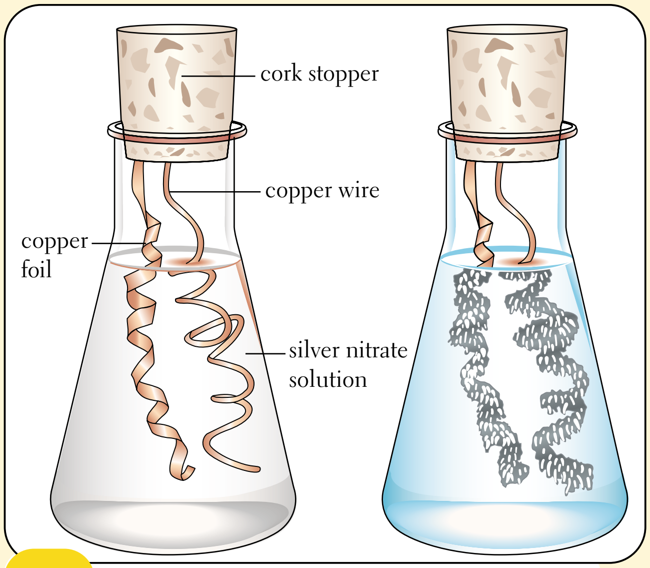

Fig 1.4.4 Making silver crystals

2 Have your teacher check your method and, if it is approved, set up your experiment.
3 Place the flask in a safe, dark place for a few days.

Question

1 'Copper ions give solutions a blue colouring.' What two observations would support this inference?

Unit 1.4 Prac 3 Changing the properties of metals

Steel is about 98% iron. Heating can change the size of its crystals and its properties.

You will need

Four steel hairpins, steel wool, Bunsen burner, bench mat, matches, 250 mL beaker filled with water, wooden peg, safety glasses, pliers (optional)

What to do

1 Copy the table below into your workbook:

Treatment	Number of bends needed to break pin	Effect of treatment
None		
Normalising		
Quenching		
Tempering		

2 Repeatedly bend a hairpin until it breaks. Count how many times it took.

3 *Normalising*: Take another hairpin and heat the middle in a blue Bunsen burner flame until it is red hot. Allow it to cool on the bench mat.

4 *Quenching*: Heat another hairpin in the same way, then drop it into a beaker of water.

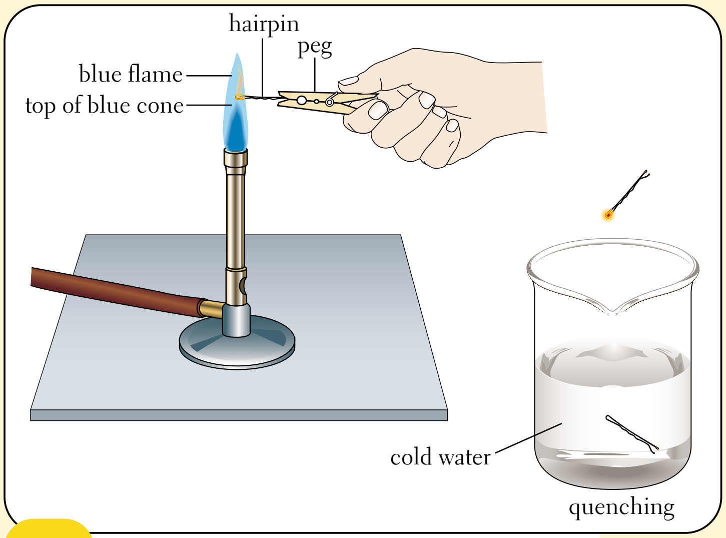

Fig 1.4.5 Rapid cooling produces small crystals.

5 *Tempering*: Heat and quench the remaining hairpin, then polish it with steel wool. Re-heat the shiny part of the pin. Remove the pin occasionally to check if it has gone blue. Once it has, remove the pin from the flame and allow it to cool on the mat.

6 Bend each of the pins until they break. Record your counts.

Questions

1 Describe what the terms 'normalising', 'quenching' and 'tempering' mean.

2 What treatment caused the steel to become:
   a more brittle?
   b more malleable?

3 Fast cooling produces small crystals; slow cooling makes bigger ones. Which of the samples produced the biggest crystals?

4 Why would bigger crystals make steel tougher?

5 What is the difference between iron and steel?

Unit 1.4 Prac 4
Using metals to make non-metals

You will need

Samples of magnesium, iron and copper, 2 M hydrochloric acid in a dropping bottle, test tubes and rack, matches, safety glasses

What to do

1 Place the samples of metal in separate test tubes.

2 Use the dropping bottle to add sufficient hydrochloric acid to cover the metal in each.

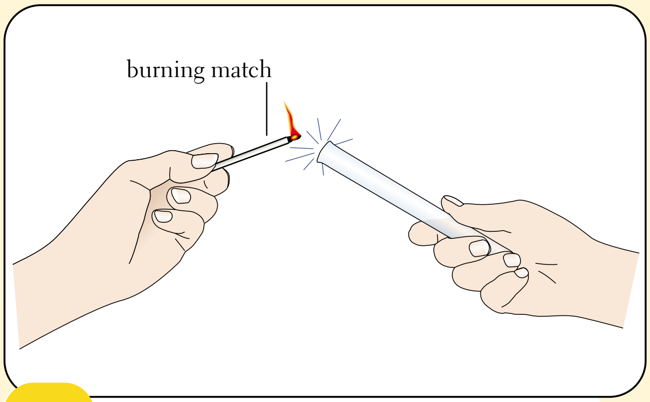

Fig 1.4.6 Making and testing a gas

3 If bubbles form, test the type of gas produced by placing a lit match near the mouth of the tube. You may need to place your finger gently over the mouth to gather sufficient gas to test.

4 Record your observations.

Questions

1 What gas is present if a lit match:
   a causes a 'popping' sound?
   b flares up brightly?
   c is extinguished?

2 Are the gases in question 1 elements or compounds?

3 What can be said about the reactions of metals with acids?

Unit 1.5 Families of importance

Although all members of a family are different, they do share some characteristics. Let's investigate some special families of elements.

Fig 1.5.1 Like humans, elements belong in families. Each member is different but shares similarities with other elements in their family.

Group VIII—the noble gases

All these elements are colourless gases that occur naturally in the atmosphere. All can be distilled from liquid air. They are incredibly stable and react only under rare and extreme circumstances. Helium is safe and light enough to be used for balloons and airships. Balloons of the other noble gases get progressively heavier; although the atoms get bigger, they also get heavier and more dense.

Science snippet

Squeaky voices

Our voices go high and squeaky when we breathe in helium from a party balloon. Because helium is lighter than air, our vocal cords vibrate more quickly, making the pitch go higher. Don't try this, though: who knows, the effect might be permanent!

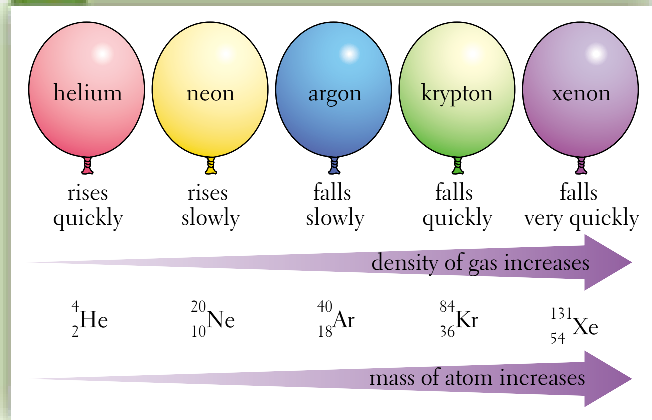

Fig 1.5.2 Noble gases get bigger and heavier as we go down the group.

Group VII—the halogens

These atoms:

- form ions with a charge of –1.
- are never found in their pure form in nature but are in various types of salts, including sea salt
- have coloured and poisonous vapours
- all form molecules, each being made up of two atoms

All convert hydrogen sulfide H_2S (rotten egg gas) into sulfur S, forming very similar, strong acids.

$F_2 + H_2S \rightarrow S + 2HF$

$Cl_2 + H_2S \rightarrow S + 2HCl$

↑

a common strong acid, hydrogen chloride or hydrochloric acid

home

They also react in a similar way with iron—see Fig 1.5.5.

As we move down the group the atoms get bigger and become less reactive.

Prac 1
p. 26

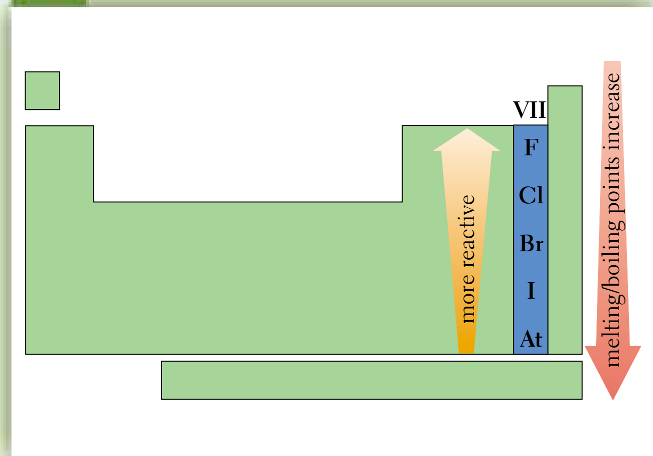

Fig 1.5.3 The halogens

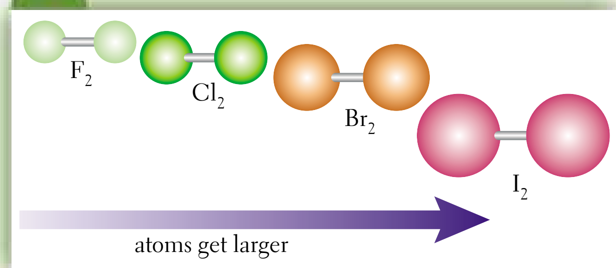

Fig 1.5.4 Halogen molecules

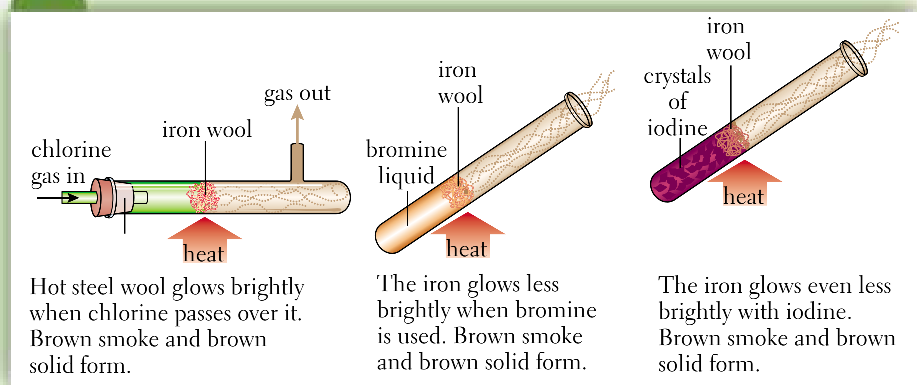

Fig 1.5.5 Halogen family reactions with iron

Group VII	State at room temperature	Melting point (°C)	Boiling point (°C)	Uses of halogen compounds
Fluorine	Greenish yellow gas	–220	–188	Prevention of tooth decay, etching of glass, insecticides, Teflon and the anaesthetic Fluothane
Chlorine	Green gas	–101	–35	Disinfectant, sterilising agent, bleach, food seasoning, PVC, neoprene rubber, insecticides
Bromine	Red liquid with red vapour	–7	59	Photographic film, sedatives
Iodine	Black solid with purple vapour	114	184	Disinfectant, control of goitre

Group I—alkali metals

These metals:

- form +1 ions
- are far too reactive to be found free in nature, but are found in mineral salts
- have typical metallic properties
- display similar chemically extreme behaviours

Science snippet

Dead bumblebees!

The Swedish chemist Carl Scheele separated chlorine gas in 1774 and wrote that he was glad that he 'did not take more than a tiny whiff as a large bumblebee died instantly when put into the vapour'. Scheele often tasted his discoveries and this is probably what killed him at the age of 43.

home

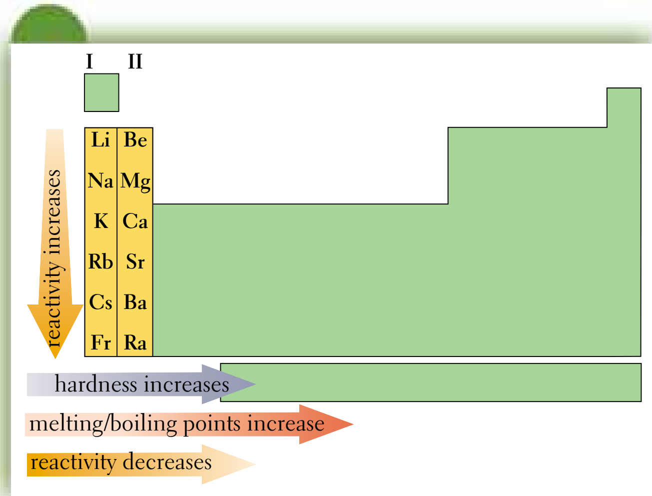

Fig 1.5.6 Alkali metals and alkaline earths

Lithium, sodium and potassium are light enough to float on water and are so soft that they can be cut with a knife. They all burn in chlorine gas (and in the other halogens) and produce similar white salts.

$2Li + Cl_2 \rightarrow 2LiCl$

$2Na + Cl_2 \rightarrow 2NaCl$

$2K + Cl_2 \rightarrow 2KCl$

↑

example of a salt (potassium chloride)

They all react violently with water, producing an alkaline (basic) solution and hydrogen gas, which often ignites due to the heat produced. To avoid this happening accidentally, Group I metals are usually stored in paraffin oil to keep them moisture-free.

$2K + 2H_2O \rightarrow 2KOH + H_2$

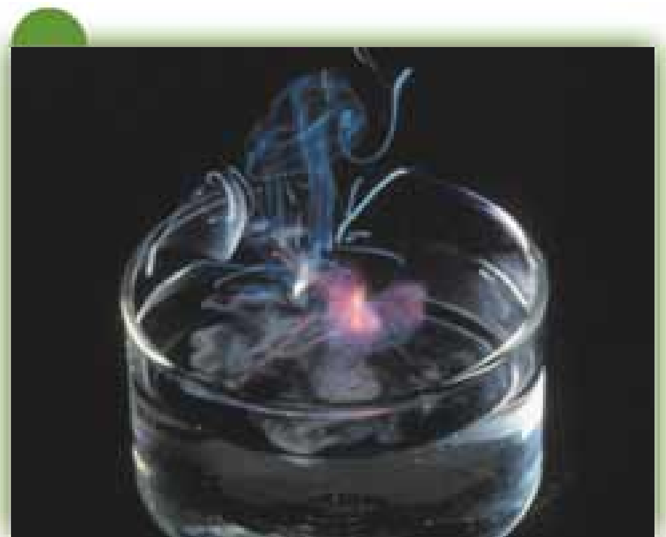

Fig 1.5.7 Potassium in water. Reactions become more violent as we move down Group I.

Prac 2
p. 27

Group I	Melting Point (°C)	Boiling point (°C)	Uses of Group I compounds
Li	181	1342	Alloys, carbon dioxide filters, water absorbent
Na	98	883	Vapour lamps, fertilisers, sedatives, in manufacture of paper, soap, textiles and other chemicals
K	63	760	Alloys, coolant in nuclear reactors
Rb	39	686	Radioactive tracer used to detect brain tumours

Group II—the alkaline earths

These metals all act in a similar, but slightly less reactive, way to those in Group I.

Group II	Melting point (°C)	Boiling point (°C)	Uses of Group II compounds
Be	1278	2970	Watch springs, spark-free tools
Mg	649	1107	Alloys, rust protection, anatacid, laxatives
Ca	839	1484	Alloys, quicklime in mortar, plaster, cement
Sr	769	1384	Fallout from nuclear explosions
Ba	725	1640	Used in medical diagnosis, rat bait

home

Group IV

Group IV begins with atoms that are non-metals (carbon and silicon), moves through the metalloid germanium, then the metallic atoms of tin and lead, to finish with the synthetic element ununquadium.

Carbon exists in molecules in every living thing on Earth (e.g. trees) and anything that was living (wood and paper come from trees). Pure carbon exists in three different forms or **allotropes**: amorphous carbon, diamond and graphite. Amorphous carbon is the black powder on the top of burnt toast, charcoal and coal.

Fig 1.5.8 Diamond, an allotrope or form of carbon

Diamond is the hardest known natural substance and does not conduct electricity. Over 80% of diamonds are not gem-grade but are used as tips for dentist drills, glass, metal and masonry cutting tools or are crushed to make abrasives.

Graphite is a soft solid. It conducts electricity well and is used as the central electrode of non-rechargeable batteries and as 'brushes' in electric motors. It is slippery and is a wonderful lubricant. The 'lead' in pencils is a graphite/clay mix.

Silicon is found as silicon dioxide and metal silicates, which together make up 75% of the Earth's crust: sand, clay, asbestos, quartz and many gemstones contain silicon. It is the major component of glass.

Mendeleev predicted the existence of germanium 15 years before its discovery, naming it 'eka-silicon'. Germanium is used as the **catalyst** in fluorescent lights and its oxides are used in the production of lenses for optical instruments such as microscopes. Both silicon and germanium are semiconductors and are widely used in electronic components.

Prac 4
p. 28

Tin and lead are typical metals.

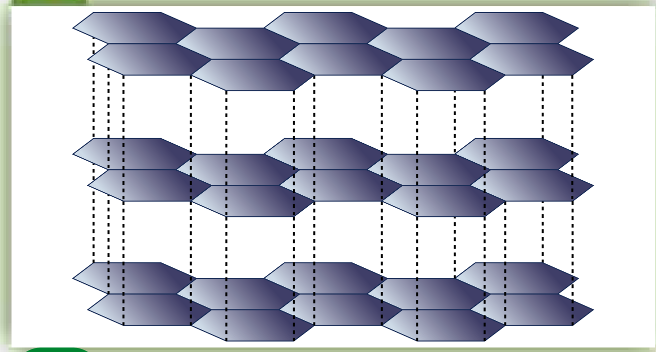

Fig 1.5.9 The layered structure of graphite makes it slippery.

The transition metals

The transition metals include many of our most useful, colourful and valuable metals such as iron, copper, zinc, gold and silver. The transition metals have very similar properties: for example, the Period 4 metals iron, cobalt and nickel are all magnetic. All transition metals tend to be relatively hard and most have similar, high melting points.

Science snippet

Have you seen my ring?

Sir Humphry Davy (1778–1829) demonstrated that diamond was a form of carbon by burning a diamond that belonged to his wealthy wife! All that was left was carbon dioxide. Diamond needs about 800°C to be converted to graphite. To turn graphite into diamond a pressure of between 50 000 and 120 000 times that of normal air pressure is needed.

Fig 1.5.10 The salts of transition elements are as colourful as the metals.

Science snippet

Scandium, agent Sc-46!

East German secret police (the Stasi) regularly sprayed opponents of the government with radioactive scandium, Sc-46. The unknowing dissidents were then traced with a Geiger counter strapped under the armpits of agents. Vibrations alerted the agent that their trace was nearby. The Stasi also used radioactive silver bullets that could be safely shot into the tyres of cars they wanted to track.

WS 1.3 WS 1.4

Unit 1.5 Questions

1 What are the advantages of using helium and not hydrogen in airships?

2 What happens to the melting point and the boiling points of the halogens as we move down the group?

3 Which halogens would be solid, liquid or gaseous at these temperatures?
- a 20°C
- b 100°C
- c −199°C
- d 150°C

4 Which of the halogens is used as:
- a a disinfectant?
- b a sedative?
- c goitre control?
- d a bleach?
- e an anaesthetic?

5 Which of the alkali metals:
- a has a melting point of 98°C?
- b is in caustic soda?
- c is used as an air filter?
- d would be the most reactive?
- e would be the smallest atom?

6 Which of the alkaline earths:
- a would be closely related to potassium?
- b is used as a 'meal'?
- c is found in plaster?
- d is used to protect iron from rusting?
- e would be the least reactive?

7 These statements are about Group IV. Are they true or false?
- a The group contains both metals and non-metals.
- b All the elements in this group contain four electrons in their outer shell.
- c Diamond and graphite are forms of silicon.
- d Carbon is in all living things, but not in things that are dead.

8 What are the main uses for:
- a diamond?
- b graphite?
- c silicon?
- d germanium?

9 What percentage of diamonds is valuable?

10 Carbon could be classified as a metalloid and not a non-metal. Explain.

11 Carbon has been known for over 2000 years. Suggest why it was found much earlier than most other non-metals.

12 Name three transition elements that:
- a are in Period 5
- b are magnetic or can be made magnetic
- c are used for jewellery
- d are 'silver' grey in colour
- e have symbols from old Greek or Latin names

13 Carbon forms a compound CH_4. Predict the formula of compounds formed out of hydrogen and:
- a silicon
- b germanium
- c tin
- d lead

14 Use family resemblances to predict the reactions of:
- a sodium Na and water H_2O
- b rubidium Rb with water H_2O
- c lithium Li with iodine I_2
- d caesium Cs with chlorine Cl_2
- e sodium Na with bromine Br_2

15 Use the reactions given for the halogens to predict the reaction of hydrogen sulfide H_2S with:
- a bromine Br_2
- b iodine I_2

16 Tin acts like a non-metal below 13°C. In 1913 Captain Robert Scott and two fellow explorers froze to death in Antarctica after they ran out of stored heating fuel. Suggest why they unexpectedly ran out.

Unit 1.5 Research / Extension

1. Find out what goitre is.
2. Find what the different noble gases are used for.
3. What are lead and tin used for and why?
4. Plot a line graph of:
   - **a** melting point versus period number for the alkali metals
   - **b** boiling point versus period number for the halogens

Unit 1.5 Practical activities

Unit 1.5 Prac 1
Halogen precipitates

You will need

Test-tube rack, 5 test tubes, filter funnel and 4 filter papers, beaker, wash bottle with water, disposable gloves, safety glasses, saturated lead nitrate solution, dropping bottles of saturated solutions of potassium fluoride, potassium chloride, potassium bromide and potassium iodide

What to do

1. Quarter-fill a test tube with potassium fluoride solution.
2. Add the potassium chloride, bromide and iodide solutions to the other test tubes.
3. Use the dropping bottles to add 10 drops of lead nitrate solution to the first test tube. Lead nitrate is toxic. Do not get it on you. Wash your hands well after the prac, as toxic lead precipitates are produced and must be cleaned off.
4. Add similar amounts of the other potassium solutions to the remaining test tubes.
5. Record your observations.
6. Fold a filter paper and place in the funnel. Use a little water to keep the paper in place. Pour the material from the test tube into the paper, making sure not to overfill it. Collect the remaining solution (the filtrate) in the beaker and dispose of it in the container provided.
7. Unfold the filter paper and allow it to dry.

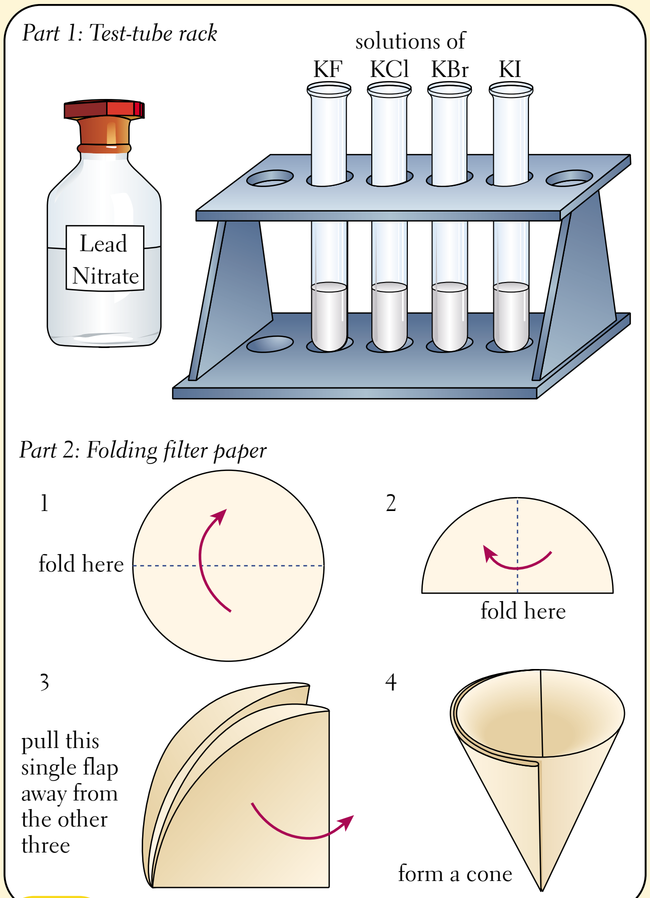

Fig 1.5.11 Making and filtering precipitates

Questions

1. The solid formed was a precipitate. What is a precipitate?
2. How were the compounds formed similar?
3. How were they different?
4. The precipitates were lead fluoride, lead chloride, lead bromide and lead iodide. What can be said about the halogen family from these results?

home

Unit 1.5 Prac 2
The alkali metals

TEACHER DEMONSTRATION

You will need

Perspex screen, safety glasses, pneumatic trough, scalpel/spatula, filter paper/paper towel, small samples of lithium and sodium metals in paraffin oil, phenolphthalein, three 250 mL beakers, one filled with water, one with a dilute acid and the other with a dilute alkaline solution

What to do

Teacher

1. Ensure that all students are wearing safety glasses and are behind the perspex screen.
2. Half-fill the pneumatic trough with cold water.
3. Use a dry scalpel/spatula to cut a small piece of lithium no bigger than a rice grain.
4. Blot up the paraffin oil with paper towel.
5. Carefully place the lithium into the centre of the pneumatic trough. Do not get the scalpel wet.
6. Add a few drops of phenolphthalein into the water after the reaction has stopped.
7. Replace the water and repeat for sodium.
8. Place a couple of drops of phenolphthalein into all three beakers as a reference for colour changes.

Questions

1. Describe the colour and shine of each sample of metal.
2. Were the metals hard or soft?
3. Was their density higher or lower than the density of water? How you can tell?
4. Which was the most reactive—Li or Na?
5. What happens to reactivity as we move down Group I?
6. What gas is produced in the reaction?
7. Where did the metal go after the reaction?
8. Was the water acidic, alkaline (basic) or neutral after the reaction?

Unit 1.5 Prac 3
The alkaline earths

You will need

2 test tubes and rack, Bunsen burner, tripod, bench mat, matches, safety glasses, distilled water, one 5 cm strip of magnesium, steel wool or emery paper, small sample of calcium

What to do

Part A

1. Clean the magnesium strip with steel wool and then coil it around a pen.
2. Place the coil in a test tube and cover it with distilled water.
3. Watch *very* carefully over the next 5 minutes. Look for bubbles.
4. If nothing happens, heat gently over a yellow flame.
5. When finished add 1 drop of phenolphthalein to the solution. Record the colour.

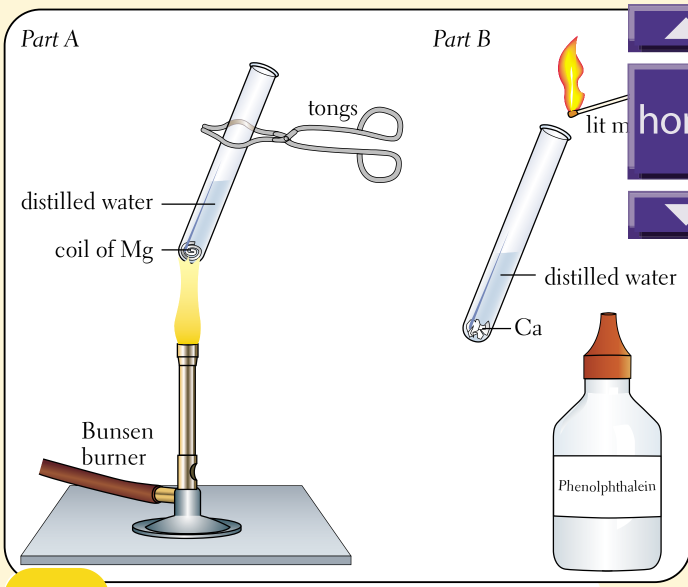

Fig 1.5.12 Comparing alkaline earths

Part B

1. Put about 5 cm of distilled water into a test tube.
2. Add a piece of calcium.
3. Test the gas given off with a lit match.
4. Add one drop of phenolphthalein.
5. Record your observations.

Questions

1. Which is more reactive, Mg or Ca?
2. What happens to reactivity as we move down Group II?

3 Is the reaction of these metals with water similar to that of the alkali metals in Prac 2? Explain.
4 Are Group II metals more or less reactive than Group I?

Unit 1.5 Prac 4
Group IV

You will need

Samples of charcoal, graphite, silicon, lead, power pack or battery, leads with alligator clips, light

What to do

1 Describe carefully the appearance of each sample.
2 Test if each conducts electricity using the apparatus used in Prac 2 of Unit 1.2.

Questions

1 Which Group IV elements are metals, non-metals and metalloids?
2 What happens to the properties of Group IV as we move down the group?

Chapter review questions

1 Sketch an outline of the Periodic Table, then use different colours to show the location of:
   a the noble gases
   b the transition metals
   c the metalloids
   d the non-metals
2 In which groups are these families?
   a Halogens
   b Inert gases
   c Alkaline earths
3 Say the Arabic words *Al galiy* (meaning 'roasted ashes') out aloud to find what group they stand for.
4 How many p^+, n and e^- do these atoms have?
   a $^{35}_{17}Cl$
   b $^{3}_{1}H$
   c $^{118}_{79}Au$
5 Copy and complete the table:

Atom	Atomic number	Mass number	Number of protons	Number of neutrons	Number of electrons	Atomic symbol
Sulfur		32		16		
Hydrogen	1			0		
Beryllium		9			4	
Iodine		127		74		
Nickel	28	59				$^{59}_{28}Ni$

6 What are the names of the shells and how many electrons can they hold?
7 What do the period number and the group number represent?
8 Why are elements of the same 'family' always found in the same group?
9 Why can hydrogen and helium be placed in a number of places in the Periodic Table?
10 What happens to the size and weight of elements as we move down any group?
11 What are five ways metals are different to non-metals?
12 What is the difference between a chlorine atom and a chloride ion?
13 True or false?
   a The mass number of an atom is the number of protons it has.
   b Mercury is a solid at room temperature.
   c There are millions of different types of atoms.
   d Group V atoms all have five electrons in their outer shell.
   e Period 4 atoms all have four shells in use.
   f An atom with an electronic configuration of 2,8,5 would be in Period 5, Group III.
   g Carbon dioxide is an element.
   h Air is a compound.
   i The element carbon is found in all living things.
   j In an atom the number of electrons equals the number of protons.
   k Ions are always charged.
   l Ions are formed when atoms lose or gain protons.
   m If an atom loses electrons it becomes a negative ion.
   n An atom that has gained three electrons would now be an ion of charge –3.
14 What are the three allotropes of carbon?

15 What would be the most likely charge of ions formed from an atom of:
- a five electrons?
- b seventeen electrons?
- c oxygen?
- d neon?
- e Group II?
- f Group V?

16 What is the name of an ion of:
- a chlorine?
- b oxygen?
- c nitrogen?
- d bromine?
- e sulfur?

17 Which has the highest electronegativity: metals or non-metals?

18 Explain what happens if a potassium atom meets a fluorine atom in a chemical reaction.

19 Why do the outer electrons control what the atom does in a chemical reaction?

20 Carbon also forms a molecule CCl_4. Predict what compounds would form out of chlorine and the other Group IV elements.

Sci-words

Unit 1.1 What's the matter?

	Word	Clue
1	ne ___ ___ ___ al	The overall charge of an atom.
2	___ ___ ___ ___ ic number	The number of protons.
3	___ ___ ___ ___ number	The number of protons and neutrons.
4	___ ___ ___ ment	Only made of one type of atom.
5	c___ ___ ___ ou ___ ___	Two or more elements combined.
6	m ___ ___ ___ure	Easily separated.
7	b___ ___ ___ ed	Joined.
8	mol ___ ___ ___ ___ e	Different atoms joined together.
9	___ ___ ___ ___ eus	Contains protons and neutrons.

Unit 1.2 Development of a table

	Word	Clue
1	___ ___ ___ ___ ___ ___ eev	He developed the Periodic Table.
2	M___ ___ ___ ___	He co-developed the Periodic Table with Mendeleev.
3	___ ___ ___ iod	Horizontal row of the Periodic Table.
4	___ ___ oup	Vertical column of the Periodic Table.
5	___ yn ___ ___ etic	Made in the laboratory.
6	___ ___ ___ si ___ ___ l properties	Melting, boiling point, colour, etc.
7	ch ___ ___ ___ ___ al properties	How an element reacts.
8	f ___ ___ ___ ___ ine	Most reactive non-metal.
9	f ___ ___ ___ ___ ium	Most reactive metal.

Unit 1.3 The role of electrons

	Word	Clue
1	___ ___ ___ lls	Energy levels.
2	e___ ___ ___tro ___ ___ ___ con ___ ___ ___uration	Way electrons are arranged.
3	___ ___ n	An atom that has lost/gained e^-.
4	___ ___ ___ up number	Number of electrons in outer shell.
5	p ___ ___ ___ od number	Number of shells.
6	___ ___ ert gases	Noble gases.
7	___ ___ able	Rarely react.

Unit 1.4 Metals, non-metals and metalloids

	Word	Clue
1	lust ___ ___ ___ ___	Shiny.
2	___ ___ ___ ___ eable	Able to be bent.
3	___ ___ ___ tile	Able to be drawn into thin wires.
4	c ___ ___ duc ___ ___ rs	Able to pass heat or electricity.
5	elec ___ ___ ___neg ___ ___ ___ ___ity	Holding power of an atom for electrons.
6	m ___ ___ ___ ls	80% of the elements.
7	___ ___ ___-metals	Mainly gases and liquids.
8	___ ___ ___ ___ ___ ___ oids	Has properties of both metals and non-metals.

Unit 1.5 Families of importance

	Word	Clue
1	___ ___ ___ ___e gases	Group VIII.
2	h___ ___ ___ ___ ___ ___ ___	Group VII.
3	___ ___ ___ ali metals	Group I.
4	al ___ ___ ___ ___ ne earths	Group II.
5	___ ___ ___ ___sit ___ on metals	Some of our most useful metals.
6	allo ___ ___ ___ ___ ___ ___	A different form of the same element.
7	___ ___ ___ ___ hite	A slippery form of carbon.
8	___ iam ___ ___ ___	A hard form of carbon.

home