PEARSON

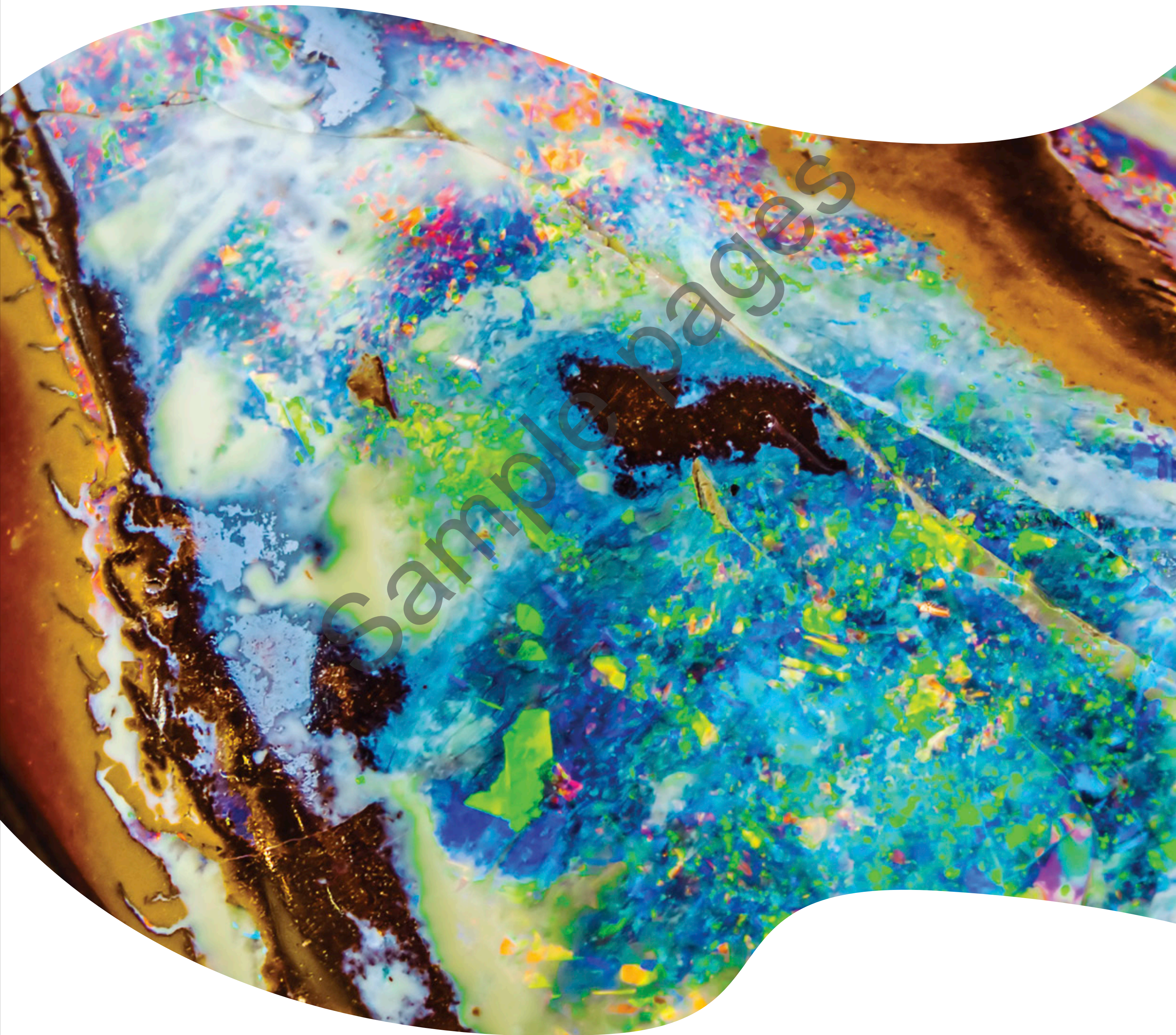
CHEMISTRY

QUEENSLAND

SKILLS AND ASSESSMENT

11

UNITS 1 & 2



QCE 2019 SYLLABUS

Elissa Huddart

Contents

Pearson Chemistry 11 QLD Skills and Assessment book

Contents

How to use this book

The *Pearson Chemistry 11 Queensland Skills and Assessment Book* takes an intuitive, self-paced approach to science education that ensures every student has opportunities to practise, apply and extend their learning through a range of supportive and challenging activities.

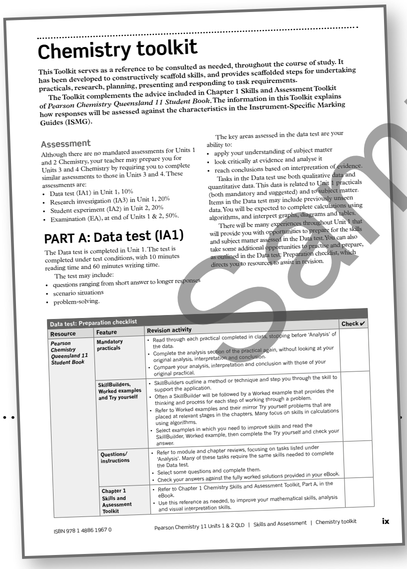
This resource has been developed by highly experienced and expert author teams, with lead Queensland specialists who have a working understanding of what teachers are looking for to support teaching and learning across the new Queensland Certificate of Education (QCE).

Fully written to the new QCE Year 11 & 12 Syllabus, the skills and assessment Book is organised by units and topics, and the **unit opener** outlines the unit objectives that are addressed. The Skills and Assessment Book is further organised into topics. Each **topic** addresses all of the subject matter and mandatory practicals, from the Syllabus.

All activities integrate into the Pearson *Chemistry 11 Units 1 & 2 Queensland Student Book* for a complete teaching, learning and assessment program, making integration of practice and rich learning activities a seamless inclusion. The resource has been designed so it can be used independently of the Student Book, providing flexibility in when and how the Skills and Assessment Book is engaged with.

TOOLKIT

A complementary Toolkit supports development of the skills and techniques needed to undertake Practical investigations, the Data test, Student experiment and Research investigation, and also study skills. It also includes checklists and helpful hints to assist in fulfilling all assessment requirements.



Chemistry toolkit

This Toolkit serves as a reference to be consulted as needed, throughout the course of study. It has been developed to constructively scaffold skills, and provides scaffolded steps for undertaking practicals, research, planning, presenting and responding to task requirements.

The Toolkit complements the advice included in Chapter 1 Skills and Assessment Toolkit of *Pearson Chemistry Queensland 11 Student Book*. The information in this Toolkit explains how responses will be assessed against the characteristics in the Instrument-Specific Marking Guides (ISMG).

Assessment

Although there are no mandated assessments for Units 1 and 2 Chemistry, your teacher may prepare you for Units 3 and 4 Chemistry by requiring you to complete similar assessments to those in Units 3 and 4. These assessments are:

- Data test (IA1) in Unit 1, 10%
- Research investigation (IA3) in Unit 1, 20%
- Student experiment (IA2) in Unit 2, 20%
- Examination (EA), at end of Units 1 & 2, 50%.

PART A: Data test (IA1)

The Data test is completed in Unit 1. The test is completed under test conditions, with 10 minutes reading time and 60 minutes writing time.

The test may include:

- questions ranging from short answer to longer responses
- scenario situations
- problem-solving.

The key areas assessed in the data test are your ability to:

- apply your understanding of subject matter
- look critically at evidence and analyse it
- reach conclusions based on interpretation of evidence.

Tasks in the Data test use both qualitative data and quantitative data. This data is related to Unit 1 practicals (both mandatory and suggested) and to subject matter. Items in the Data test may include previously unseen data. You will be expected to complete calculations using algorithms, and interpret graphs, diagrams and tables.

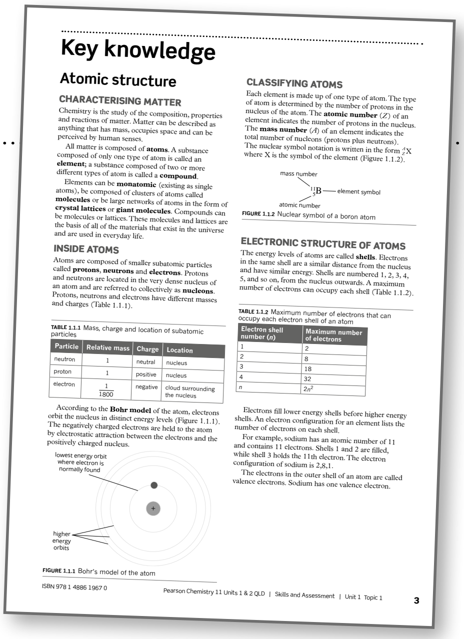
There will be many experiences throughout Unit 1 that will provide you with opportunities to prepare for the skills and subject matter assessed in the Data test. You can also take some additional opportunities to practise and prepare, as outlined in the Data test: Preparation checklist, which directs you to resources to assist in revision.

Data test: Preparation checklist			
Resource	**Feature**	**Revision activity**	**Check ✔**
Pearson Chemistry Queensland 11 Student Book	**Mandatory practicals**	• Read through each practical completed in class, stopping before 'Analysis' of the data. • Complete the analysis section of the practical again, without looking at your original analysis, interpretation and conclusion. • Compare your analysis, interpretation and conclusion with those of your original practical.	
	SkillBuilders, Worked examples and Try yourself	• SkillBuilders outline a method or technique and step you through the skill to support the application. • Often a SkillBuilder will be followed by a Worked example that provides the thinking and process for each step of working through a problem. • Refer to Worked examples and their mirror Try yourself problems that are placed at relevant stages in the chapters. Many focus on skills in calculations using algorithms. • Select examples in which you need to improve skills and read the SkillBuilder, Worked example, then complete the Try yourself and check your answer.	
	Questions/ instructions	• Refer to module and chapter reviews, focusing on tasks listed under 'Analysis'. Many of these tasks require the same skills needed to complete the Data test. • Select some questions and complete them. • Check your answers against the fully worked solutions provided in your eBook.	
	Chapter 1 Skills and Assessment Toolkit	• Refer to Chapter 1 Chemistry Skills and Assessment Toolkit, Part A, in the eBook. • Use this reference as needed, to improve your mathematical skills, analysis and visual interpretation skills.	

ISBN 978 1 4886 1967 0 Pearson Chemistry 11 Units 1 & 2 QLD | Skills and Assessment | Chemistry toolkit ix

KEY KNOWLEDGE

Each topic begins with a key knowledge section. Key knowledge consists of a set of succinct summary notes that cover the subject matter for each topic of the Syllabus. This section is highly illustrative and written in a straightforward style to assist students of all abilities in focusing on the salient points. Key terms are bolded for ease of navigation and are reflected in the Student Book glossary. The key knowledge also serves as a ready reference when completing worksheets and practical activities, and provides a handy set of revision and study notes.



Key knowledge

Atomic structure

CHARACTERISING MATTER

Chemistry is the study of the composition, properties and reactions of matter. Matter can be described as anything that has mass, occupies space and can be perceived by human senses.

All matter is composed of **atoms**. A substance composed of only one type of atom is called an **element**; a substance composed of two or more different types of atom is called a **compound**.

Elements can be **monatomic** (existing as single atoms), be composed of clusters of atoms called **molecules** or be large networks of atoms in the form of **crystal lattices** or **giant molecules**. Compounds can be molecules or lattices. These molecules and lattices are the basis of all of the materials that exist in the universe and are used in everyday life.

INSIDE ATOMS

Atoms are composed of smaller subatomic particles called **protons**, **neutrons** and **electrons**. Protons and neutrons are located in the very dense nucleus of an atom and are referred to collectively as **nucleons**. Protons, neutrons and electrons have different masses and charges (Table 1.1.1).

TABLE 1.1.1 Mass, charge and location of subatomic particles

Particle	Relative mass	Charge	Location
neutron	1	neutral	nucleus
proton	1	positive	nucleus
electron	$\frac{1}{1800}$	negative	cloud surrounding the nucleus

According to the **Bohr model** of the atom, electrons orbit the nucleus in distinct energy levels (Figure 1.1.1). The negatively charged electrons are held to the atom by electrostatic attraction between the electrons and the positively charged nucleus.

FIGURE 1.1.1 Bohr's model of the atom

CLASSIFYING ATOMS

Each element is made up of one type of atom. The type of atom is determined by the number of protons in the nucleus of the atom. The **atomic number** (Z) of an element indicates the number of protons in the nucleus. The **mass number** (A) of an element indicates the total number of nucleons (protons plus neutrons). The nuclear symbol notation is written in the form ${}^{A}_{Z}X$ where X is the symbol of the element (Figure 1.1.2).

FIGURE 1.1.2 Nuclear symbol of a boron atom

ELECTRONIC STRUCTURE OF ATOMS

The energy levels of atoms are called **shells**. Electrons in the same shell are a similar distance from the nucleus and have similar energy. Shells are numbered 1, 2, 3, 4, 5, and so on, from the nucleus outwards. A maximum number of electrons can occupy each shell (Table 1.1.2).

TABLE 1.1.2 Maximum number of electrons that can occupy each electron shell of an atom

Electron shell number (n)	Maximum number of electrons
1	2
2	8
3	18
4	32
n	$2n^2$

Electrons fill lower energy shells before higher energy shells. An electron configuration for an element lists the number of electrons on each shell.

For example, sodium has an atomic number of 11 and contains 11 electrons. Shells 1 and 2 are filled, while shell 3 holds the 11th electron. The electron configuration of sodium is 2,8,1.

The electrons in the outer shell of an atom are called valence electrons. Sodium has one valence electron.

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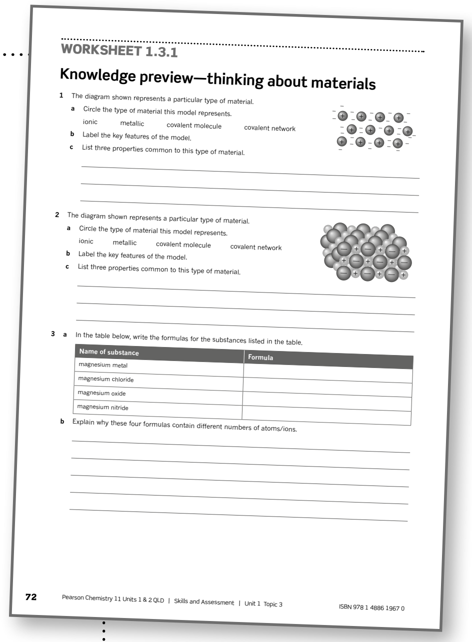
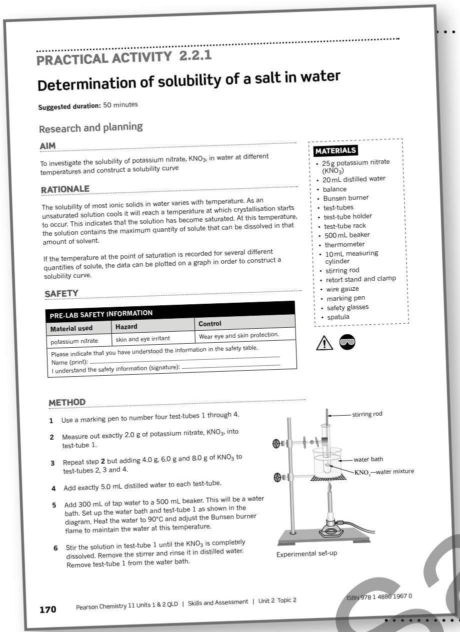
WORKSHEETS

A diverse offering of instructive and self-contained worksheets is included in each topic. Common to all topics are the initial 'Knowledge preview' worksheets to activate prior knowledge; a 'Literacy review' worksheet to explicitly build language and application of scientific terminology; and finally, a 'Thinking about my learning' worksheet, which encourages students to reflect on their learning and identify areas for improvement. Other worksheets, with their range of activities and tasks, focus on application of subject matter to assist in the consolidation of learning and the making of connections between subject matter.

Worksheets may be used as formative assessment and are clearly aligned to the Syllabus. A range of questions building from foundation to challenging are included in the worksheets, which are written to reflect the Marzano and Kendall taxonomy instructional verbs.


WORKSHEET 1.3.1

Knowledge preview—thinking about materials


PRACTICAL ACTIVITY 2.2.1

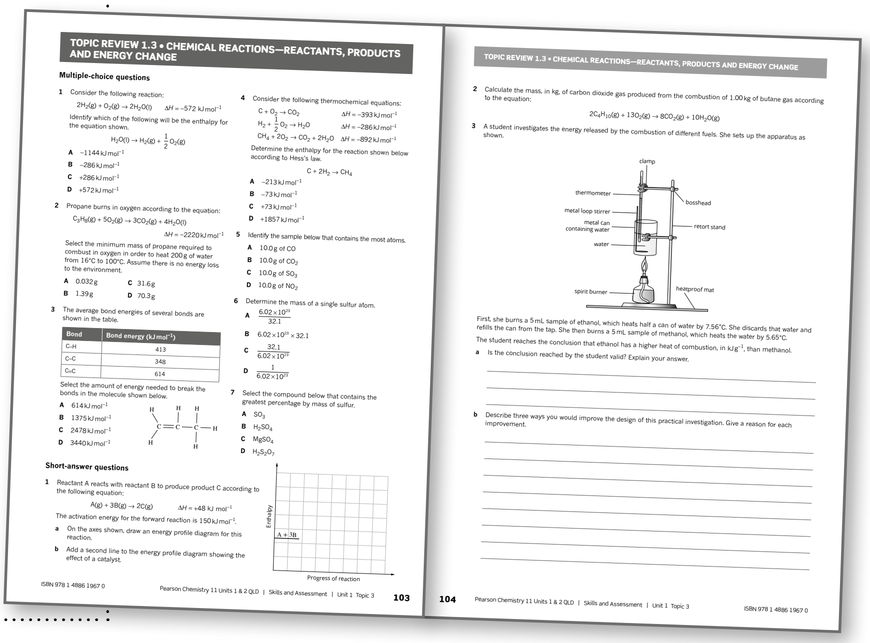
Determination of solubility of a salt in water

PRACTICAL ACTIVITIES

Practical activities take a highly scaffolded approach from beginning to completion and give students the opportunity to complete practical work related to the subject matter covered in the Syllabus. Practical activities include a rich assortment of tasks that maximise the learning opportunities and build experience in skill application to perform calculations and analysis of data, which are necessary for the Data test. Every mandatory practical is featured, as well as many suggested practicals. Like the worksheets, a range of questions building from foundation to challenging are included, which are written to reflect the Marzano and Kendall taxonomy instructional verbs.

TOPIC REVIEW QUESTIONS

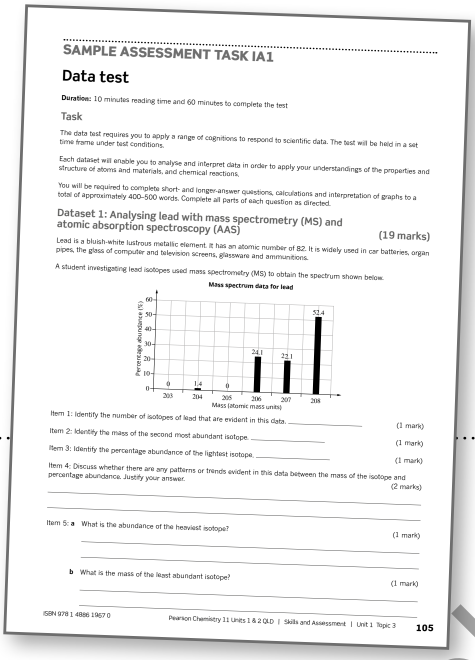
Each topic concludes with a comprehensive set of question items consisting of multiple-choice and short-answer responses written in an exam style. This provides students with exposure to and the opportunity to practise drawing together subject matter and skills to respond to, examination-style assessment.


TOPIC REVIEW 1.3 • CHEMICAL REACTIONS—REACTANTS, PRODUCTS AND ENERGY CHANGE

ISBN 978 1 4886 1967 0

SAMPLE ASSESSMENT TASKS

Sample assessment tasks for the **Data Test**, **Student experiment** and **Research investigation** provide opportunities for students to practise responding to these assessment tasks. The activities are designed to support students by guiding and scaffolding them through each aspect of these assessments.



SAMPLE ASSESSMENT TASK IA1

Data test

Duration: 10 minutes reading time and 60 minutes to complete the test

Task

The data test requires you to apply a range of cognitions to respond to scientific data. The test will be held in a set time frame under test conditions.

Each dataset will enable you to analyse and interpret data in order to apply your understandings of the properties and structure of atoms and materials, and chemical reactions.

You will be required to complete short- and longer-answer questions, calculations and interpretation of graphs to a total of approximately 400–500 words. Complete all parts of each question as directed.

Dataset 1: Analysing lead with mass spectrometry (MS) and atomic absorption spectroscopy (AAS) (19 marks)

Lead is a bluish-white lustrous metallic element. It has an atomic number of 82. It is widely used in car batteries, organ pipes, the glass of computer and television screens, glassware and ammunitions.

A student investigating lead isotopes used mass spectrometry (MS) to obtain the spectrum shown below.

Item 1: Identify the number of isotopes of lead that are evident in this data. ______ (1 mark)

Item 2: Identify the mass of the second most abundant isotope. ______ (1 mark)

Item 3: Identify the percentage abundance of the lightest isotope. ______ (1 mark)

Item 4: Discuss whether there are any patterns or trends evident in this data between the mass of the isotope and percentage abundance. Justify your answer. (2 marks)

Item 5: **a** What is the abundance of the heaviest isotope? (1 mark)

b What is the mass of the least abundant isotope? (1 mark)

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ICONS AND FEATURES

Every Mandatory practical is supported by a complementary SPARKlab alternative practical.

The *Pearson Chemistry Skills and Assessment Book* icons in the Student Book indicate the best time to engage with an activity from the Skills and Assessment Book. Use the activities for practise, application and revision of subject matter.

The type of activity is indicated by the following icons in the Student Book:

Worksheet (WS) — WS 1.2.1

Mandatory practical (MP) — MP 1

Practical activity (PA) — PA 1.2.1

Topic review (TR) — TR 1.1

Sample assessment task (SAT). — SAT 1A2

The **safety icon** highlights significant hazards, indicating caution is needed.

The **safety glasses icon** highlights that protective eyewear is to be worn during the practical activity.

RATE MY LEARNING

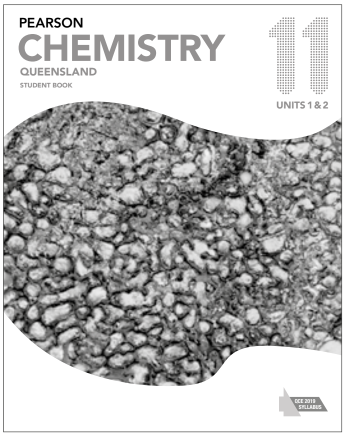
This innovative feature appears at the end of most worksheets, all practical activities and sample assessment tasks. It provides students with the opportunity for self-reflection and self-assessment. Students are encouraged to consider how they can continue to improve, and identify areas of focus for further skill and subject matter development. This tool has been based on the Marzano and Kendall taxonomy.

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

Teacher support

Fully worked solutions, suggested answers and responses to sample assessment tasks, as well as practical activity support including full **risk assessments**, **expected results** and **handy hints**, are provided for teachers through the teacher support subscription.

Series overview

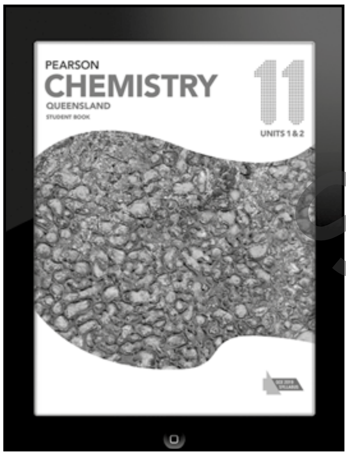


Student Book

Pearson Chemistry 11 Units 1 & 2 Queensland has been developed by experienced Queensland teachers to address all the requirements of the new QCE Chemistry 2019 Syllabus. The series features the very latest developments and applications of chemistry, literacy and instructional design to ensure the content and concepts are fully accessible to all students.

Skills and Assessment Book

The *Pearson Chemistry 11 Skills and Assessment Book* gives students the edge in preparing for all forms of assessment. Specifically prepared to provide opportunities to consolidate, develop and apply subject matter and science inquiry skills, this resource features a toolkit, key knowledge summaries, worksheets, practical activities and guidance, assessment practice and exam-style topic review question sets.



Reader+ the next generation eBook

Pearson Reader+ lets you use your Student Book online or offline, anywhere and anytime, on any device. Pearson Reader+ retains the look and integrity of the printed book.

Teacher Support

Pearson Chemistry 11 Units 1 & 2 Queensland Teacher Support provides:

- complete answers, fully worked solutions or suggested answers to all *Student Book and Skills and Assessment Book* tasks
- mandatory practical expected results, common mistakes, suggested answers and full safety notes and risk assessments
- teaching, learning and assessment programs

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UNIT 1 Chemical fundamentals—structure, properties and reactions

TOPIC 1 Properties and structure of atoms

TOPIC 2 Properties and structure of materials

TOPIC 3 Chemical reactions—reactants, products and energy change

Unit 1 objectives

Students will:

- describe and explain the properties and structure of atoms and materials, and chemical reactions in terms of reactants, products and energy change
- apply understanding of the properties and structure of atoms and materials, and chemical reactions in terms of reactants, products and energy change
- analyse evidence about the properties and structure of atoms and materials, and chemical reactions in terms of reactants, products and energy
- interpret evidence about the properties and structure of atoms and materials, and chemical reactions in terms of reactants, products and energy change
- investigate phenomena associated with properties and structure of atoms and materials, and chemical reactions in terms of reactants, products and energy change
- evaluate processes, claims and conclusions about the properties and structure of atoms and materials, and chemical reactions in terms of reactants, products and energy change
- communicate understandings, findings, arguments and conclusions about the properties and structure of atoms and materials, and chemical reactions in terms of reactants, products and energy change.

TOPIC 1

Properties and structure of atoms

- ☐ Worksheet 1.1.1 Knowledge preview—thinking about matter

PERIODIC TABLE AND TRENDS

- ☐ Worksheet 1.1.3 Tracking trends—patterns in properties in the periodic table
- ☐ Practical activity 1.1.3 Investigating periodic trends, patterns and relationships—data analysis

ATOMIC STRUCTURE

- ☐ Worksheet 1.1.2 Shells, subshells and orbitals—electron configuration
- ☐ Worksheet 1.1.3 Tracking trends—patterns in properties in the periodic table
- ☐ Practical activity 1.1.2 Simulating Rutherford's gold foil experiment

INTRODUCTION TO BONDING

- ☐ Worksheet 1.1.4 The inside story on salts—formation of ions and writing ionic formulas
- ☐ Worksheet 1.1.5 Water, methane and oxygen gas—making molecules

ISOTOPES

- ☐ Worksheet 1.1.6 How big is that atom?—mass spectrometry

ANALYTICAL TECHNIQUES

- ☐ Worksheet 1.1.6 How big is that atom?—mass spectrometry
- ☐ Worksheet 1.1.7 Using light for analysis—atomic absorption spectroscopy
- ☐ Practical activity 1.1.1 Flame colours of selected metals

- ☐ Worksheet 1.1.8 Literacy review—comparing similar terms
- ☐ Worksheet 1.1.9 Thinking about my learning
- ☐ **Topic review 1.1**

 ISBN 978 1 4886 1967 0

Key knowledge

Atomic structure

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Particle	Relative mass	Charge	Location
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electron	$\frac{1}{1800}$	negative	cloud surrounding the nucleus

According to the **Bohr model** of the atom, electrons orbit the nucleus in distinct energy levels (Figure 1.1.1). The negatively charged electrons are held to the atom by electrostatic attraction between the electrons and the positively charged nucleus.

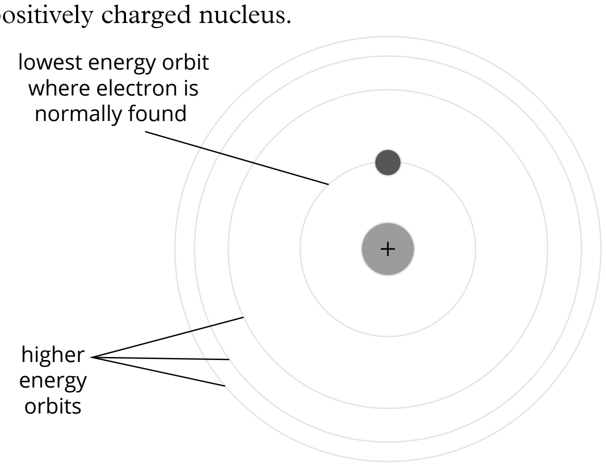


FIGURE 1.1.1 Bohr's model of the atom

CLASSIFYING ATOMS

Each element is made up of one type of atom. The type of atom is determined by the number of protons in the nucleus of the atom. The **atomic number** (Z) of an element indicates the number of protons in the nucleus. The **mass number** (A) of an element indicates the total number of nucleons (protons plus neutrons). The nuclear symbol notation is written in the form $^{A}_{Z}X$ where X is the symbol of the element (Figure 1.1.2).

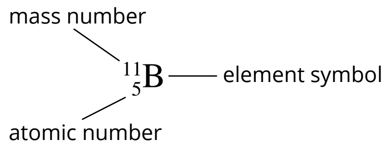


FIGURE 1.1.2 Nuclear symbol of a boron atom

ELECTRONIC STRUCTURE OF ATOMS

The energy levels of atoms are called **shells**. Electrons in the same shell are a similar distance from the nucleus and have similar energy. Shells are numbered 1, 2, 3, 4, 5, and so on, from the nucleus outwards. A maximum number of electrons can occupy each shell (Table 1.1.2).

TABLE 1.1.2 Maximum number of electrons that can occupy each electron shell of an atom

Electron shell number (*n*)	Maximum number of electrons
1	2
2	8
3	18
4	32
n	$2n^2$

Electrons fill lower energy shells before higher energy shells. An electron configuration for an element lists the number of electrons on each shell.

For example, sodium has an atomic number of 11 and contains 11 electrons. Shells 1 and 2 are filled, while shell 3 holds the 11th electron. The electron configuration of sodium is 2,8,1.

The electrons in the outer shell of an atom are called valence electrons. Sodium has one valence electron.

QUANTUM MECHANICAL MODEL OF THE ATOM

Erwin Schrödinger proposed a new model of the atom using quantum mechanics. His model proposed that electrons should be regarded as having wave-like properties. According to his model, electrons are not restricted to a specific orbit but behave as negative clouds of charge found in regions of space called **orbitals** (Figure 1.1.3).

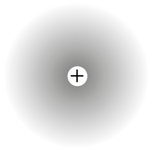


FIGURE 1.1.3 Electron cloud around a nucleus

Electrons make up most of the volume of an atom. The 'negative clouds' of electrons are organised into orbitals in subshells within shells (Table 1.1.3).

TABLE 1.1.3 Different levels of organisation of electrons

Level of organisation	Definition	Label
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 two 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. This is known as the **Aufbau principle**. However, some subshells are higher in energy than subshells of the next shell (Figure 1.1.4).

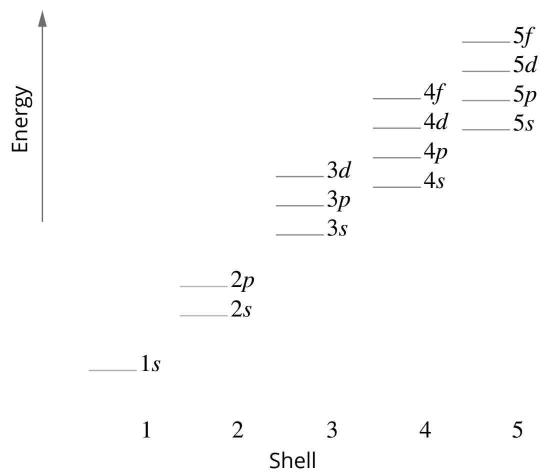


FIGURE 1.1.4 Energy levels in an atom

For instance, the unfilled 3*d* subshell is higher in energy than the unfilled 4*s*-subshell. Therefore, the 4*s* subshell is filled before the 3*d*.

The electron configurations of lithium, nitrogen, potassium and nickel using the quantum mechanical model are shown in Table 1.1.4.

TABLE 1.1.4 Electron configurations of some elements using the quantum mechanical model

Element	Atomic number	Electron 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	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

Chromium and copper are exceptions to the usual order of filling. In these cases there is increased stability in having a half or completely full *d*-subshell, so an electron from the 4*s*-subshell is promoted to a 3*d*-orbital. Their electron 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 occupy the shell furthest from the nucleus. The valence electrons determine an element's chemical properties. Atoms lose or gain the valence electrons to form **ions**.

Condensed electron configuration

Condensed electron configuration is an abbreviated version of the full configuration. The symbol of the noble gas, enclosed in square brackets, is used in the electron configuration to represent the inner-shell electrons. Only the valence electrons are shown in their shells or subshells.

Orbital diagrams

Orbital diagrams represent individual electrons in the orbitals of an atom. Electrons have **spin** that can be characterised as being in either the up or down direction. The pair of electrons in a single orbital must have opposite spin (Figure 1.1.5).

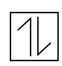
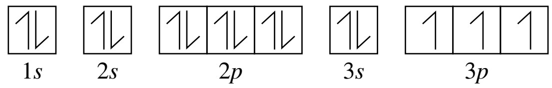
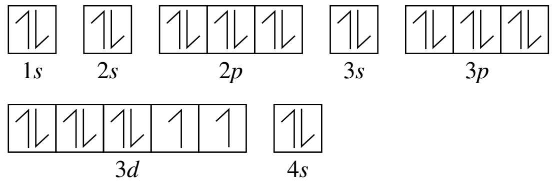


FIGURE 1.1.5 Diagrammatic representation of a pair of electrons in an orbital. The arrows show the opposite spin.

Hund's rule states that every orbital in a subshell must contain a single electron before any orbital contains two electrons. The first electron in each orbital is always written with an upward spin as shown in Table 1.1.5 on the following page.

ISBN 978 1 4886 1967 0

TABLE 1.1.5 Different types of electron configurations and orbital representations

Element	Electron configuration	Electron configuration using quantum mechanical model	Condensed electron configuration using quantum mechanical model	Orbital diagram
$^{31}_{15}P$	2,8,5	$1s^22s^22p^63s^23p^3$	$[Ne]3s^23p^3$	
$^{59}_{28}Ni$	2,8,16,2	$1s^22s^22p^63s^23p^63d^84s^2$	$[Ar]3d^84s^2$	

Isotopes

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** (Figure 1.1.6).

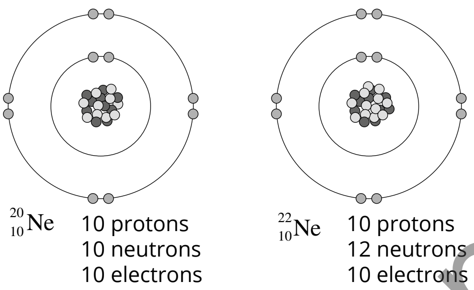


FIGURE 1.1.6 Isotopes of neon

The isotopes in Figure 1.1.6 are represented by the symbols ^{20}Ne and ^{22}Ne or 20-Ne and 22-Ne. Isotopes have the same number of electrons, and therefore the same electron configuration, which gives them identical chemical properties.

The physical properties of isotopes differ because the different number of neutrons changes the mass of the atom and the nuclear structure. Properties, such as density, thermal conductivity, viscosity and the existence of radioactivity, can all differ between isotopes.

MASSES OF PARTICLES

Masses used in chemistry are *relative* masses. They are relative to the standard of the common isotope **carbon-12** (^{12}C) being given a mass of exactly 12 units. Two of the masses chemists use for different elements are:

- **relative isotopic mass (I_r)**, which is the relative mass of each individual isotope of an element. Isotopes have different masses because of their different numbers of neutrons.
- **relative atomic mass** (A_r), which is the weighted average of the relative masses of the naturally occurring isotopes of a particular element. The relative atomic mass of each element is included in the periodic table.

Periodic table and trends

ELEMENTS AND 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. All 118 known elements are listed on the table in order of increasing atomic number, and elements that share chemical properties are grouped together. A full version of the periodic table can be found on page 6.

The modern periodic table has the following features.

- Each box of the periodic table contains one element and information about it (Figure 1.1.7).
- Horizontal rows are called **periods**. Periods are numbered 1–7.
- Vertical columns are called **groups**. Groups are numbered 1–18. Elements in the same group have similar chemical properties. Some groups in the periodic table have particular names. Some examples are given in Table 1.1.6.

TABLE 1.1.6 Names of some different groups in the periodic table

Group number	Name
1	alkali metals
2	alkaline earth metals
17	halogens
18	noble gases

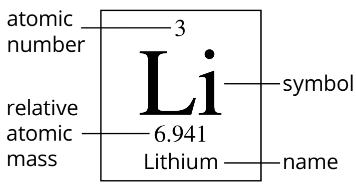


FIGURE 1.1.7 Periodic table information for lithium. Different periodic tables may contain different information.

Metals, non-metals and metalloids

The elements in the periodic table can be described as metals, non-metals or metalloids (Table 1.1.7). Metallic elements and non-metallic elements share properties.

Knowing the location of an element on the periodic table (Figure 1.1.8) can allow the prediction of some of its physical properties.

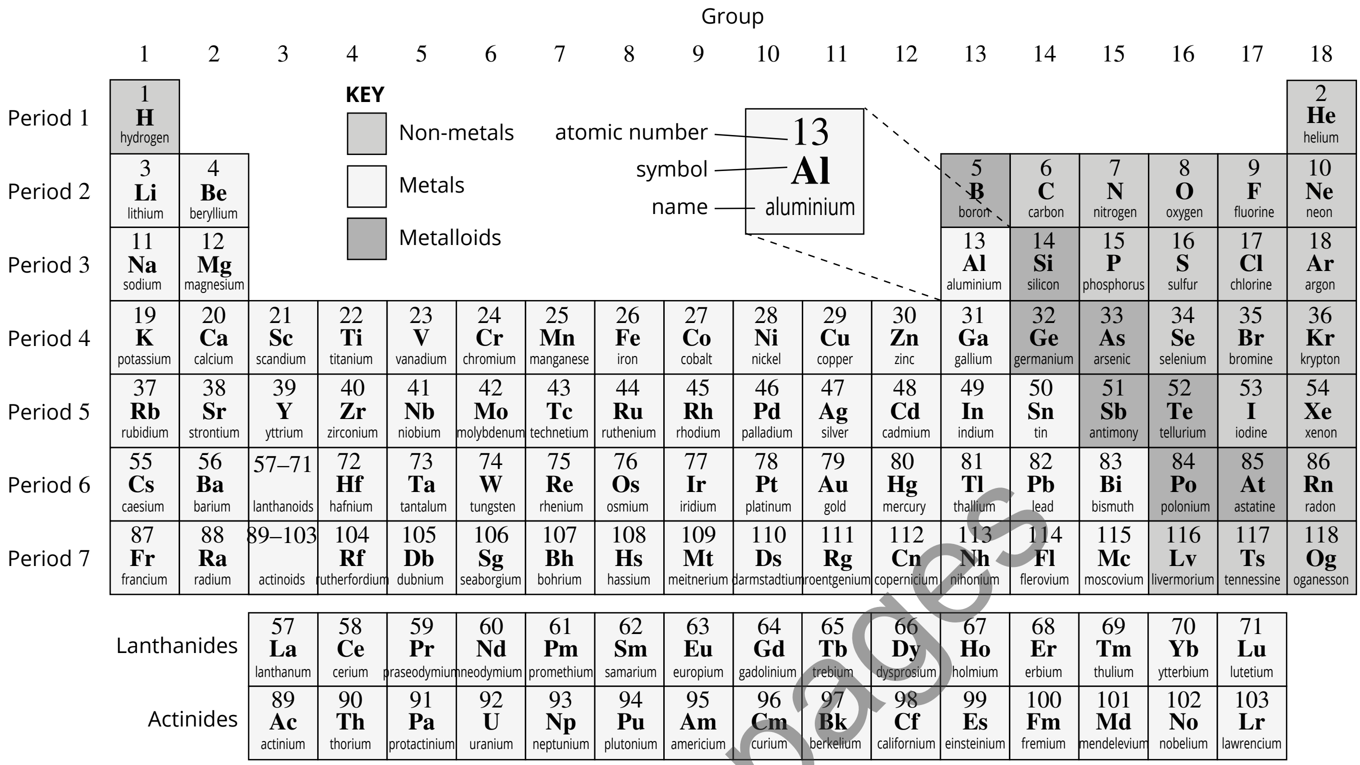


FIGURE 1.1.8 Elements are classified as metals, non-metals or metalloids in the periodic table.

TABLE 1.1.7 Typical properties of metals, metalloids and non-metals

Metals	Metalloids	Non-metals
• lustrous (shiny) • malleable • ductile (can be drawn into a wire) • silvery colour • dense • high melting and boiling points • good conductors of electricity • good conductors of heat	Metalloids have some metallic and some non-metallic properties.	• dull • not malleable • not ductile • not dense • lower melting and boiling points than metals • poor conductors of electricity • poor conductors of heat

In addition to being classified as metals or non-metals, elements are placed in specific groups (columns) in the periodic table. In general, elements in the same group have similar physical and chemical properties (Table 1.1.8).

TABLE 1.1.8 Properties of elements in some groups of the periodic table

Group number	Elements in the group	Physical and chemical properties shared by elements in that group
1 (alkali metals)	lithium (Li), sodium (Na), potassium (K), rubidium (Rb), caesium (Cs), francium (Fr)	low melting and boiling points, soft, low density, highly reactive
17 (halogens)	fluorine (F), chlorine (Cl), bromine (Br), iodine (I)	coloured, highly reactive gases

Based on its position in the periodic table, an element can be predicted to have the general properties of either a metal or a non-metal. It will have even more properties in common with those of elements within the same group.

ELECTRON CONFIGURATION AND THE PERIODIC TABLE

In terms of electron configuration, the periodic table has the following features.

- Elements in the same period of the periodic table have the same number of occupied electron shells.
- Elements in the same group have the same outer-shell electron configuration so the same number of valence electrons.

The periodic table is arranged into four large blocks based on the level of the last subshell being filled in the electron configuration of the element (Table 1.1.9) on the following page.

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TABLE 1.1.9 *s*-, *p*-, *d*- and *f*-blocks in the periodic table

Block	Part of periodic table	Shell being filled
s	groups 1 and 2	*s*-subshell
p	groups 13–18	*p*-subshell
d	transition metals, groups 3–12	*d*-subshell
f	lanthanides and actinides	*f*-subshell

TRENDS IN THE PERIODIC TABLE

Trends in properties observed in the periodic table (Table 1.1.10) are a reflection of changing numbers of protons and electrons.

- Going down a group, the number of occupied electron shells increases by one each row, so atomic radius is increasing. Valence electrons become further from the nucleus and there is an increased **shielding effect**. This makes the valence electrons less tightly held, meaning they are more easily removed.
- Going across a period, the **effective nuclear charge** of successive elements increases by one each element (effective nuclear charge = no. protons – no. inner-shell electrons). As the effective nuclear charge increases, the valence electrons experience a greater attraction to the nucleus and are held more tightly. They become more difficult to remove.

TABLE 1.1.10 Trends in the periodic table

Property	What it indicates	Trend going down a group	Trend going from left to right across a period
electron configuration	number of electrons in each shell (Bohr) or subshell (Schrödinger) written in order of increasing energy	The number of occupied shells increases.	The number of valence electrons increases.
effective nuclear charge	effective nuclear charge = no. protons – no. inner-shell electrons	The effective nuclear charge does not change.	Effective nuclear charge increases.
valency	charge on an ion of the atom due to electrons lost or gained	The valency does not change.	Groups 1, 2 and 13 have valencies of +1, +2 and +3 respectively. Groups 15, 16 and 17 have valencies of –3, –2 and –1 respectively. Elements in groups 14 and 18 do not form ions.
atomic radius	radius of an atom	Atomic radius increases.	Atomic radius decreases.
ionic radius	radius of an atom's ion	Ionic radius increases.	Ionic radius decreases then increases.
first ionisation energy	minimum amount of energy required to remove the highest energy electron from an atom or ion	First ionisation energy decreases.	First ionisation energy increases.
electronegativity	ability of an atom to attract shared electrons in a molecule	Electronegativity decreases.	Electronegativity increases.

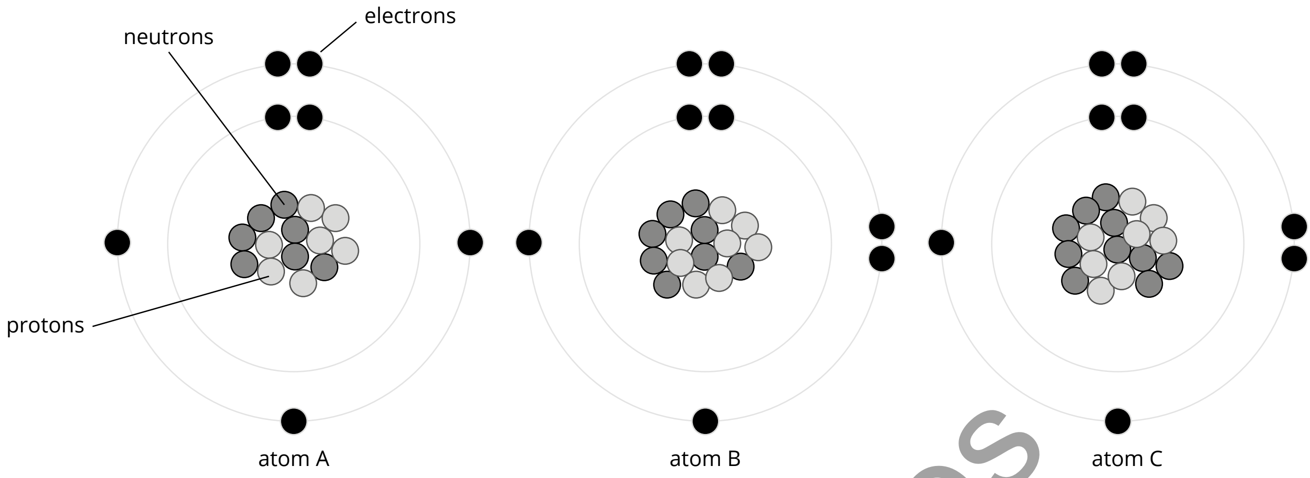
Reactivity of metals and non-metals

The more readily a metal loses its electrons, the more reactive it will be. Going down group 1, the alkali metals become more reactive as increasing shielding means the electrostatic attraction between valence electrons and the nucleus decreases. Going across a period, the reactivity of metals decreases as the increasing effective nuclear charge means valence electrons are held more tightly.

The reactivity of a non-metal is based on how readily the atom can gain electrons. Going down group 17, the halogens become less reactive as the valence shell becomes further from the nucleus and therefore less able to attract electrons. Going across a period, the reactivity of non-metals increases as there is a greater effective nuclear charge to attract electrons.

Knowledge preview—thinking about matter

Examine the three 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 Three types of subatomic particles are labelled in atom A.

a Identify the subatomic particle that has a negative charge. __________

b Identify the subatomic particle that has a positive charge. __________

c Identify the two subatomic particles that are assigned a mass of 1. __________

3 The diagrams above are representations of the structure of atoms. Describe two limitations of these diagrams.

4 When a chemical reaction occurs, the atoms in the reactants are rearranged to become the products. Identify each statement below about chemical reactions as true or false.

Statement about chemical reactions	True or False
Mass is always conserved in a chemical reaction.	
The rate of a chemical reaction will change with changes in temperature.	
The total mass of the products may be slightly less or greater than the starting mass of the reactants.	
The number of protons in a particular atom might change during a chemical reaction.	
If there are six carbon atoms in the reactants of a chemical reaction, there must also be six carbon atoms in the products.	

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WORKSHEET 1.1.2

Shells, subshells and orbitals—electron configuration

1 The order of subshell filling in the quantum mechanical model is represented in the table. Fill in the number of electrons in each subshell for each element shown. Carbon has been completed as an example.

Shell	Subshell	Carbon (no. electrons = 6)	Chlorine (no. electrons = ________)	Copper (no. electrons = ________)	Vanadium (no. electrons = ________)	Selenium (no. electrons = ________)
1	*s*	2				
2	*s*	2				
	p	2				
3	*s*	0				
	p	0				
4	*s*	0				
3	*d*	0				
4	*p*	0				

2 Complete the following table for each element.

Element	Electron configuration using shells	Full electron configuration using *spdf* notation	Condensed electron configuration using *spdf* notation	Number of valence electrons for each element
carbon				
chlorine				
copper				
vanadium				
selenium				

3 Complete the orbital diagrams for the following elements.

a carbon

1*s* 2*s* 2*p* 3*s* 3*p* 3*d* 4*s*

b copper

1*s* 2*s* 2*p* 3*s* 3*p* 3*d* 4*s*

c selenium

1*s* 2*s* 2*p* 3*s* 3*p* 3*d* 4*s* 4*p*

4 Questions **1–3** required you to apply the Aufbau principle, Hund's rule and the Pauli exclusion principle. Outline how each of these principles contributes to the way you placed electrons and provide an example of each.

a Aufbau principle

b Hund's rule

c Pauli exclusion principle

5 Examine the following *spdf* notations for the element sodium.

species A: $1s^2 2s^2 2p^6 3s^1$

species B: $1s^2 2s^2 2p^6 3p^1$

Identify which species, A or B, represents an excited sodium atom. ______

Explain your answer.

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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WORKSHEET 1.1.3

Tracking trends—patterns in properties in the periodic table

1 Consider the elements lithium and fluorine and fill in the gaps to complete the sentences correctly.

Lithium and fluorine 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 a period on the periodic table from lithium to fluorine.

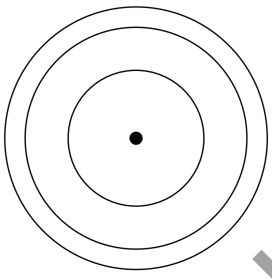
Property	**Trend**
a atomic radius	increases/decreases
b ionic radius	increases/decreases
c first ionisation energy	increases/decreases
d electronegativity	increases/decreases

3 Add electrons to the atom outlines to represent Bohr models of the lithium and fluorine atoms. Then write the number of protons in each nucleus and the effective nuclear charge next to the atoms. Also write an electron configuration using *spdf* notation.

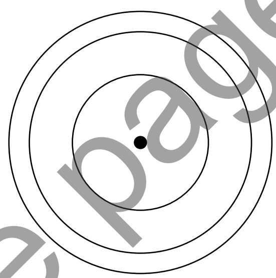
number of protons: ___

effective nuclear charge: ___

electron configuration: ______



lithium atom



fluorine atom

number of protons: ___

effective nuclear charge: ___

electron configuration: ______

4 Referring to the diagrams you have drawn, list any differences between the lithium and fluorine atoms.

____

____

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

____

____

6 Explain how these differences account for the different first ionisation energies of lithium and fluorine.

____

____

7 The metallic character of an element is an indication of how many properties of a metal the element has. The more metallic elements tend to lose their valence electrons more easily. Predict the trend for metallic character of the elements from top to bottom of a group. Give a reason for your answer.

____

____

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

The inside story on salts—formation of ions and writing ionic formulas

1 Natural spring water contains a number of different dissolved ions. The following table shows a typical mineral analysis from the label of a bottle of spring water.

Ion	Concentration (mg L^{-1})
sodium	11
chloride	20
calcium	1
magnesium	4.7
potassium	0.5
sulfate	80

Complete the table for the listed ions.

Ion	Number of valence electrons in a neutral atom	Number of electrons lost or gained to form an ion	Charge on ion	Symbol of ion	Anion or cation?
sodium					
chloride					
calcium					
magnesium					
potassium					

2 With reference to electron configurations, explain the following statements.

a Sodium and chlorine atoms form ions with opposite charges.

b The sodium ion has a charge of +1 and the magnesium ion has a charge of +2.

3 List the chemical formulas of all possible compounds that could be formed using the ions listed for the mineral water.

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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PRACTICAL ACTIVITY 1.1.1

Flame colours of selected metals

Suggested duration: 20 minutes

Research and planning

AIM

To observe some characteristic flame colours of metal ions and use the results to identify an unknown metal ion in solution

RATIONALE

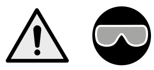
Distinctive colours are obtained when certain metals or their salts are heated in a flame. Heating metals in a flame gives the electrons in their atoms enough energy to move to higher energy levels. As the electrons return to lower energy levels, they give off energy as a distinctive colour. Observing the colour produced by an unknown metal in a flame may allow the metal to be identified.

SAFETY

PRE-LAB SAFETY INFORMATION		
Material used	**Hazard**	**Control**
chlorides of 0.1 M sodium, potassium, calcium, strontium and copper solutions	skin irritant; may be toxic by inhalation and ingestion	Wear safety glasses and a laboratory coat.
0.1 M barium chloride	hazardous substance; toxic if ingested	Wear safety glasses and a laboratory coat.
Please indicate that you have understood the information in the safety table. Name (print): ______ I understand the safety information (signature): ______		

MATERIALS

- 100 mL spray bottles of each of the following 0.1 M solutions:
  - potassium chloride
  - calcium chloride
  - barium chloride
  - lithium chloride
  - strontium chloride
  - copper(II) chloride
  - sodium chloride
- 100 mL spray bottle containing a solution of an unknown metal chloride
- matches
- Bunsen burner and heatproof mat
- safety glasses



METHOD

1 Make sure that the room is as dark as possible before starting this experiment.

2 Select a spray bottle of one of the metal solutions and, holding the bottle approximately 10 cm from the top of the barrel of the Bunsen burner, spray a mist upwards into the Bunsen burner flame at a 45° angle.

3 Repeat this process for each of the seven solutions. Record the flame colours in Table 1.

4 Collect a spray bottle for the unknown solution and spray the solution in the Bunsen burner flame. Record the colour in Table 1.

VARIABLES

i Identify the independent variable: ______

ii Identify the dependent variable: ______

iii Identify any controlled variables: ______

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Analysing

RAW DATA

1 Record your observations in Table 1.

TABLE 1 Flame colours of different metal chlorides

Carbonate	Flame colour
potassium chloride	
calcium chloride	
barium chloride	
strontium chloride	
copper chloride	
sodium chloride	
lithium chloride	
unknown solution	

ANALYSIS

2 Explain which causes flame colour: the cation or the anion. Justify your answer.

3 Explain, in terms of the movement of electrons, why light is produced by these metals when they are heated in the Bunsen burner flame. Draw a labelled diagram as part of your answer.

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4 Describe why each metal produces a different flame colour.

5 Identify which metal ion solution you think was in the bottle labelled 'unknown'. Describe the evidence you have used to make this choice.

6 Some metals, such as magnesium and beryllium, do not produce a coloured flame when their solutions are sprayed into a Bunsen burner flame. Considering the energy of the electrons in these metals, explain why this might be the case.

7 Identify at least two limitations of using a flame test to determine which metal ions are present in an unknown compound.

Interpreting and communicating

CONCLUSION

1 State your conclusion, including reference to specific evidence collected that leads to this conclusion. Ensure your conclusion relates directly back to the aim.

EVALUATION

2 Identify any errors that might have occurred as you conducted this experiment. How might they have affected the results?

IMPROVEMENTS AND EXTENSIONS

3 If you were to repeat this experiment, identify how you could change the method in order to improve the results. Explain your answer.

4 Propose an extension to this experiment that would allow you to further investigate the aim of this experiment or a related aim.

RATE MY LEARNING	• I get it. • I can apply/teach it.	• I get it. • I can show I get it.	• I almost get it. • I might need help.	• I get some of it. • I need help.	• I don't get it. • I need lots of help.

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