UNIT 1

How can the diversity of materials be explained?

AREA OF STUDY 1

How can knowledge of elements explain the properties of matter?

Outcome

Relate the position of elements in the periodic table to their properties, investigate the structures and properties of metals and ionic compounds, and calculate mole quantities.

Key knowledge

Elements and the periodic table

- the relative and absolute sizes of particles that are visible and invisible to the unaided eye: small and giant molecules and lattices; atoms and sub-atomic particles; nanoparticles and nanostructures
- the definition of an element with reference to atomic number; mass number; isotopic forms of an element using appropriate notation
- spectral evidence for the Bohr model and for its refinement as the Schrödinger model; electronic configurations of elements 1 to 36 using the Schrödinger model of the atom, including s, p, d and f notations (with copper and chromium exceptions)
- the periodic table as an organisational tool to identify patterns and trends in, and relationships between, the structures (including electronic configurations and atomic radii) and properties (including electronegativity, first ionisation energy, metallic/non-metallic character and reactivity) of elements.

Metals

- the common properties of metals (lustre, malleability, ductility, heat and electrical conductivity) with reference to the nature of metallic bonding and the structure of metallic crystals, including limitations of representations; general differences between properties of main group and transition group metals
- experimental determination of the relative reactivity of metals with water, acids and oxygen
- the extraction of a selected metal from its ore/s including relevant environmental, economic and social issues associated with its extraction and use
- experimental modification of a selected metal related to the use of coatings or heat treatment or alloy production
- properties and uses of metallic nanomaterials and their different nanoforms including comparison with the properties of their corresponding bulk materials.

Ionic compounds

- common properties of ionic compounds (brittleness, hardness, high melting point, difference in electrical conductivity in solid and liquid states) with reference to their formation, nature of ionic bonding and crystal structure including limitations of representations
- experimental determination of the factors affecting crystal formation of ionic compounds
- the uses of common ionic compounds.

Quantifying atoms and compounds

- the relative isotopic masses of elements and their representation on the relative mass scale using the carbon-12 isotope as the standard; reason for the selection of carbon-12 as the standard
- determination of the relative atomic mass of an element using mass spectrometry (details of instrument not required)
- the mole concept; Avogadro constant; determination of the number of moles of atoms in a sample of known mass; calculation of the molar mass of ionic compounds
- experimental determination of the empirical formula of an ionic compound.

Elements and the periodic table

CHEMISTRY FUNDAMENTALS

Chemistry is the study of the composition, properties and reactions of matter.

All matter is composed of **atoms**. When a substance is composed of only one type of atom it is called an **element** and when a substance is composed of two or more different types of atoms it is called a **compound**.

Elements can be composed of single atoms, clusters of atoms called **molecules** or large networks of atoms that form **lattices**. Compounds can be composed of molecules or lattices. These molecules and lattices form the basis of all of the materials that are used in everyday life.

Sizes of particles

Atoms are composed of even smaller subatomic particles called **protons**, **neutrons** and **electrons**. **Nanomaterials** consist of particles and structures that contain enough atoms to be measured at the nanoscale.

$$1 \text{ nm} = 10^{-9} \text{ m}$$

Nanoparticles are single particles that range from about 0.1–100 nm in size. **Nanostructures** include nanotubes, nanorods and nanospheres which have dimensions at the nanoscale (Table 1.1).

Table 1.1 Absolute sizes of some different types of particles

Type of particle	Example	Diameter of particle	Visibility to the unaided eye
Subatomic particle	Proton	1×10^{-15} m	Invisible
Atom	Helium, He	6.2×10^{-11} m	Invisible
Simple molecule	Water, H_2O	2.9×10^{-10} m	Invisible
Nanoparticle	Carbon buckyball	7×10^{-10} m	Invisible
Lattice	Table salt (sodium chloride, NaCl)	1×10^{-4} m	Visible

ELEMENTS

All atoms contain three types of subatomic particles—neutrons, protons and electrons (Table 1.2). Atoms of the same type of element always contain the same number of protons.

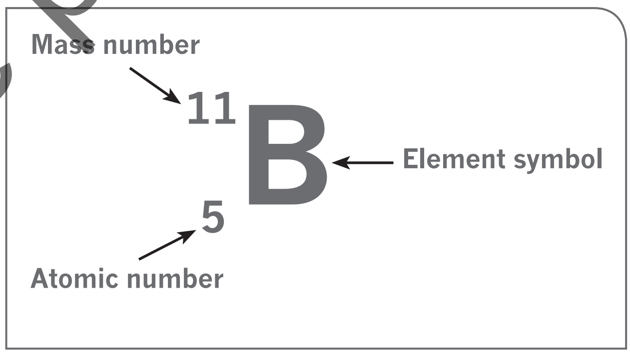
Table 1.2 Subatomic particles

Particle	Relative mass	Charge	Location
Neutron	1	Neutral	Nucleus
Proton	1	Positive	Nucleus
Electron	$\frac{1}{1836}$	Negative	Orbiting nucleus

Atoms are electrically neutral because they contain an equal number of negative electrons and positive protons.

Isotopes

The nucleus of an atom contains neutrons and protons held together by the nuclear strong force. The **atomic number** of an element gives the number of protons in the nucleus. The **mass number** of an element gives the number of protons plus the number of neutrons.



All atoms of the same element have identical atomic numbers. However, atoms of the same element can have different mass numbers, that is, they can have different numbers of neutrons. Atoms of the same element with different masses are called **isotopes** (Fig. 1.1).

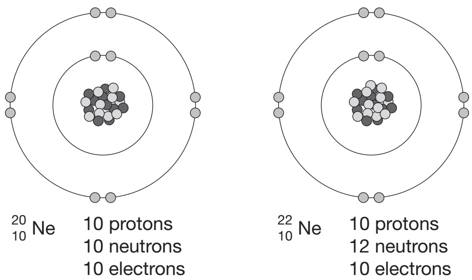


Figure 1.1 Isotopes of neon.

ATOMIC THEORY

The Bohr model of the atom places electrons in certain well-defined orbits of fixed energies called **shells**. The shell model (Fig. 1.2) explains the existence of **emission spectra**.

- Electrons are able to absorb energies to move from lower to higher energy levels causing the atom to move into an excited state.
- An excited atom is unstable so the promoted electrons immediately return to the lower energy levels. The atom returns to its ground state.
- The extra energies the electrons had absorbed are now emitted as photons of light.
- These fixed-energy jumps appear in emission spectra and are unique to each element.

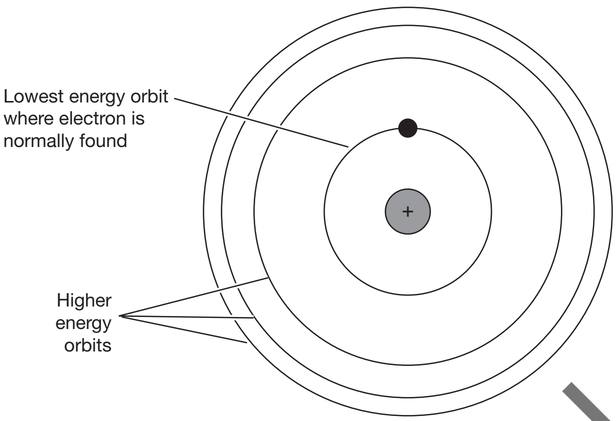


Figure 1.2 Bohr's shell model.

Erwin Schrödinger refined Bohr's model by proposing that electrons should be regarded as having wave-like properties. Electrons are not restricted to a given orbit but behave as negative clouds of charge found in regions of space called **orbitals** (Fig. 1.3).

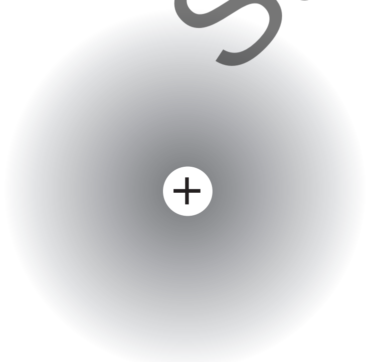


Figure 1.3 Electron cloud around a nucleus.

Electronic configuration

Electrons make up most of the volume of an atom. Electrons are located in orbitals in subshells within shells (Table 1.3).

Table 1.3 Different levels of organisation of electrons

Level of organisation	Definition	Label used
Shell	Major energy levels within an atom	1, 2, 3, 4, 5 etc.
Subshell	Energy levels within a shell	s, p, d, f
Orbital	Regions in subshells in which electrons move	

The **Pauli exclusion principle** states that each orbital may hold a maximum of 2 electrons.

- An s subshell has 1 orbital and can hold up to 2 electrons.
- A p subshell has 3 orbitals and can hold up to 6 electrons.
- A d subshell has 5 orbitals and can hold up to 10 electrons.
- An f subshell has 7 orbitals and can hold up to 14 electrons.

The subshells closest to the nucleus have the lowest energy and are filled first.

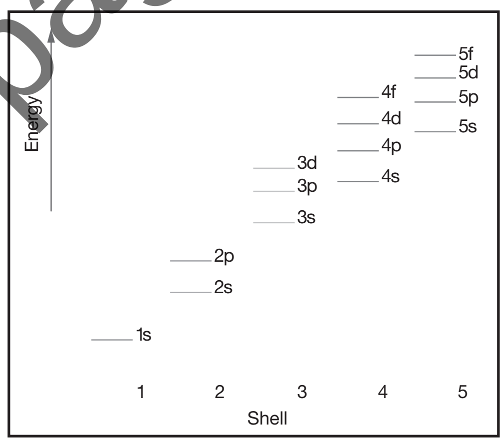


Figure 1.4 Energy levels in the atom.

Note that some subshells are higher in energy than subshells of the next shell (Figure 1.4). For instance, the unfilled 3d subshell is higher in energy than the unfilled 4s subshell. Therefore the 4s subshell is filled before the 3d. The electronic configurations of lithium, nitrogen, potassium and nickel are shown in Table 1.4.

Chromium and copper are exceptions to the usual order of filling. In these cases there is increased stability in

Table 1.4 Electronic configurations of some elements

Element	Atomic number	Electronic configuration
Lithium	3	$1s^2 2s^1$
Nitrogen	7	$1s^2 2s^2 2p^3$
Potassium	19	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$
Nickel	28	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

having a half or completely full d subshell, so an electron from the 4s subshell is excited and is promoted to a 3d orbital. Their electronic configurations are:

Cr $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$

Cu $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$

Valence electrons are the electrons that occupy the shell furthest from the nucleus. The valence electrons determine an element's chemical properties. Atoms can lose or gain valence electrons to form charged particles called **ions**.

THE PERIODIC TABLE

The **periodic table** is an extremely useful organisational tool for chemists. It can be used to identify patterns, trends and relationships between the structures and properties of elements.

The modern periodic table has the following features:

- Each box of the periodic table contains one element and information about it (Fig. 1.5).

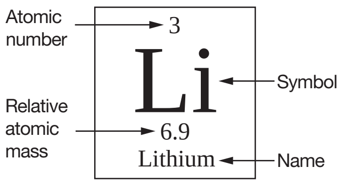


Figure 1.5 Periodic table information for lithium. Different periodic tables may contain different information.

A full version of the periodic table can be found on page 182.

- Horizontal rows are called **periods**. Elements in the same period have the same number of occupied electron shells.
- Vertical columns are called **groups**. Elements in the same group have the same outer shell electron configuration.
- Four large blocks of the periodic table can be identified (Table 1.5).

Table 1.5 Blocks in the periodic table

Block	Part of periodic table	Similarities in elements
s	Groups 1 and 2	An s subshell is being progressively filled.
p	Groups 13–18	A p subshell is being progressively filled.
d	Transition metals Groups 3–12	A d subshell is being progressively filled.
f	Lanthanides and actinides	An f subshell is being progressively filled.

Trends in the periodic table

Trends in properties observed in the periodic table (Table 1.6 on page 5) are a reflection of changing numbers of protons and electrons.

- Going down a group, the number of occupied electron shells is increasing so atomic radii are increasing and valence electrons are becoming further from the nucleus. This makes these electrons less tightly held so they can be more easily removed.
- Going across a period, the **core charge** of successive elements is increasing by one (core charge = no. protons – no. inner shell electrons).

As the core charge increases, the valence electrons experience a greater attraction to the nucleus and are held more tightly. They become more difficult to remove.

Metals

Common properties of metals:

- **lustrous** or reflective when freshly cut or polished
- good **conductors of heat**
- good **conductors of electricity**
- **malleable**, which means they can be shaped by beating or rolling
- **ductile**, which means they can be drawn into a wire.

Not all metals have all of these properties. A limitation of the metallic bonding model is that it cannot explain these exceptions.

METALLIC BONDING MODEL

Metal atoms generally have one, two or three electrons in their outer shell and have a tendency to lose electrons in their interactions with other atoms.

The bonding model of metals (Table 1.7 on page 5) is a **metallic lattice**, which consists of a regular arrangement of stable, positively charged metal ions, called **cations**, surrounded by a 'sea' of freely moving **delocalised** outer shell electrons. The metal atoms achieve stability by releasing their outer shell electrons to become the surrounding 'sea'. **Metallic bonds** are an electrostatic attraction between the cations and the freely moving electrons.

Structure of metallic crystals

When a metal is cooled down from its liquid form, or when a metal is produced from a solution by a chemical reaction, the lattice starts to form into **crystals** at many different places at once. Generally, the smaller the crystals, the less free movement there will be of layers of ions over each other, hence the metal becomes harder and less malleable. In addition, smaller crystals means there are more disruptions to the lattice overall so the metal also becomes more brittle.

Transition metals

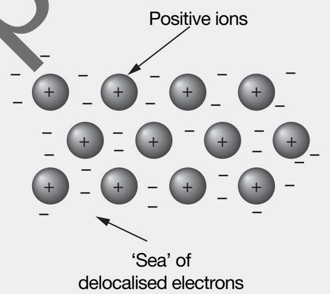
The **transition metals** are a block of elements that occupy groups 3 to 12 in the periodic table. Transition metal atoms are generally a smaller size than main group metal atoms due to their greater core charge. Their smaller size allows them to pack together more tightly in the metallic lattice with stronger bonds.

KEY KNOWLEDGE

Table 1.6 Trends within the periodic table

Property	Description	Trend going down a group	Trend going from left to right across a period
Atomic number	Indicates the number of protons located in the nucleus of the atom	Increases	Successive elements increase by one
Atomic radius	Indicates the size of the atom	Increases	Decreases
Electronegativity	Indicates the ability of an atom to attract electrons in a molecule. It reflects how strongly the valence electrons are attracted to the nucleus.	Electronegativity decreases	Electronegativity increases
First ionisation energy	Minimum amount of energy required to remove the highest energy electron from an atom or ion. It reflects how tightly the highest energy electron is held to the nucleus.	First ionisation energy decreases	First ionisation energy increases
Metallic/non-metallic character	The more metallic an element the more properties of a metal it has. Metallic properties are often evident in elements whose atoms tend to readily lose their valence electrons.	Metallic character increases	Metallic character decreases
Chemical reactivity of metals	Measure of how readily an element will react with another element. It reflects how readily a metal atom will release its outer shell electrons.	Reactivity of metals increases	Reactivity of metals decreases
Chemical reactivity of non-metals	Reflects how readily a non-metal atom will accept an electron	Reactivity of non-metals decreases	Reactivity of non-metals decreases. However, the last element in each period is an unreactive noble gas.

Table 1.7 Summary of metallic bonding

Type of material	Constituent particles	Bonding model	Properties
Metals (e.g. iron)	Metal cations formed when metal atoms lose their outer shell electrons Delocalised outer shell electrons		Generally high melting temperature Good conductor of electricity Malleable Ductile Lustrous

Compared to the main group metals, transition metals tend to:

- be harder
- have higher densities
- have higher melting points
- have magnetic properties (only some transition metals)
- be less reactive, although their reactivity varies.

REACTIVITY OF METALS

The **reactivity** of a metal is a reflection of its tendency to lose its valence electrons. Metals can be reacted with water, acid and/or oxygen in order to experimentally determine their relative reactivities.

- In reactions with water or acid, the presence and vigour of bubbling are an indication of the metal's reactivity.
- When a metal reacts with oxygen it forms an oxide. Naturally occurring metals in the Earth's crust often exist as oxides. Very unreactive metals, such as gold and platinum, exist in the Earth's crust in their pure form.

A **reactivity series of metals** (Fig. 1.6 on page 6) lists metals in order of their relative reactivity based on experimental data. Group 1 metals are the most reactive metals whilst transition metals are the least reactive.

KEY KNOWLEDGE

platinum, Pt	
gold, Au	
silver, Ag	
copper, Cu	
hydrogen, H	
lead, Pb	
iron, Fe	increasing reactivity ↓
zinc, Zn	
aluminum, Al	
magnesium, Mg	
calcium, Ca	
sodium, Na	
potassium, K	

Figure 1.6 Reactivity series of metals.

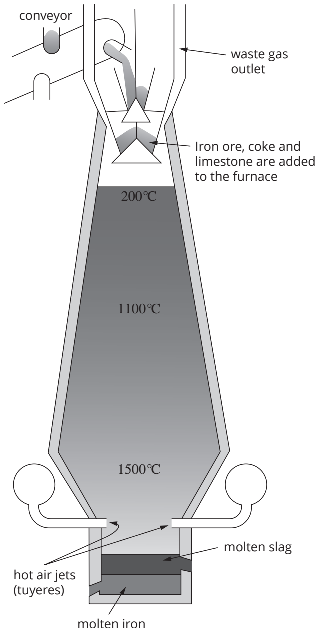


Figure 1.7 A blast furnace.

EXTRACTION OF A METAL FROM ITS ORE

Students should note that the extraction of one selected metal from its ore needs to be studied. The metal chosen for this workbook is iron. Students or teachers may select an alternative metal.

Iron exists in the Earth's crust as **iron ore**. Iron ore is a mixture that contains iron oxides and other substances. In Australia, the iron oxides are usually in the form of haematite, Fe_2O_3. The extraction of iron from its ore occurs in a blast furnace.

The blast furnace

A **blast furnace** is a tall tower shaped like a giant bottle (Fig. 1.7). **Iron ore**, **coke** and **limestone** are added at the top of the furnace while hot air blasts into the bottom. The ascending hot air meets the descending raw materials and a number of reactions occur (Table 1.8).

Iron and slag, a mixture of waste products, both sink to the bottom of the furnace where they are regularly drained.

There are a number of environmental, economic and social issues associated with the mining of iron ore and the extraction of iron.

MODIFYING THE PROPERTIES OF METALS

Most metals need to be modified in order to produce desired properties and make them more useful. The following are some common modifications.

- **Alloys** are formed by mixing two or more metals or mixing a metal with a small amount of a non-metal (Figs 1.8, 1.9). Alloys are generally harder and less malleable than their constituent metals. Of the iron ore that is mined and extracted around the world, 98% of it is used to make the alloy steel. Carbon steel is an alloy of iron and carbon. Stainless steel is an alloy of iron, nickel and chromium.

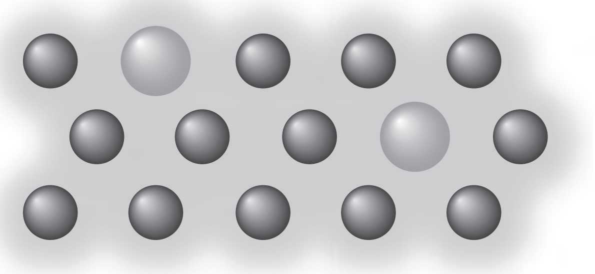


Figure 1.8 This is an alloy in which atoms of one element have taken the lattice positions of some of the atoms of the second element.

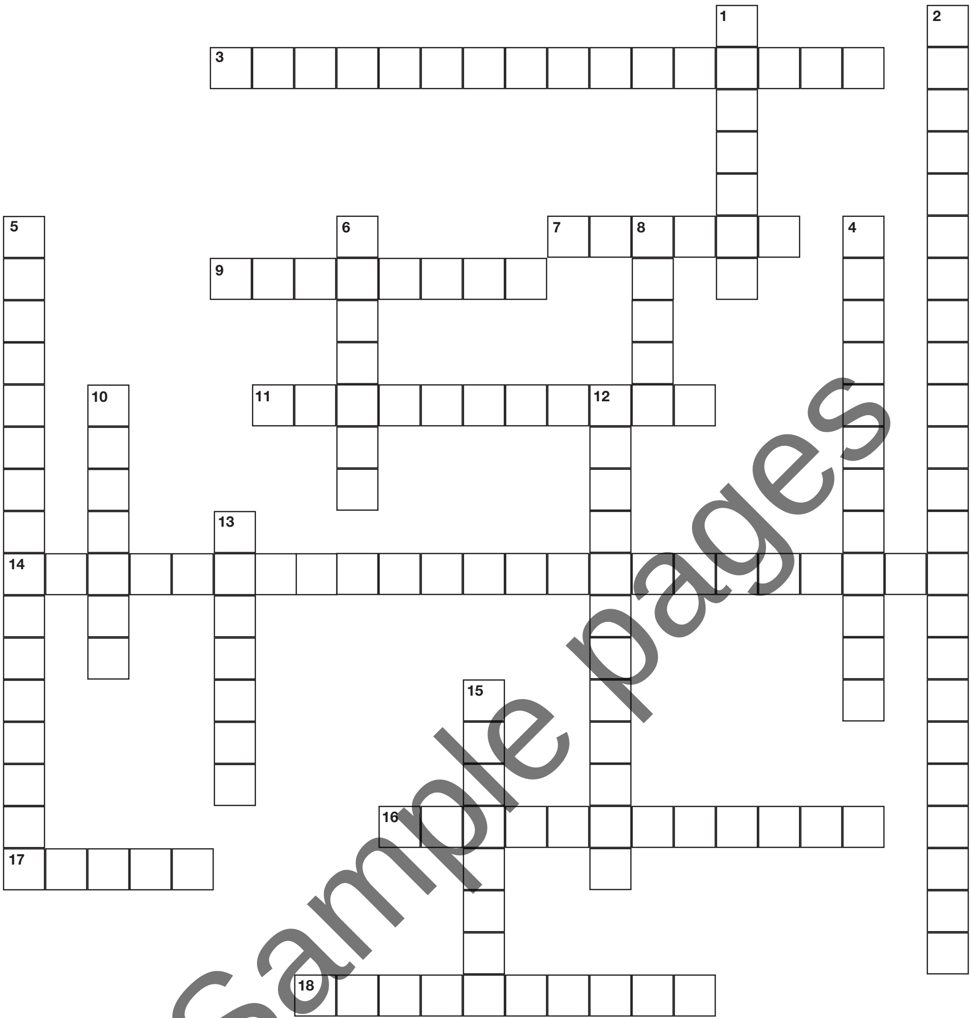
Table 1.8 Reactions that occur in the blast furnace

Reaction	Summary equation	Level in furnace
Coke reacts with heated air.	$C + O_2 \rightarrow CO_2$	Lower
More coke reacts with carbon dioxide to produce carbon monoxide.	$C + CO_2 \rightarrow 2CO$	Bottom
Carbon monoxide reacts with iron ore.	$3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$	Upper
Limestone breaks down to form calcium oxide and carbon dioxide.	$CaCO_3 \rightarrow CaO + CO_2$	Upper
Calcium oxide reacts with unwanted material in iron ore to produce slag.	$CaO + SiO_2 \rightarrow CaSiO_3$	Mid

WORKSHEET 1

Crossword—atomic theory

Complete the crossword to help you check your knowledge and understanding of key terms and processes in Chapter 1, *Heinemann Chemistry 1*, 5th edition.



Across

3 Minimum amount of energy required to remove an electron from an atom or ion, in gaseous state. (10, 6)

7 Positively charged particle located in the nucleus of an atom. (6)

9 Energy level within a shell. (8)

11 State of an atom or ion in which all electrons are at their lowest energy levels. (6, 5)

14 Arrangement of electrons into energy levels in an atom. (10, 13)

16 State of an atom or ion in which at least one electron has absorbed energy and is not at its lowest energy level. (7, 5)

17 Major energy level in an atom. (5)

18 Number of protons plus the number of neutrons in an atom. (4, 6)

Down

1 Neutral particle located in the nucleus of an atom. (7)

2 Principle that an atomic orbital can contain 0, 1 or 2 electrons. (5, 9, 9)

4 A type of particle that is 3.5×10^{-8} m in size. (12)

5 Model used to describe the behaviour of very small particles, such as electrons orbiting an atom. (7, 9)

6 An atom with the same atomic number as another atom, but different mass number. (7)

8 Path an electron takes as it moves around the nucleus. (5)

10 Very dense centre of an atom. (7)

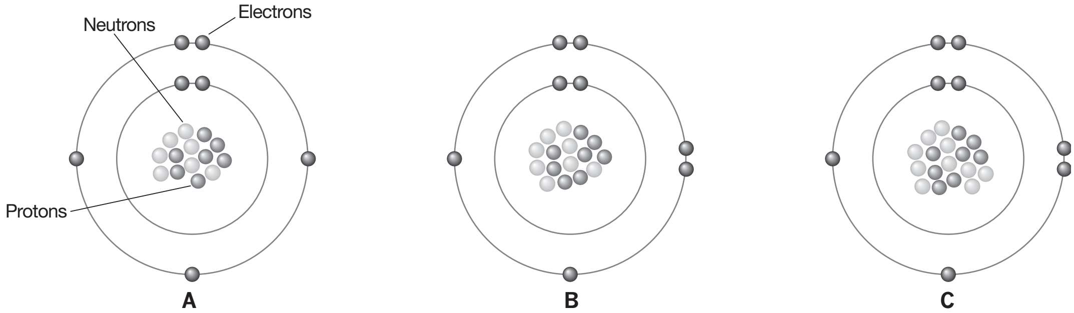
12 Number of protons in an atom. (6, 6)

13 Region in which electrons move. (7)

15 Negatively charged particle, which orbits the nucleus. (8)

Protons, neutrons and electrons—structure of the atom

Examine the atoms represented by these shell models.



1 Complete the information for each atom.

	Atom A	Atom B	Atom C
Atomic number			
Mass number			
Name of element			

2 **a** Which two atoms in Question 1 are isotopes? __________

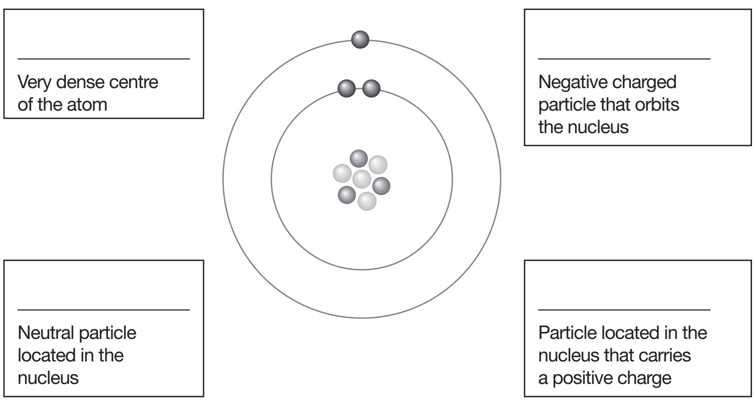
b Explain what makes them isotopes.

____

____

3 Read the following definitions. Write each term in the box corresponding to its definition. Draw a straight line from each definition to correctly label the model of the neutral atom depicted.

proton	neutron	electron	nucleus



WORKSHEET 3

Filling shells—electronic configuration

1 The order of orbital filling is represented in the table below. Fill in the number of electrons in each orbital for each element shown, remembering that:

- each orbital may hold a maximum of 2 electrons
- each orbital within a subshell will be filled with 1 electron before any orbitals are filled with their second electron.

Carbon has been done for you as an example.

Shell	Subshell	Orbital number	Carbon No. electrons = 6	Chlorine No. electrons =	Copper No. electrons =	Vanadium No. electrons =	Selenium No. electrons =
1	s	1	2				
2	s	1	2				
	p	1	1				
		2	1				
		3	0				
3	s	1	0				
	p	1	0				
		2	0				
		3	0				
4	s	1	0				
3	d	1	0				
		2	0				
		3	0				
		4	0				
		5	0				
4	p	1					
		2					
		3					

2 Write (i) the electronic configuration and (ii) the number of valence electrons for each element:

a carbon (i) ____________ (ii) ____________

b chlorine (i) ____________ (ii) ____________

c copper (i) ____________ (ii) ____________

d vanadium (i) ____________ (ii) ____________

e selenium (i) ____________ (ii) ____________

3 Examine the following electronic configurations, both for the element fluorine:

- species A $1s^2 2s^2 2p^5$
- species B $1s^2 2s^2 2p^6$

Which species, A or B, represents a neutral fluorine atom? ____________

WORKSHEET 4

Organising elements—the modern periodic table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H 1																	He 2
Li 3	Be 4											B 5	C 6	N 7	O 8	F 9	Ne 10
Na 11	Mg 12											Al 13	Si 14	P 15	S 16	Cl 17	Ar 18
K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35	Kr 36
Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Tc 43	Ru 44	Rh 45	Pd 46	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te 52	I 53	Xe 54
Cs 55	Ba 56	La 57	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	At 85	Rn 86
Fr 87	Ra 88	Ac 89	Rf 104	Db 105	Sg 106	Bh 107	Hs 108	Mt 109	Ds 110	Rg 111	Uub 112	Uut 113	Fl 114	Uup 115	Lv 116	Uus 117	Uuo 118
				Ce 58	Pr 59	Nd 60	Pm 61	Sm 62	Eu 63	Gd 64	Tb 65	Dy 66	Ho 67	Er 68	Tm 69	Yb 70	Lu 71
				Th 90	Pa 91	U 92	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102	Lr 103

1 Use different colours to shade and/or clearly label the s, p, d and f blocks, as well as period 4 and group 2.

2 Explain the information given by the label p-block.

___

3 List the symbols of the noble gases.

___

4 List the symbols of the actinides.

___

5 Refer to the periodic table to complete the following table.

Element	Symbol	Atomic number	No. occupied electron shells	No. electrons in outer shell
Carbon				
	K			
		27		
			4	7
	Cs			

WORKSHEET 5

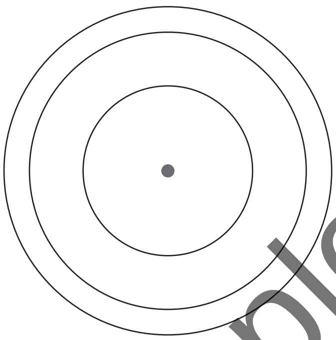
Tracking trends—patterns in properties in the periodic table

1 Consider the elements lithium and fluorine. They are both located in period ________. Lithium is in group ________ and fluorine is in group _________.

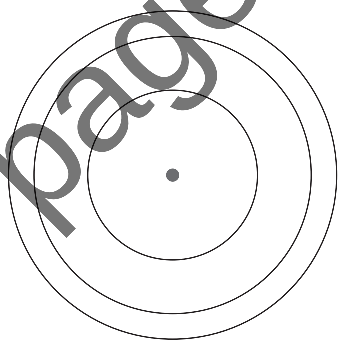
2 Consider the following properties of elements. Circle 'increases' or 'decreases' to describe the trend from left to right across the periodic table from lithium to fluorine.

Property	Trend
First ionisation energy	increases/decreases
Atomic size	increases/decreases
Chemical reactivity of metals	increases/decreases
Electronegativity	increases/decreases
Metallic character	increases/decreases

Number of protons: ____
Core charge: ____



Lithium atom



Fluorine atom

Number of protons: ____
Core charge: ____

3 Add electrons to the atom outlines to represent shell models of the lithium and fluorine atoms. Also write the number of protons in each nucleus and the core charge next to the atoms.

4 Describe the differences between the lithium and fluorine atoms.

____

____

____

5 Explain how these differences account for the different atomic sizes of lithium and fluorine.

____

____

____

6 Explain how these differences account for the different metallic characters of lithium and fluorine.

____

____

____

PRACTICAL ACTIVITY 1

Particle theory of matter

INTRODUCTION

The particle theory of matter can be used to explain how particles behave in our everyday lives.

PURPOSE

To consolidate an understanding of the particle theory of matter.

MATERIALS

- dark food colouring
- 100 mL beaker
- 250 mL beaker
- 10 mL measuring cylinder
- 2 × 100 mL measuring cylinders
- glass rods for stirring solution
- ethanol
- can of air freshener
- safety glasses

PRE-LAB SAFETY INFORMATION		
Material used	**Hazard**	**Control**
Food dye	Stains skin	Wear eye and skin protection
Ethanol	Highly flammable	Keep away from naked flame; use eye protection

Please indicate that you have understood the information in the safety table.

Name (print): ______________________________

I understand the safety information (signature): ______________________________

PROCEDURE

A MAKING AND DILUTING A COLOURED SOLUTION

1 Use a 10 mL measuring cylinder to measure out 5 mL of dark-coloured food dye. Place the food dye into a 100 mL beaker, add water to make the volume up to 100 mL and stir; take 10 mL of this solution and dilute again to 100 mL and stir. Repeat until the colour is no longer discernible.
Describe in Table 1.17 what happens during the activity and record how many dilutions were undertaken.

Table 1.17 Diluting a coloured solution

Dilution	Observations
5 mL of food dye up to 100 mL of new solution	
10 mL of previous solution up to 100 mL of new solution	
10 mL of previous solution up to 100 mL of new solution	
10 mL of previous solution up to 100 mL of new solution	
10 mL of previous solution up to 100 mL of new solution	
10 mL of previous solution up to 100 mL of new solution	
10 mL of previous solution up to 100 mL of new solution	
10 mL of previous solution up to 100 mL of new solution	

Number of dilutions required until colour is no longer discernible: ______________

B MIXING EQUAL VOLUMES OF WATER AND ETHANOL (TEACHER DEMONSTRATION ONLY)

Measure out 50 mL of water in a 100 mL measuring cylinder. Measure out 50 mL of ethanol in another 100 mL measuring cylinder. Add the ethanol to the water and record the total volume of the mixture in Table 1.18.

Table 1.18 Mixing water and ethanol

Solution	Volume (mL)
Water	
Ethanol	
Ethanol and water	

C USING AN AIR FRESHENER

A sample of air freshener should be sprayed from one corner of the classroom. Each student should record in Table 1.19 the time that elapses before each student detects the smell of the air freshener.

Table 1.19 Detecting the smell of an air freshener

Student	Time taken (s)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

DISCUSSION

1 Use the particle theory to explain what happens to the particles of the coloured food dye when they are mixed with water and diluted a number of times.

2 Explain, in terms of the particle theory of matter, the change in volume when ethanol and water are mixed.

3 Explain, in terms of the particle theory of matter, your observations of the spread of air freshener.

CONCLUSIONS

4 Describe evidence from these investigations that supports the hypothesis that 'all matter is composed of particles'.

5 Use your observations to describe the difference in particle movement in liquids and gases.

PRACTICAL ACTIVITY 2

Flame colours of selected metals

MATERIALS

- 100 mL of 2 M hydrochloric acid
- small quantities of sodium carbonate, potassium carbonate, calcium carbonate, barium carbonate, strontium carbonate and copper carbonate
- evaporating dish
- spatula
- Bunsen burner and heatproof mat
- safety glasses


INTRODUCTION

Ionic substances are composed of a mixture of metal and non-metal ions. Distinctive colours are obtained when certain metals or their salts are placed in a flame. Heating the metals in the flame gives the electrons in their atoms enough energy to move to higher energy levels. As the electrons return to lower energy levels they give off energy as a distinctive colour.

PURPOSE

To observe some characteristic flame colours of metal ions.

PRE-LAB SAFETY INFORMATION

Material used	Hazard	Control
2 M hydrochloric acid	Toxic by all routes of exposure; lung and skin irritant; corrosive	Wear eye and skin protection
Carbonates of sodium, potassium, calcium, strontium and copper	May cause irritation to skin; may be toxic by inhalation and ingestion	Wear eye and skin protection
Barium carbonate	Hazardous substance; toxic if ingested	Wear eye and skin protection

Please indicate that you have understood the information in the safety table.

Name (print): ______________________________

I understand the safety information (signature): ______________________________

PROCEDURE

1. Place the evaporating dish on the heatproof mat.
2. Use the spatula to transfer a small amount of one of the carbonates to the evaporating dish. Leave sodium carbonate until last because it can mask the other colours.
3. Add approximately 5 mL hydrochloric acid to the evaporating dish and direct the non-luminous (blue) flame of the Bunsen burner onto the area above the mixture, where bubbles of gas are being released.
4. Repeat for each carbonate, and record your observations in Table 1.20.

Table 1.20 Flame colours of different carbonates

Carbonate	Flame colour
Potassium carbonate	
Calcium carbonate	
Barium carbonate	
Strontium carbonate	
Copper carbonate	
Sodium carbonate	

PRACTICAL ACTIVITY 2

DISCUSSION

1 What causes the flame colour: the cation or the anion? How can you tell?

2 Why does each metal produce a distinctive flame colour?

CONCLUSION

3 Can you think of any limitations of using a flame test to determine which metal ions are present in an unknown compound?