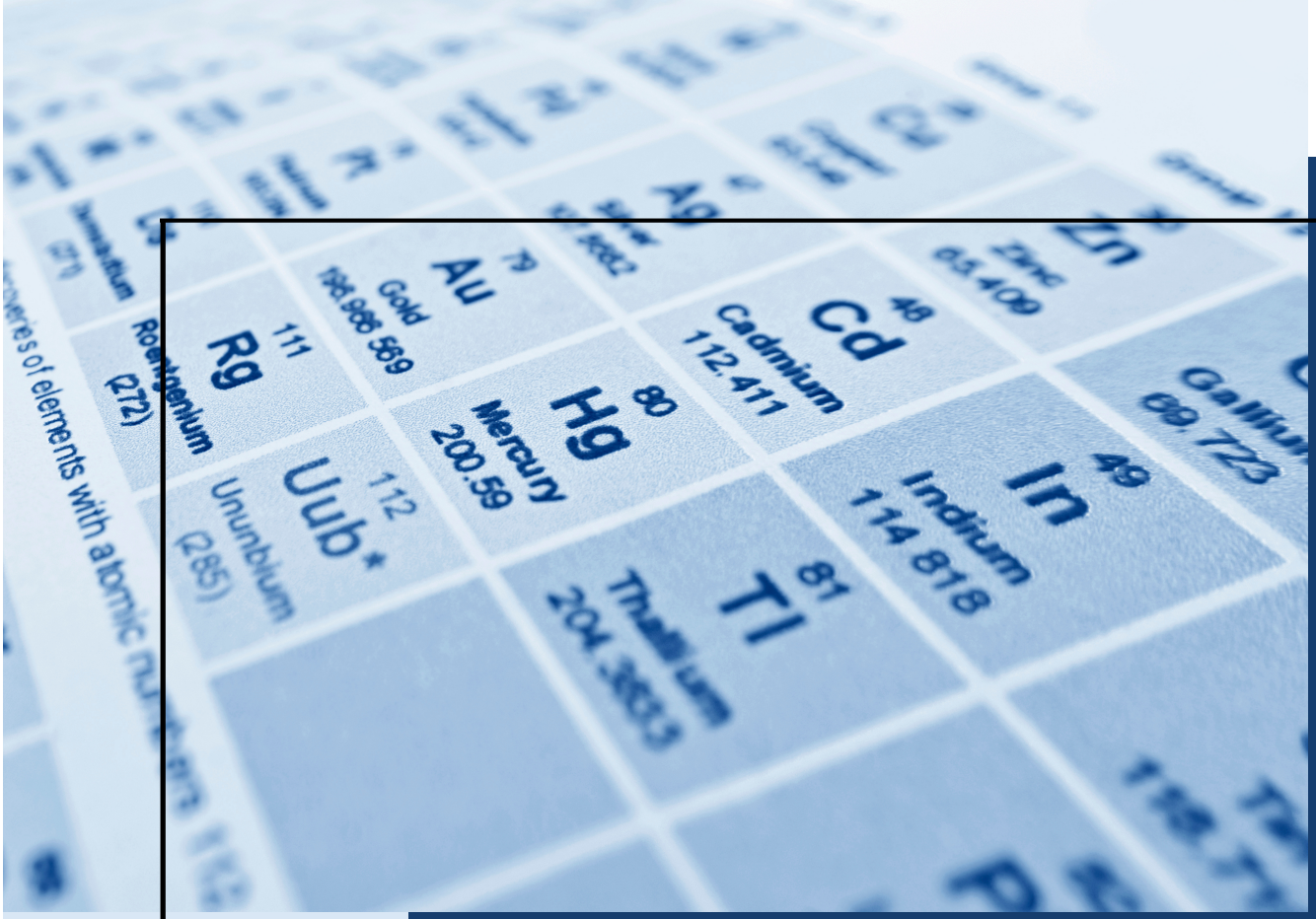


Unit Preparation Booklet

C3.1 The Periodic Table

Teacher name:

Science
Mastery

Ark**Curriculum+**

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Steps to Success

		What?	Why?	Who?	Page #
Preparing to teach	**1**	☐ Print this booklet or save a copy in a personal folder	To allow for engagement during planning and co-planning	*All teachers*	
	2	☐ Engage with the unit preparation checklist	To prepare for delivering the sequence of lessons	*All teachers*	4
	3	☐ Read the scope and sequence for the unit	To review the scope and sequence of the unit	*All teachers*	5
	4	☐ Complete the pre-unit quiz reflections task after administering to class	To plan how to remedy prior knowledge gaps	*New to teaching the unit only*	11
	6	☐ Complete the Mastery Quiz and exam-style questions activity	To learn/revisit the key assessment objectives of the unit	*New to teaching the unit only*	12-19
	7	☐ Complete the misconception activities	To develop a strong understanding of the most common misconceptions for the unit and how to address them	*New to teaching the unit only*	20-23
Delivering the unit	**8**	☐ Use the lesson-by-lesson objectives to monitor progression through the unit	To maintain a record of completion and to recognise what needs to be reviewed after each lesson	*Novice teachers only*	24-38
Utilise other features of the booklet	**9**	☐ Complete the advanced subject knowledge activity	To develop an understanding of where the unit can lead	*Non A-level specialists*	39
	10	☐ Engage in the keywords and new scientists for the unit	To identify the correct definitions for keywords throughout the unit	*Novice teachers only*	40-43

Unit preparation checklist

Resources can and should be tailored to meet your pupils' needs. We have aimed to do as much resourcing as possible so that teachers' time can be spent on co-planning and preparation; however, they are only ready for your pupils once you have decided how to make use of them.

Here is a suggested checklist:

Locate:

- ☐ **Find** the unit resources using MyMastery or SharePoint

Engage:

- ☐ Work through the preparation booklet. Complete the pre-unit quiz and mastery quiz yourself and reflect (all enclosed)
- ☐ Set your class the **pre-unit quiz** (in advance of the unit).
- ☐ Note which topics are **areas of weakness** for the class (space available in this booklet or on the planning pro-forma)
- ☐ **Decide** which topics you will re-visit 'in advance' and which to tackle during the unit (space available in this booklet or on the planning pro-forma)
- ☐ Identify where in the sequence of learning there are opportunities for embedding **guided reading**
- ☐ Use the **lesson planning guidance** to develop a grasp of the purpose of each lesson element

Adapt:

- ☐ Consider key timings for each lesson. Identify which lessons may need to be adapted to account for the length of your lessons or ability level of your class
- ☐ Identify what could be used as **homework** activities to support in-class learning in line with school policy
- ☐ Review the resources ahead of each lesson and ensure you are clear on the objectives of each lesson
- ☐ **Select** appropriate activities for each lesson from the selection within each lesson folder/on the slide deck
- ☐ **Administer** exit tickets and use outcomes of this to plan 'fix-it' tasks to tackle misunderstanding or misconception.
- ☐ Set the **mastery quiz** for your class. Use the information to plan a suitable re-teach lesson and further response, using the resources available.

Scope and Sequence

Scope

In this unit, pupils will develop their knowledge of atomic structure. They will learn about the nuclear model of the atom, as well as the development of our understanding of the atom, with an overview of some of the key discoveries and scientists that have paved the way so far. Important here also is that pupils understand that our knowledge of the atom is still evolving now. As part of the learning about the atomic structure, pupils will be introduced to isotopes and the term 'relative atomic mass'. Pupils will study the structure of the periodic table and the distinct properties of some of the groups within it, as well as the link between those properties and the electronic configurations of the elements. Finally pupils will look at the history of the periodic table and the contribution of Mendeleev.

This unit falls under the big idea 'Structure Determines Properties'. Upon completion of this unit, pupils will be able to relate the atomic structure of an element to its chemical properties.

Sequence

Prior to this unit, pupils will have an understanding of the fundamentals of matter and be able to distinguish between atoms, elements, compounds and mixtures. They will be able to use the particle model to explain the properties of solids, liquids and gases and be able to explain the difference between physical changes and chemical changes. They will have a basic understanding of the arrangement of the Periodic Table and be able to use chemical symbols and formulae. They will have an understanding of conservation of mass and be able to use this idea to explain why equations must be balanced.

This unit begins with a foundation of understanding atomic structure as we understand it today. Pupils will look at the various ways we can represent the atom and the sub-atomic particles within, including electronic configuration. From here, pupils are introduced to isotopes, building on their knowledge of atomic structure to show that not all atoms of the same element are exactly the same. Pupils are then taken on a journey looking at the history of our understanding of the atom and how this understanding has developed with the aid of ground-breaking experiments and scientists. Finally, this understanding of atoms is placed within the context of the periodic table. Pupils will look at the different groups within the table and how they behave, linking this back to the atomic structure of each group. The big idea here 'Structure Determines Properties' is key – pupils must have a good understanding of the structure of the atoms before being able to link that to their properties – which is the goal of the lessons on the groups of the periodic table. Finally, pupils will explore some of the history of the periodic table and the contribution of Mendeleev.

A good understanding of the ideas discussed in this unit will be pivotal to an understanding of chemical bonding and the formation of compounds. Pupils will build on their electronic configuration diagrams to represent ionic and covalent bonding and the resulting compounds. Pupils will also build further on periodicity at A-Level, understanding more about atomic structure and patterns in the Periodic Table. Pupils likely to pursue a Higher Tier route at GCSE will also need to be secure in their writing and balancing of chemical equations to enable them to access all aspects of quantitative chemistry.

The skills introduced in this unit, especially the use of standard form and making order of magnitude calculations, will give pupils vital tools to be able to interpret very large and very small numbers, and therefore quantify on large or small scales. This is something that will be invaluable across all areas of science study, from the measurement of tiny atoms and sub-

cellular structures to huge distances across space.

A full set of knowledge objectives for this unit can be found as **Appendix 5.**

1	**2**	**3**	**4**
Prior Knowledge Review	Maths in Science Lesson 15: Standard form	Maths in Science Lesson 16: Orders of magnitude	Atoms
5	**6**	**7**	**8**
Electronic Configuration	Isotopes	Understanding the Atom	The Periodic Table
9	**10**	**11**	**12**
The Noble Gases	The Alkali Metals	The Halogens	Reactions of the Halogens
13	**14**		
The Transition Elements (Chemistry Only)	Feedback lesson		

TASKS:

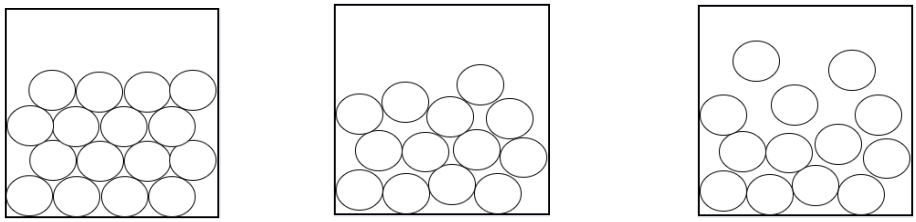
New teachers: Organise the lesson titles into those you feel most to least confident about *Experienced teachers:* Reflect on prior experience of teaching this unit. Which lessons have gone well? Which would you like to target for improvement this year?

Pre-unit quiz

TASK: Below is the pre-unit quiz available for your pupils. Complete yourself and set for your pupils ahead of starting the unit. There is space to record the key outcomes from marking the quiz for your class. **See Appendix 1 for the mark scheme.**

1. Which diagram best represents the arrangement of particles in a liquid? [1]

   Tick (✓) **one** box.



(a) ☐ (b) ☐ (c) ☐

2. When a student cools water enough, it becomes a colourless solid. Do the particles change? Choose the best answer. [1]

   Tick (✓) **one** box.

   (a) Yes, liquid particles turn into solid particles ☐

   (b) Yes, water particles turn into ice particles ☐

   (c) No, they are the same particles of water ☐

3. Which of the following are all examples of elements? [1]

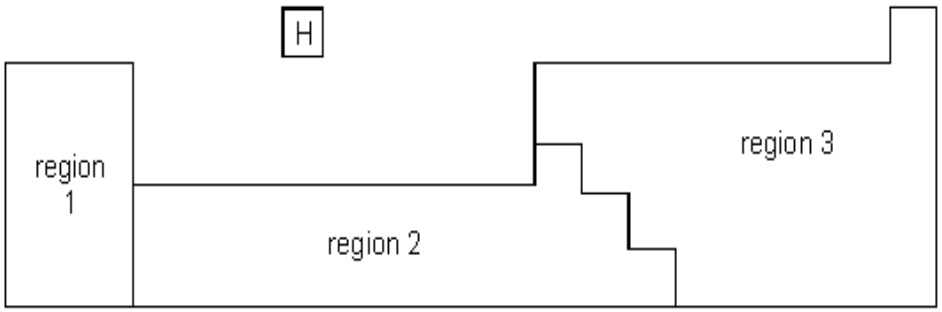
   Tick (✓) **one** box.

   (a) Oxygen, carbon and nitrogen ☐

   (b) Water, potassium and carbon dioxide ☐

   (c) Alcohol, sugar and cellulose ☐

4. The Periodic Table lists all the known elements.



In which region of the Periodic Table are unreactive metals (such as gold and silver) found?

[1]

Tick (✓) **one** box.

(a) Region 1 ☐

(b) Region 2 ☐

(c) Region 3 ☐

5. The Periodic Table is organised into groups and periods. Which shows the correct group and period of Lithium? [1]

Tick (✓) **one** box.

(a) Group 1, Period 1 ☐

(b) Group 1, Period 2 ☐

(c) Group 2, Period 1 ☐

6. What compound would be formed when copper reacts with oxygen? [1]

Tick (✓) **one** box.

(a) Copper oxygen ☐

(b) Oxygen copperide ☐

(c) Copper oxide ☐

7. A chemical formula gives the symbols for each element in the compound and the number of atoms of each element. The formula for phosphoric acid is H_3PO_4. How many atoms of each element are present? [1]

Tick (✓) **one** box.

(a) 3 hydrogen atoms, 1 phosphorus atom and 4 oxygen atoms ☐

(b) 1 hydrogen atom, 3 phosphorus atoms and 4 oxygen atoms ☐

(c) 3 hydrogen atoms, 4 phosphorus atoms and 4 oxygen atoms ☐

8. A small piece of metal burns in air to produce a bright white flame. What is the piece of metal reacting with? [1]

Tick (✓) **one** box.

(a) Air ☐

(b) Fire ☐

(c) Oxygen ☐

9. Which of the following equations is an example of an acid and alkali/base neutralisation reaction? [1]

Tick (✓) **one** box.

(a) Magnesium oxide + hydrochloric acid → magnesium chloride + water ☐

(b) Magnesium carbonate + hydrochloric acid → magnesium chloride + water ☐

(c) Magnesium + hydrochloric acid → magnesium chloride + water ☐

10. Match each equation a – d with the correct products from the box. Write only one number for each word equation. Numbers can be used once, more than once or not at all.

[1]

1. Zinc chloride + water + hydrogen 2. Zinc chloride + water + carbon dioxide 3. Zinc chloride + carbon dioxide 4. Zinc chloride + water 5. Zinc chloride + hydrogen

(a) Zinc carbonate + hydrochloric acid → ☐

(b) Zinc + hydrochloric acid → ☐

(c) Zinc hydroxide + hydrochloric acid → ☐

(d) Zinc oxide + hydrochloric acid →

Total = ___ /10

Pre-unit quiz reflections

To be completed once you have reviewed your pupils' response to the pre-unit quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout the unit?

Other notes

Mastery Quiz

TASK: Below is the mastery quiz available for your pupils to sit at the end of the unit. Complete yourself and consider the key misconceptions this quiz aims to address. See **Appendix 2** for the mark scheme.

Section A

You can use your periodic table during this quiz.

1. Choose which describes a property of alkali metals. [1]

   Tick (✓) **one** box.

   A. Unreactive ☐

   B. Very high melting point ☐

   C. Soft ☐

2. The radius of a nucleus is …[1]

   Tick (✓) **one** box.

   A. over 10 000 times smaller than the radius of an atom. ☐

   B. 100 times smaller than the radius of an atom. ☐

   C. approximately half the radius of an atom. ☐

3. Choose the product of the following chemical reaction.[1]

   Lithium + fluorine ⟶

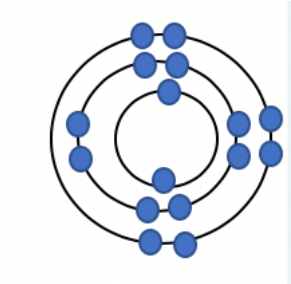
   Tick (✓) **one** box.

   A. Lithium fluorate ☐

   B. Lithium fluoride ☐

   C. Lithium fluorine ☐

4. Choose which element is represented by the following electronic configuration. [1]



Tick (✓) **one** box.

A. Phosphorous ☐

B. Oxygen ☐

C. Sulfur ☐

5. Choose the greatest number. [1]

Tick (✓) **one** box.

A. 1 kV (kilovolt) ☐

B. 1 GV (gigavolt) ☐

C. 1 mV (millivolt) ☐

6. The current model of the atom is different to previous models.

The current model … [1]

Tick (✓) **one** box.

A. is proven correct. If new evidence is discovered, then this won't change the current model. ☐

B. may not be the most accurate. If new evidence is discovered then the model will be improved. ☐

C. will never change because we know everything about atoms. ☐

7. Choose the number that is the same as **3 x 10^4**. [1]

Tick (✓) **one** box.

A. 0.3000 ☐

B. 0.0003 ☐

C. 30000 ☐

D. 3000 ☐

8. Choose the correct electronic configuration of a sodium atom

The atomic number of sodium is 11. [1]

Tick (✓) **one** box.

A. 2,8,1 ☐

B. 2,9 ☐

C. 4,7 ☐

9. Choose the reactants that would result in a displacement reaction. [1]

Tick (✓) **one** box.

A. Fluorine + sodium fluoride ☐

B. Chlorine + sodium bromide ☐

C. Iodine + sodium bromide ☐

10. Choose the best explanation for why noble gases are unreactive. [1]

Tick (✓) **one** box.

A. They all have 8 electrons in their outer shell ☐

B. They have a stable electron arrangement ☐

C. They are neutral because they have equal numbers of protons and electrons ☐

11. Choose the definition of an **isotope**. [1]

Tick (✓) **one** box.

A. Atoms of the same element that have gained or lost electrons ☐

B. Atoms of the same element that have different numbers of neutrons ☐

C. Atoms with the same mass number but different atomic numbers ☐

12. Choose the best explanation for how the periodic table got its name. [1]

Tick (✓) **one** box.

A. Because the rows are called periods ☐

B. Because similar properties occur at regular intervals ☐

C. Because elements are arranged by atomic number ☐

13. Choose how Mendeleev's periodic table was different to the modern periodic table we use today. [1]

Tick (✓) **one** box.

A. Mendeleev didn't use groups and periods like the modern periodic table ☐

B. Mendeleev arranged the elements by atomic weight rather than atomic number ☐

C. Mendeleev had to leave gaps where some elements hadn't been discovered yet ☐

14. Choose the best explanation for why the relative atomic mass of chlorine is 35.5.

Chlorine has an atomic number of 17. [1]

Tick (✓) **one** box.

A. There is a greater abundance of chlorine-18 than chlorine-20 ☐

B. It has 35.5 neutrons in its nucleus ☐

C. It has 17 protons and 18.5 neutrons in its nucleus ☐

15. Choose the correct statement comparing chromium and sodium. [1]

Tick (✓) **one** box.

A. Both chromium and sodium react with water ☐

B. Both chromium and sodium produce ions with difference charges ☐

C. Chromium produces coloured compounds but sodium does not ☐

15

Section B

1. Complete this table:

Subatomic particle	Relative charge	Relative mass
Proton		
Neutron		
Electron		

2. Write out the word and balanced symbol equation for the reaction of sodium and water.
Word equation:

_____

Balanced symbol equation:

_____

3. State how the melting and boiling points of the halogens change going down the group and explain why.

_____

_____

_____

4. The plum pudding model of the atom was replaced by the nuclear model.

The nuclear model was developed after the alpha particle scattering experiment.

Compare the plum pudding model with the nuclear model of the atom.

_____

_____

_____

_____

_____

_____

Mastery quiz reflections

Which aspects of this unit are likely to be the most challenging to teach?	
What are your pupils likely to find most challenging and why?	
Challenging.....	Because....
E.g. The relative atomic mass of Chlorine is 35.5	*This requires an understanding of isotopes as well as the use of a range of mathematical skills*
How can you pre-empt some of the key misconceptions the mastery quiz aims to identify?	
Misconception	**How to avoid**

Exam-style questions

TASK: Using exampro (or the software used by your exam board), look through the typical exam-style questions for this topic. These sorts of questions are posed throughout the unit and pupils should be prepared to answer similar questions in the end-of-year assessments.

Suggested questions to guide this process:

How is knowledge from this unit typically assessed? What are the most common questions?
Which question types are the most challenging?
What general trends can you spot in the typical errors pupils make (from examiner reports/notes)?
How could you help prepare your students for answering these types of questions?

Common mistakes, errors and misconceptions

How would you tackle the following common mistakes, errors and misconceptions by pupils?

TASK: Consider why each of the following typically seen statements is a mistake/misconception. What possible approaches can you plan to pre-empt and respond to this? Which lessons do these correlate to?

CHALLENGE: Cover the middle column and explain yourself why each is a mistake.

Mistake	**Reason why it's a mistake**	**Possible approaches to pre-empt and respond?**
Misunderstanding the relative size of atoms and equating them in size with cells.	Students can often think that cells are the smallest unit of life and do not recognise that cells are made of atoms.	
Electrons are bigger than protons and neutrons because they have more space to occupy	Students can think this as they can see through diagrams that electrons occupy more space.	
Confusing atomic stability with neutrality.	Students can think atoms are stable when they have a full outer shell of electrons. They see that as you go through the period the number of electrons and protons increases and so electrical neutrality is then equated with ionic stability.	
If the mass number has changed then the isotope is actually a different element.	Students see the relative atomic mass number change and don't notice that the atomic number has remain unchanged. It is the atomic number that determines the element.	
Students can not see the developmental stages of a current model or scientific idea.	Students can assume that because we study a version of a theory or model it must have always been that way so can find it difficult to understand that there were different theories before.	

Students assume that the periodic table is arranged by increasing atomic mass, rather than atomic number	It is a cognitive conflict - size order seems to be common sense) - pupils may find it	
8 electrons can occupy an atomic shell. A full outer shell has 8 electrons.	Students cannot connect that the first shell can only hold two electrons. When students talk about full outer shells, they often talk about 8 electrons, for helium they must talk about two electrons.	

Planning for the misconceptions

Misconception: Students can not see the developmental stages of a current model or scientific idea.
You can read about the history of the periodic table to familiarise yourself in its development*. You can see by reading its history, the dynamic development that occurred to get to the modern periodic table. In order for students to understand Mendeleev's periodic table and those that came before his, the process needs to be modelled. *We recommend chapter 7 of Bill Bryson's 'A Short History of Nearly Everything'
Supporting pupil understanding
✓ Use the 'Development of the Periodic Table' comprehension exercise in the associated lesson ✓ Alternatively, you could choose to do an extended activity into this with your students. 1. Start with some elements that were known during the middle ages. Write their formulae and relative atomic masses (but call it atomic weights). Provide basic information such as their state. Ask students to sort them into groups. 2. Give students more cards and ask them to sort again. Keep giving cards, until there are enough for them to start looking like a periodic table. By now students will have ordered them to reperesent Newlands periodic table. Pose the question whether thats the end and what should be done to enhance. If students are allowed to compare their version with the modern version they will realise that they need to leave gaps. ✓ Modelling each aspect themselves will lead students to appreciate the dynamic development of the periodic table.
Taking it further
You can link the history of the atom to the development of the periodic table. Once they get to the modern periodic table link the electronic configurations to groups and periods.

Misconception: If the mass number has changed then the isotope is a different element.

Students need to know the definition of isotope (same number of protons, differing neutrons). When studying isotopes, you can see that the number of protons remains the same for a particular element yet the number of neutrons changes.

$^{35}_{17}Cl$	$^{37}_{17}Cl$
P = 17	P =17
E =17	E =17
N= 18	N =20

Supporting pupil understanding

In order for students to understand this concept. You can use the analogy of cars, by introducing makes and models we can equate makes to elements and models with isotopes. You can use various pictures of cars to show this.

- ✓ The PEN method is useful for helping students to spot that the number of protons (and electrons) remain the same for two isotopes. For example, show students the two isotopes of chlorine (above) with the relative atomic masses and the proton numbers. Get them to calculate the number of protons, electrons and neutrons. You can question students on similarities and differences. You can then give different isotopes for example oxygen and ask students to repeat the process until they can create their own definition of an isotope by spotting the pattern that an isotope contains the same number of protons but differing number of neutrons . It's also important that students are specific in their language and quote the number of protons and neutrons.

Taking it further

Students can use calculations to determine why the relative atomic mass of $^{35.5}_{17}Cl$ is 35.5. Students have not encountered the idea of weighted averages but can instinctively feel that there must be a reason why we use $^{35.5}_{17}Cl$ and not $^{36}_{17}Cl$. You can provide clues and talk about how means are calculated. Why the mean leans more towards 35 should lead students to reason that there must be more of $^{35}_{17}Cl$ than $^{37}_{17}Cl$

Unit objectives: knowledge, skills and concepts

As you teach the lessons, track here the objectives you meet.

TKT = to know that TBAT = to be able to

Critical: it is critical that all pupils become proficient; future learning will be very challenging for them if they do not and it is likely they will not come across this content again. These are priority objectives for reteaching, revision, and intervention. Before moving on, discuss a strategy with your HOD if some pupils are not making progress with these objectives.
Core: it is important for all pupils to learn this, and it will be essential for success at GCSE. However, it will not impede them in other units if they are not (yet) proficient in it as they are likely to revisit it again in subsequent units.
Stretch: pupils should have the opportunity to be work on this aspect of science. This content is crucial for pupils to achieve the highest GCSE grades and to succeed at A-level.
Key skill: pupils should have the opportunity to develop this key skill as part of this unit.

Intended outcome for separate sciences pupils are denoted in blue and italised.

Lesson 1: Prior Knowledge Review

Intended outcome	Example questions
*This lesson is a review of content from previously studied units relating to this big idea	
TBAT Define an atom, an element, a mixture and a compound	Define an atom, an element, a mixture and a compound Through diagrams, identify atoms, an element, a mixture, a molecule and a compound Identify the elements within a compound Identify the different number of elements and atoms within a compound Identify the elements within a compound
TBAT Describe the arrangement of particles in each state of matter	Draw and describe the arrangement of particles in each state of matter Appreciate that the limitation to this model is that it is 2D and cannot show the energy of the particles
TBAT Describe how elements are arranged in the Periodic Table	Recall the features of the periodic table Define periods and groups Recall symbols of common elements and their placement within the periodic table
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 2: Maths in Science Lesson 15, Standard Form

Intended outcome	Example questions
TBAT Recall why scientists write numbers in standard form	Appreciate that scientist can use very big and very small numbers Appreciate how these numbers within calculations can be complex Explain the key word standard form Explain why scientists and engineers would simplify these numbers into standard form
TBAT Convert large numbers to and from standard form.	Convert large numbers to and from standard form using the jumping method. Practise converting large numbers to and from standard form
TBAT Convert small numbers to and from standard form	Convert small numbers to and from standard form using the jumping method. Practise converting small numbers to and from standard form
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 3: Maths in Science Lesson 16, Orders of Magnitude

Intended outcome	Example questions
TBAT Recall that a number one order of magnitude greater than another is 10 times greater.	Define the term order of magnitude
TBAT Identify how many orders of magnitude difference there are between two numbers.	Calculate orders of magnitude Explain the relevance between the number used for the order of magnitude and the number of zeros present in determining the magnitude
TBAT Define common prefixes used with SI units, such as 'centi-', 'kilo-' and 'milli-'.	Define the terms, prefixes and SI units Link prefixes to the order of magnitude Calculate the magnitudes for prefixes like kilo- and centi-
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 4: Atoms

Intended outcome	Example questions
TBAT State the names and charges of the subatomic particles	Define the terms charges, nucleus, shells and subatomic particles Name the subatomic particles State the charges of the subatomic particles Appreciate the radius of the atom in its standard form
TBAT State the definition of atomic number and mass number	Define the terms atomic number and mass number Identify the atomic number and mass number of a given element from the periodic table Identify patters across the period for the atomic number and mass number
TBAT Calculate the number of subatomic particles in different atoms	Calculate the number of subatomic particles in different atoms using the PEN method Explain how the atom of an element differs from the atom of another element
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 5: Electronic Configuration

Intended outcome	Example questions
TBAT Describe the electronic configurations of different atoms	Define the terms nucleus, shell, configuration. State the positions of the subatomic particles within an atom Explain Draw Bohr diagrams for particular electronic configurations Write electronic configurations for elements from their atomic numbers
TBAT Explain why atoms are electrically neutral	Define the term electrically neutral Explain why atoms are electrically neutral
TBAT Define the term 'ion'	Define the term ion Explain how positive and negative ions are formed Explain the importance of ions Explain the stability of ions Draw Bohr diagrams and write electronic configurations for different ions
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 6: Isotopes

Intended outcome	Example questions
TBAT State the definition of isotopes	State the definition of isotope, abundance,
TBAT Compare the number of subatomic particles in isotopes	Calculate the number of protons and neutrons of isotopes of the same element Appreciate that there is no change in the number of protons of isotopes of the same element
TBAT Explain why mass number is not always a whole number	Appreciate that some elements like chlorine and copper do not have a mass number that is whole Explain why chlorine has a mass number of 35.5 qualitatively and quantitatively
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 7: Understanding the Atom

Intended outcome	Example questions
TBAT Describe the structure of the atom	Define the terms charges, nucleus, shells and subatomic particles Name the subatomic particles State the charges of the subatomic particles Appreciate the radius of the atom in its standard form Define the terms nucleus, shell, configuration. State the positions of the subatomic particles within an atom Explain Draw Bohr diagrams for particular electronic configurations Write electronic configurations for elements from their atomic numbers Identify the atomic number and mass number of a given element from the periodic table
TBAT Describe the different theories of the structure of the atom	Describe the contribution of the following scientists to the development of atomic theory: Democritus, Dalton, Thompson , Rutherford, Bohr, Chadwick Describe the alpha particle scattering experiment Compare the similiraities and differences between the nuclear and plum pudding model of the atom
TBAT Explain how scientific models and theories develop over time	Explain how scientific models and theories develop over time Appreciate that with new experimental evidence theories can change or replace previous ones Appreciate that this is a dynamic process where some theories develop in isolation and others through collaboration
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 8: The Periodic Table

Intended outcome	Example questions
TBAT Describe how elements are arranged in the Periodic Table	Define metals, non-metal, group and period State the position of metals and non-metals within the periodic table Explain the link between the number of electrons in the outer shell and its group
TBAT Describe Mendeleev's contribution to the Periodic Table	Describe the work of Dobereiner, Newlands and Mendeleev in developing the periodic table Appreciate the relevance of leaving gaps for undiscovered elements in the periodic table
TBAT Compare early periodic tables with the modern Periodic Table	Appreciate that with new experimental evidence theories can change or replace previous ones Appreciate that this is a dynamic process where some theories develop in isolation and others through collaboration Compare early periodic tables with the modern Periodic Table
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 9: The Noble Gases

Intended outcome	Example questions
TBAT State where the noble gases are found in the periodic table	State where the noble gases are found in the periodic table State the uses for helium and neon Describe the melting /boiling point, atomic radius and density trends as you go down the group
TBAT Describe the electronic configurations of the noble gases	Draw Bohr diagrams for particular electronic configurations Write electronic configurations for elements from their atomic numbers State that Helium is the only noble gas that doesn't have 8 electrons in its outer shell
TBAT Explain why noble gases do not easily form molecules	Define the words stable and electrically neutral Explain why noble gases do not easily form molecules Link the electronic configurations of the noble gasses to ions
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 10: The Alkali Metals

Intended outcome	Example questions
TBAT State where the alkali metals are found in the periodic table	State where the alkali metals are found in the periodic table Draw Bohr diagrams for Lithium, Sodium and potassium Write electronic configurations for these elements from their atomic numbers and relate them to their position within the periodic table
TBAT Describe the pattern of reactivity in the alkali metals	Describe the reaction of the alkali metals with water and oxygen Explain why group 1 metals are called alkali metals State the order of reactivity as you go down group 1 Link Bohr diagrams for Lithium, Sodium and Potassium to their order of reactivity Write a word equation and a **balanced** symbol equation to show the reaction of lithium, sodium and potassium with oxygen and water
TBAT Explain the pattern of reactivity in the alkali metals	Explain why exposing the alkali metals to air tarnishes them and why this is a faster process for potassium in comparison to lithium Explain why these metal float in water Explain why potassium reacts faster in water in comparison to lithium Explain why the alkali metals are stored in oil Suggest a reason why you are unable to see a demonstration of the reaction between rubidium and water in a classroom.
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 11: The Halogens

Intended outcome	Example questions
TBAT State where the Halogens are found in the periodic table	State where the Halogens are found in the periodic table Draw Bohr diagrams for fluorine and chlorine Write electronic configurations for these elements from their atomic numbers and relate them to their position within the periodic table Define the term 'diatomic molecule'
TBAT Describe the properties of the Halogens	State the colour of the halogens Describe the trend in melting /boiling points of the Halogen as you go down the group Predict the colour and state for Astatine
TBAT Explain the pattern of reactivity in the Halogens	Using Bohr diagrams explain why reactivity decreases as you go down the group Compare the reactivity of the alkali metals to Halogens as you go down the group
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 12: Reactions of the Halogens

Intended outcome	Example questions
TBAT Describe the chemical reactions between hydrogen and the halides	Describe the reactions between the halogens and the alkali metals Describe the reactions between the halogens and hydrogen Write word and balanced symbol equations for these reactions
TBAT Predict the outcomes of displacement reactions	Define displacement Make accurate observations Describe the reactions between a halogen and halide Predict the order of reactivity from displacement reactions
TBAT Explain observations made during displacement reactions	Using your observations explain why reactivity decreases as you go down group 7
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Lesson 13: The Transition Metals (Chemistry only)

Intended outcome	Example questions
TBAT State where the transition metals are found in the periodic table	*Define the word transition* *State where the transition metals are found in the periodic table*
TBAT Describe the properties of transition metals	*Describe the physical and chemical properties of transition metals* *Describe the reactions of transition metals with chlorine, water and oxygen*
TBAT Compare the properties of transition metals with the alkali metals	*Compare the physical and chemical properties of transition metals with the alkali metals*
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Mastery Quiz re-teach planning

To be completed once you have reviewed your pupils' response to the mastery quiz.

What topics are your pupils confident with?
What topics need to be reviewed?
What are the **highest leverage** piece(s) of knowledge (2-3) to explicitly re-teach?
What could be interleaved throughout another unit? When will that be taught?

Other notes

Lesson 14: Feedback lesson

Intended outcome	Example questions
This is dependent on the information gained from the mastery quiz. Please fill in according to your class needs	
What did the Exit Ticket data tell me?	
What do I need to review in future lessons?	

Advanced subject knowledge

Where does this learning lead?

At A-level, student will expand on their knowledge of atomic structure and periodicity. This topic sets the foundation for a significant number of concepts at A level.

Chemical properties are dependent on the arrangement of electrons around the nucleus as such students will encounter the following:

Atomic structure

- Providing evidence for shells through first ionisation energies and successive ionisation energies
- Schrodinger's work and orbital theory
- Calculating relative atomic masses gathered from mass spectroscopy data

Periodicity

- Relating atomic radii, ionisation energies, structure, bonding and intermolecular forces to the properties and reactions of the elements
- Period 3 and group 2 and 7 chemistry
- REDOX and disproportionation
- The role of halogens and halogenoalkanes in ozone depletion
- Complex ions and transition metal chemistry

Have a look at the questions below and think about what this means for this unit.

How does learning from this unit develop at KS4?
What content from this unit is fundamental to student understanding at KS4?
How could you check that students have grasped these fundamentals?

Vocabulary and literacy

Tier 3 vocabulary and phrases in this unit that pupils are likely to already know:

Word	Definition	Example in context
Atom	The smallest part of an element that can exist independently.	*The centre of an atom is called the nucleus.*
Boiling point	The temperature at which a substance changes state from liquid to gas. It is also the temperature at which a substance changes from gas to liquid (condenses).	*The boiling point of elements in group 1 decrease as you go down the group.*
Chemical formula	A series of chemical symbols showing the number of atoms of each element in a compound.	*The chemical formula for Magnesium Oxide is MgO.*
Chemical symbol	A letter or series of letters used to represent an element. The first letter is always uppercase (capital).	*C for carbon, Na for sodium.*
Compound	A substance made up of two or more different elements chemically bonded together.	*Water is a compound of hydrogen and oxygen.*
Element	A substance made of only one type of atom.	*Oxygen is an example of an element.*
Melting point	The temperature at which a substance changes from solid to liquid (melts). It is also the temperature at which a substance changes from liquid to solid (freezes).	*The melting point of water is 0° Celsius.*
Mixture	material consisting of two or more different substances that are not chemically combined.	A *Air is a mixture of gases.*
Radius	The distance from the centre to the circumference of a circle or sphere.	*Radius of an atom is 0.1 nm (1×10^{-10} m)*

Tier 3 vocabulary that will need to be explicitly taught in context:

Word	Definition	Example in context
Alkali metal	An element in group 1 of the periodic table.	*Lithium is an example of an alkali metal.*
Alpha scattering experiment	The experiment that suggested that the mass of an atom was concentrated in the nucleus and that the nucleus had a positive charge. The experiment led to the nuclear model of the atom, which replaced the plum pudding model.	*Ernest Rutherford designed the alpha scattering experiment.*
Atomic model	A model that represents the structure of the atom.	*The atomic model has been revised over time as new evidence has become available.*

Atomic number	The number of protons in an atom of an element. This is the smallest number of the two numbers provided beside each element on the periodic table.	*The atomic number of magnesium is 12.*
Displacement reaction	*A reaction in which a more reactive substance displaces a less reactive substance.*	*A more reactive halogen will displace a less reactive halogen from a compound in a displacement reaction.*
Electron	A sub-atomic particle with a negative charge of -1 and a very small relative mass. Electrons are located in the electron cloud surrounding the nucleus.	*Electrons have a much smaller mass than protons.*
Electronic structure	The number of electrons in each energy level (shell) of an atom.	*A sodium atom has an electronic structure of 2, 8, 1.*
Energy level	The distance from the nucleus of an atom where electrons orbit. Also called a shell.	Sodium has 3 energy levels.
Groups	A column in the periodic table that contains elements with similar chemical properties.	*Group 7 is an example of a group in the periodic table.*
Halogens	An element in group 7 of the periodic table. *Chlorine is a halogen.*	
Inert	Stable and unreactive.	*The group 8 elements are inert due to them having a stable electronic configuration.*
Ion	An atom or molecule with an overall positive or negative charge, due to the loss or gain of electrons.	*A sodium ion has a positive charge.*
Isotopes	Atoms of the same element with mass numbers due to different numbers of neutrons in the nucleus.	Oxygen has three isotopes
Mass number	The total number of protons and neutrons in the nucleus of an atom. It is the larger of the two numbers beside each element in the periodic table.	*Oxygen has a mass number of 16.*
Mendeleev	The name of the scientist who developed the periodic table.	Mendeleev left gaps in the periodic table for undiscovered elements.
Neutron	A sub-atomic particle with no charge found in the nucleus of the atom.	*Neutrons are found in the nucleus of an atom.*
Noble gas	An inert gas found in group 0 of the periodic table.	Argon is a noble gas.
Nucleus	The centre of the atom which consists of protons and neutrons.	*The nucleus is positively charged.*
Outer shell	The energy level of an atom furthest from the nucleus.	*Magnesium has 2 electrons in its outer shell.*

Periodic table	A table of all the known elements arranged in order of atomic number so that elements with similar properties are in columns, known as groups.	*All of the elements we know are represented in the periodic table.*
Plum pudding model	This is the name given to Thomson's model of the atom that suggested that the whole atom is a ball of positive charge with negative electrons embedded in it.	*The Plum pudding model was an important step in the development of atomic theory.*
Proton	A sub-atomic particle with a positive charge of +1 found in the nucleus of the atom. It has the same mass as a neutron.	*Lithium has 3 protons.*
Sub-atomic particle	A particle smaller than an atom, such as a proton, neutron or electron.	*Sub-atomic particles have different locations within the atom.*
Transition metal	An element positioned in the central block of the periodic table, between Group 2 and Group 3.	*Iron is an example of a transition metal.*

New scientists:

Scientist	**Famous for**	**Background**
Democritus	Said that everything is made up of indivisible building blocks	Ancient Greek philosopher 500BD
John Dalton'	Discovered that: • atoms of a given element are identical. • The atoms of different elements vary in mass and size. • Atoms are indestructible. Chemical reactions may result in their rearrangement, but not their creation or destruction.	6 September 1766 – 27 July 1844. He was a chemist, physiciist and meterologist. Belonged to a really poor family so started to work at the age of 10.
J.J. Thomson	Discovered the electron and suggested the plum pudding model	8 December 1856 – 30 August 1940. A british physicist. Attended Manchecter university at the age of 14!
Ernest Rutherford	Designed an experiment (alpha particle scattering to test the plum pudding model and came up with the nuclear model	30 August 1871 – 19 October 1937. British, but born in New Zealand. Called the Father of Nuclear physics. Worked with J.J. Thomson.

Niels Bohr	Niels Bohr adapted Ernest Rutherford's nuclear model to include shells	7 October 1885 – 18 November 1962, Danish physicist. Won the Nobel prize in physics in 1922, Donated his medal to charity.
James Chadwick	Discovered the neutron	20 October 1891 – 24 July 1974. A physicist who recieved his Nobel prize in 1932. He was taught by Rtherferd at Manchester university. Studied with Geiger in Germany, but war broke out and was imprisoned for four years. Got his PhD at Canbridge university.
Johann Wolfgang Döbereiner	Reported trends in certain properties of selected groups of elements.	3 December 1780 – 24 March 1849 A coachman's son, so had a small amount of education. He taught himself chemistry whilst he was an apprentice apothacary.
John Newlands	Proposed the **Law of Octaves** in 1864. He arranged all the elements known at the time into a table in order of atomic weight.	26 November 1837 – 29 July 1898, He was homeschooled by his dad until he went to university.
Dimitri Mendeleev	Published a periodic table where he grouped elements of similar properties togther vertically, arranged them in atomic weights and left gaps for undiscoveed elements.	8 February 1834 – 2 February 1907. The youngest of 17 siblings (14 died in infancy). He was rejected by Moscow university as he was too poor.

Appendices

Appendix 1: Mark scheme for pre-unit quiz

Qu	Answer	Marks	Supporting information for fix-it tasks
1	B	1	Answering A or C shows a misunderstanding of the particle model and interpreting particle diagrams from Unit C1.1. *Suggested fix-it: Draw particle diagrams to show the arrangement of particles in a solid, a liquid and a gas.*
2	C	1	Answering A or B shows a misunderstanding of what happens during a change of state. The particles themselves do not change, only the spaces between them. *Suggested fix-it: Describe what happens to the particles when a block of ice melts.*
3	A	1	Answering B or C shows a misunderstanding of the definition of an element. Elements are made up of one type of atom only and can be found in the Periodic Table. *Suggested fix-it: Use particle diagrams to help you explain the difference between an element and a compound.*
4	B	1	Answering A or C shows a misunderstanding of where metals and non-metals are found in the Periodic Table (Unit C1.2). *Suggested fix-it: State where metals and non-metals are found in the Periodic Table and give an example of each.*
5	B	1	Answering A or C shows a misunderstanding of the meaning of group and period in the Periodic Table. Pupils may often forget that hydrogen and helium are in Period 1. *Suggested fix-it: Identify the group and period for oxygen, calcium and phosphorus.*
6	C	1	Answering A or B shows a misunderstanding of the rules for how compounds are named (Unit C1.2). The name of the metal always comes first and the second word ends in -ide (or -ate if the compound also contains oxygen). *Suggested fix-it: Name the compounds that would be formed from: i) lithium and fluorine, ii) calcium and sulfur and iii) iron and oxygen.*
7	A	1	Answering B or C shows a misunderstanding

			what is shown by a chemical formula (Unit C1.2). The subscripts refer to the number of atoms of the element that precedes them. *Suggested fix-it: Identify the number of atoms of each element present in sulfuric acid (H_2SO_4).*
8	C	1	Answering A or B shows a misunderstanding of chemical reaction involved in combustion. If a substance burns, it is reacting with oxygen. *Suggested fix-it: Write a word equation to show what happens when magnesium burns.*
9	A	1	Answering B or C shows a misunderstanding of the products of acid reactions (C2.1). Alkalis and bases are metal oxides or hydroxides. *Suggested fix-it: Write the general equations for acids reacting with i) metals, ii) alkalis/bases and iii) metal carbonates.*
10	A:2, B:5, C:4, D:4	1	Any errors here show a misunderstanding of acid reactions and the products of each general equation. *Suggested fix-it: Write word equations to show the products formed between i) sodium hydroxide and hydrochloric acid, ii) zinc and sulfuric acid and iii) magnesium carbonate and nitric acid*

Appendix 2: Mark scheme for mastery quiz

Section A

Qu	Answer	Marks	Supporting information for fix-it tasks
1	C	1	Answering A suggests a gap in knowledge about alkali metals being very reactive. *To fix it, remind students about the alkali metals in water demo (and/or show a video clip) and then ask them to list properties of alkali metals.* Answering B suggests a misconception that because group 1 elements are metals, they must have very high melting points, however these elements have relatively low melting and boiling points. *To fix it, give students mp and bp data on alkali metals vs transition metals and ask them to describe what the data shows.*
2	A	1	Answering C suggests the misconception that the diagrams of atomic structure are to scale. *To fix it, share with students, some scale models (e.g. if an atom was a football stadium, the nucleus would be the size of a blueberry).*
3	B	1	Answering A suggests or C suggests a gap in knowledge about metals + halogens → metal halide. *To fix it, students should write down the general equation and then use the periodic table to write out lots of example reactions.*
4	C	1	Answering A suggests that students have correctly identified 16 electrons and incorrectly inferred that electron number is derived from mass number – atomic number. They could have used phosphorus's 31-15 to give them 16. Answering B shows that pupils have incorrectly used the mass number to determine the number of electrons. *To fix it, reteach what the atomic number and mass number is and then ask students to write their own definitions, using an example of an element from the periodic table.*
5	B	1	Answering A or C shows a gap in knowledge about the order of magnitude of these units. *To fix it, give students a scale from lowest unit to greatest unit, with gaps in for completion.*
6	B	1	Answering A and C suggest that students hold the common misconceptions either that scientists are always right, or that our current models are correct and will never change. *To fix-it, remind students that scientists are still making discoveries today and that it is likely many of our models will evolve over time. Then ask students to explain what would happen if a piece of evidence disproved part of the atomic model.*
7	C	1	Answering A suggests the misconception that standard form refers to a decimal point. *To fix it, reteach the basics*

			of standard form and ask students to copy out worked examples. Answering B suggests a confusion with **3 x 10^{-4}** which may have come from the previous unit B3.1 where tiny numbers were written in standard form to show cell and organelle size. *To fix it, model how you convert standard form to a number, including numbers less than 1 and greater than 1. Then give students practise questions.* Answering D suggests the misconception that the **10^4** means that the answer should have 4 digits. *To fix it, reteach the basics of standard form and give students many practise questions.*
8	A	1	Answering B suggests a gap in knowledge about how many electrons are in the 2nd electron shell. Answering C suggests a gap in knowledge about how many electrons are in the 1st electron shell. *To fix it, reteach the rules of writing out electronic configuration and then give many practise questions.*
9	B	1	Answering A suggests a gap in knowledge about the concept of displacement reactions, because there would be no reaction taking place. *To fix it, reteach displacement reactions; it may be useful to use a different analogy to explain reactivity and displacement reactions – e.g. in terms of 'hunger' – the hungriest person will take the food from a less hungry person.* Answering C suggests that students have understood that a displacement reaction is one where an element takes the place of another but not correctly identified the order of reactivity within the Halogens. *To fix it, ask students to write out the order of reactivity of the halogens from most to least reactive. Then ask students to explain why there is no reaction of iodine + sodium bromide.*
10	B	1	Answering A suggests some understanding that a full outer shell/stable configuration causes noble gases to be unreactive, but shows a gap in knowledge that helium has only two electrons in its outer shell. *To fix it, ask students to draw out the electronic configuration of helium, neon and argon.* Answering C suggests that students have the misconception that a stable electron arrangement is an atom being electrically neutral. *To fix it, show diagrams of different types of atom, where they have equal numbers of protons and electrons, but do not have a full outer shell.*
11	B	1	Answering A suggests a confusion of isotopes with ions. *To fix it, ask students to write out definitions for ions and isotopes and then state one difference they have.*

			Answering C suggests a gap in knowledge about what mass and atomic numbers are. *To fix it, reteach these key definitions and then ask students to write out the mass number and atomic number for several elements, using their periodic table.*
12	B	1	Answering A suggests some understanding about what period are but shows a gap in knowledge about the similar properties occurring at regular intervals. Answering C suggests some understanding that elements are arranged by atomic number but shows a gap in knowledge about the similar properties occurring at regular intervals. *To fix it, ask students to explain what the groups of elements have in common.*
13	C	1	Answering A or B suggests a gap in knowledge about Mendeleev's periodic table. *To fix it, ask students to describe how elements were arranged before Mendeleev, how Mendeleev improved it and then how today's periodic table is different.*
14	A	1	Answering B suggests the misconception that the RAM = the number of neutrons. *To fix it, reteach the basic definitions of atomic number, relative atomic mass, neutron and proton. Then ask students to describe what the how the RAM is deduced.* Answering C shows some understanding about the composition of sub-atomic particles in the nucleus, however it suggests the misconception that there are half units. *To fix it, reteach the fundamental principles of isotopes and then ask students to explain why chlorine has a RAM of 35.5 but there are no half units of protons or neutrons.*
15	C	1	Answering A suggests a misconception that transition metals react with water. *To fix it, ask students to compare the differences in properties between alkali metals and transition metals.* Answering B suggests a misconception that sodium is a transition metal. *To fix it, ask students to describe where on the periodic table alkali metals are and where transition metals are. Then ask them to list 4 example elements for each.*

Section B

<table>
<tr><th>Qu</th><th>Model answer</th><th>Supporting information
Suggestions for fix-it tasks</th></tr>
<tr><td>1</td><td>
<table>
<tr><th>Subatomic particle</th><th>Relative charge</th><th>Relative mass</th></tr>
<tr><td>Proton</td><td>+ 1 (positive)</td><td>1</td></tr>
<tr><td>Neutron</td><td>0 (neutral)</td><td>1</td></tr>
<tr><td>Electron</td><td>- 1 (negative)</td><td>Very small</td></tr>
</table>
</td><td>Students may struggle to recall their knowledge when writing relative size. To fix it, reteach that protons and neutrons have a similar mass, so we can call their relative mass both 1, whereas the relative mass of an electron is negligible, but we can say very small here. Then as students to write a s sentence comparing the relative sizes of the subatomic particles in an atom.</td></tr>
<tr><td>2</td><td>Sodium + water → sodium hydroxide + hydrogen

2 Na + 2 H_2O → 2 NaOH + H_2</td><td>One common error could be to forget to add the product hydrogen. To fix it ask students what they observed when sodium reacted with water (fizzing, bubbles) and explain that this is the hydrogen product. Then ask students to describe test you could do during this practical to prove it was hydrogen gas being made.

Another potential issue is the challenge of balancing this equation. To fix it, model on the board/visualiser how to balance this equation and then ask the students to balance other symbol equations.</td></tr>
<tr><td>3</td><td>The melting and boiling points of the halogens increase going down the group because the molecules become larger, the forces between the molecules become stronger, and so more energy is needed to overcome these forces.</td><td>A potential error here might be explanation, because knowledge from C1.1 Particles is required. To fix it, ask students what happens to particles as they melt in a solid to form a liquid, ensuring the terms energy, forces, particles are used.</td></tr>
<tr><td>4</td><td>Similarities of the plum pudding model and the nuclear model of the atom are that both include positive charges, both include electrons and neither includes neutrons.

However, there are many differences between these two models. In the plum pudding model an atom is a ball of positive charge spread throughout whereas in the nuclear model the positive charge is concentrated at the centre.</td><td>A common error with this question is to not include the similarities (since there are lots of differences to talk about). To fix it, ask students to annotate their answers by circling similarities and underlining differences. There should be at least two for each.

Another error with compare style questions more generally, is not organising the writing well, so it become illogical.
To fix it, give students this success criteria to improve their answers:
To ‘compare’, your answer should:
• Give similarities.</td></tr>
</table>

	Similarly, in the plum pudding model all the mass is spread throughout the atom whereas in the nuclear model the mass is concentrated at the central nucleus. In the plum pudding model electrons are spread out and embedded in the ball of positive charge but in the nuclear mode the electrons are outside the nucleus. In the plum pudding model there is no empty space in an atom whereas in the nuclear model most of the atom is empty space.	• *Write **paired statements** that **show differences relating to the same feature**.* • *Use the term '**whereas**' to link your statements.*

Appendix 3: Core knowledge statements

The below statements list the knowledge entitlement that pupils should acquire and retain from this unit.

Atoms, Elements and Compounds

- All substances are made of atoms. An atom is the smallest part of an element that can exist
- Atoms of each element are represented by a chemical symbol, e.g. O represents an atom of oxygen, Na represents an atom of sodium
- There are about 100 different elements. Elements are shown in the periodic table
- Compounds are formed from elements by chemical reactions
- Chemical reactions always involve the formation of one or more new substances, and often involve a detectable energy change
- Compounds contain two or more elements chemically combined in fixed proportions and can be represented by formulae using the symbols of the atoms from which they were formed
- Compounds can only be separated into elements by chemical reactions
- Chemical reactions can be represented by word equations or equations using symbols and formulae

Atomic Structure

- Atoms are very small, having a radius of about $1x10^{-10}$ metres
- The basic structure of an atom is a positively charged nucleus composed of both protons and neutrons surrounded by negatively charged electrons
- The radius of a nucleus is less than 1/10 000 of the radius of an atom
- Most of the mass of an atom is concentrated in the nucleus
- In the periodic table, each element appears with two numbers: the atomic number and the mass number
- The atomic number of an element is equal to the number of protons in the nucleus of an atom of that element
- In a neutral atom (an atom with no overall charge), the number of protons (+) is equal to the number electrons (-)
- Different elements have different atomic numbers, and therefore different numbers of protons in the nucleus of their atom
- The mass number of an element is equal to the number of neutrons + protons in the nucleus of an atom of that element
- To determine the number of neutrons in the nucleus of an atom of an element, the atomic number should be subtracted from the mass number

Electronic Configuration

- The electrons are arranged at different distances from the nucleus (in different energy levels, or shells)
- The electron arrangements may change with the absorption of electromagnetic radiation (move further from the nucleus; a higher energy level) or by the emission of electromagnetic radiation (move closer to the nucleus; a lower energy level)
- The electrons in an atom occupy the lowest available energy levels first (which are the innermost available shells)
- Electrons will fill the lowest available energy level before moving to a higher energy level
- The electron shell (or energy level) closest to the nucleus can take two electrons
- The second energy level takes up to eight electrons
- If the outermost energy level is full, the atom will be stable (unreactive)
- The electronic structure of an atom can be represented by numbers or by a Bohr diagram. For example, the electronic structure of sodium is 2,8,1 or showing two

electrons in the lowest energy level, eight in the second energy level and one in the third energy level

Isotopes

- Atoms of the same element can have different numbers of neutrons. These atoms are called isotopes of that element
- Isotopes are atoms of the same element with different mass numbers due to different numbers of neutrons in the nucleus
- Isotopes of an element will all have the same atomic number, because the number of protons is always the same for all atoms of that element
- Isotopes of an element will have different mass numbers, because they have different numbers of neutrons
- Isotopes of an element can be represented as '[element name]-[mass number]', for e.g., carbon-12 and carbon-14
- The relative atomic mass of an element is an average value that takes account of the abundance of the isotopes of the element
- The relative atomic mass does not have a unit

The Atomic Model

- New experimental evidence may lead to a scientific model being changed or replaced
- Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided
- JJ Thompson discovered the electron
- JJ Thompson developed the plum pudding model of the atom. This model suggested that the atom is a ball of positive charge with negative electrons embedded in it
- Geiger, Marsden and Rutherford carried out a famous experiment called the Gold Foil (or alpha scattering) experiment. The results from this experiment led to the conclusion that the mass of an atom was concentrated at the centre (nucleus) and that the nucleus was charged
- The nuclear model of the atom replaced the plum pudding model and is the model we use to this day
- Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. The theoretical calculations of Bohr agreed with experimental observation
- James Chadwick discovered the neutron
- Our knowledge of atoms is still developing today

The Periodic Table

- The elements in the periodic table are arranged in order of atomic number and so that elements with similar properties are in columns, known as groups
- The table is called a periodic table because similar properties occur at regular intervals (periodically)
- Elements in the same group in the periodic table have the same number of electrons in their outer shell (outer electrons) and this gives them similar chemical properties
- The early periodic tables were incomplete, and some elements were placed in inappropriate groups if the strict order of atomic weights was followed
- Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered and, in some places, changed the order based on atomic weights
- The elements in Group 0 of the periodic table are called the noble gases
- They are unreactive and do not easily form molecules because their atoms have stable arrangements of electrons
- A stable electronic configuration is one in which the outer shell of electrons is full
- The noble gases have eight electrons in their outer shell, except for helium, which has only two electrons

- The boiling points of the noble gases increase with increasing relative atomic mass (going down the group)
- The elements in Group 1 of the periodic table are known as the alkali metals
- The Alkali metals have one electron in their outer shell
- Alkali metals are soft, shiny metals with low melting and boiling points
- In Group 1, the reactivity of the elements increases going down the group
- Alkali metals react vigorously with water to form the metal hydroxide and hydrogen gas
- The equations for the alkali metals' reactions with water take the form 'lithium + water → lithium hydroxide + hydrogen' which can also be written as '$2Li + 2H_2O \rightarrow 2LiOH + H_2$'.
- The metal oxides produced by the reactions of alkali metals with water are alkaline
- When added to water, the alkali metals will move rapidly across the surface of the water. This is caused by the production of hydrogen gas.
- When reacting with water, the alkali metals will form a spherical shape. This is caused by the heat of the reaction.
- When alkali metals react with water, sometimes the heat of the reaction will cause the hydrogen gas produced to be set alight. This causes an orange flame to be seen (in the case of sodium) or a lilac flame to be seen (in the case of potassium).
- The alkali metals react with oxygen to form metal oxides
- The alkali metals are stored under oil to prevent reaction with oxygen, also known as corrosion.
- Corrosion makes the alkali metals less shiny.
- The equations for the alkali metals reactions with oxygen take the form 'lithium + oxygen → lithium oxide' which can also be written as '$4Li + O_2 \rightarrow 2Li_2O$'
- The elements in Group 7 of the periodic table are known as the halogens
- The halogens all have similar reactions because they all have seven electrons in their outer shell.
- The halogens are non-metals and consist of diatomic molecules
- Diatomic molecules consist of pairs of atoms bonded together
- Chlorine is a pale green gas at room temperature
- Bromine is a brown/orange liquid at room temperature
- Iodine is a black or purple solid at room temperature
- In Group 7, the further down the group an element is the higher its relative molecular mass, melting point and boiling point
- The melting and boiling points of the halogens increase going down the group because the molecules become larger, the forces between the molecules become stronger, and so more energy is needed to overcome these forces.
- In Group 7, the reactivity of the elements decreases going down the group. This is because the atomic radius increases moving down the group. The further the outer shell is from the nucleus, the harder it will be to attract the electron required for a stable electronic configuration.
- The halogens react with metals to produce metal halides, for e.g., sodium + chlorine → sodium chloride
- The halogens react with hydrogen to produce hydrogen halides, for e.g., hydrogen + chlorine → hydrogen chloride
- A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt
- The transition elements are metals including Cr, Mn, Fe, Co, Ni, Cu with similar properties which are different from those of the elements in Group 1
- Many transition elements have ions with different charges form coloured compounds and are useful as catalysts