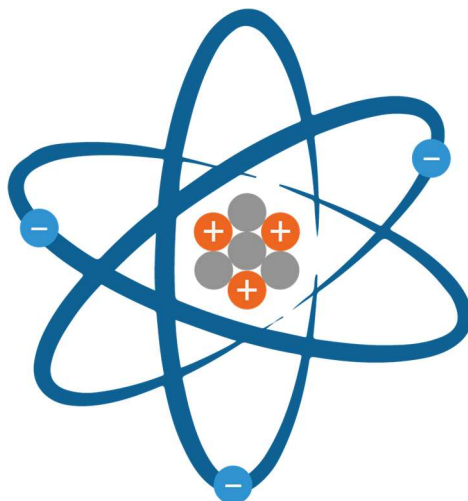




# Master Kirkcaldy High School



## N4/5 Chemistry Unit 1 - part 2 Atomic Structure

Name: \_\_\_\_\_

Class: \_\_\_\_\_

Teacher: \_\_\_\_\_

## Assessment Page

### End of topic questions

Topic title	Date	Mark/Total Mark
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### Homework

Homework title	Date	Mark/Total Mark
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### Check tests

Test title	Date	Mark/Total Mark
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**Teacher comments**

## Using Command Words

Command words in questions are crucial as they guide us on the specific type of response required. Let's delve into some examples within the context of simple chemistry concepts, focusing on the states of matter. These are arranged into the level of detail that must be given and therefore their difficulty, from least to most.

In chemistry, often a drawn diagram will give you a mark instead of a written answer as long as it is labelled.

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### **Identify:**

This command word requires you to establish and name a particular item or concept.

For instance, *"Identify the three states of matter."*

In response, you would say, *"The three states of matter are solid, liquid, and gas."*

---

**State:** This command word requires you to express the main points concisely.

For instance, *"State the process of changing from a solid to a gas."*

Your answer would be, *"The process of changing from a solid to a gas is called sublimation."*

---

**Indicate:** This command word requires you to point out or show something.

For instance, *"Indicate whether the volume of a gas is fixed or variable."*

Your answer would be, *"The volume of a gas is variable."*

---

**Provide/Give:** These command words mean you need to present a specific item or concept, often an example.

For instance, *"Provide an example of a liquid."*

You could answer, *"An example of a liquid is water."*

---

**Describe:** Here, you are expected to provide a detailed account of a particular topic.

For example, *"Describe the properties of a solid state of matter."*

You would respond by saying, *"Solids have a definite shape and volume. The particles in solids are closely packed together and vibrate in fixed positions."*

**Outline:** This command word asks you to give a brief summary or overview of a topic.

For example, *"Outline the process of evaporation."*

You might respond, *"Evaporation is the process by which liquid turns into gas upon heating. It occurs when the particles of a liquid gain enough energy to leave the liquid and become gas."*

---

**Explain:** This command word asks you to make something clear or easy to understand by describing it in more detail.

For example, *"Explain why gases easily fill their containers."*

An appropriate answer might be, *"Gases easily fill their containers because their particles are free to move in all directions and will spread out until they occupy the entire container."*

---

**Discuss:** This command word is asking you to present a detailed and balanced argument about a specific topic.

For example, *"Discuss the importance of understanding the states of matter."*

Your response would involve discussing various aspects like the role of states of matter in natural phenomena, their significance in various scientific and industrial processes, etc.

---

**Create:** This command word often represents one of the highest levels of difficulty in command words. It requires not just recall or understanding of existing knowledge, but the ability to generate new ideas or products based on that knowledge. It involves synthesis, imagination, and critical thinking, and it's often used in tasks such as designing an experiment, writing an original essay, or proposing a solution to a problem.

# Elements and the Periodic Table

## Learning Intentions

- To learn about elements and the periodic table.

## Success Criteria

- I can find and write the symbol of elements using the data booklet.
- I can identify metals and non-metals in the periodic table.
- I can determine the state of an element at room temperature using its melting/boiling point.
- I can identify selected groups from the periodic table and their properties.

## Introduction

The Periodic Table is like a big directory or a catalogue of all the **elements**, the basic ingredients that make up everything around us. Each **element** has its own spot on the table, represented by a unique **symbol**.

1 Hydrogen <b>H</b>	
3 Lithium <b>Li</b>	4 Beryllium <b>Be</b>
11 Sodium <b>Na</b>	12 Magnesium <b>Mg</b>

For example, there's "H" for **Hydrogen** (which is in water), "O" for **Oxygen** (what we breathe), "Au" for **Gold** (the shiny metal in jewellery), and "Fe" for Iron (used in structures and vehicles).

- The first letter in the symbol must be CAPITAL.
- If a second letter in the symbol this must be lower case.
- e.g. Co is the symbol for Cobalt however CO is the formula for carbon monoxide*

You can use **page 4** of your data booklet to find the name and formula for each element.

Use the data booklet to find the elements symbol for the following elements:

1. Hydrogen

2. Oxygen

3. Gold

4. Iron

5. Helium

6. Carbon

7. Nitrogen

8. Silver

9. Copper

10. Neon


11. Calcium

12. Sodium

13. Chlorine

14. Potassium

15. Magnesium

16. Lead

17. Bromine

18. Iodine

19. Uranium

20. Lithium


Use the data booklet to find the element name from the elements symbol for the following elements:

1. Hg

2. Si

3. Kr

4. Pb

5. S

6. Ar

7. Co

8. Ni

9. Se

10. Rb


11. Sr

12. Y

13. Zr

14. Mo

15. Cd

16. Xe

17. Ba

18. Pt

19. Ti

20. Al


# Metals and non-metals in the periodic table

With 2 coloured pens/pencils, label the metals and non-metals on the periodic table below.

Column 1	Column 2																			Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	
1 Hydrogen H																									2 Helium He	
3 Lithium Li	4 Beryllium Be																				5 Boron B	6 Carbon C	7 Nitrogen N	8 Oxygen O	9 Fluorine F	10 Neon Ne
11 Sodium Na	12 Magnesium Mg		TRANSITION METALS												13 Aluminium Al	14 Silicon Si	15 Phosphorus P	16 Sulfur S	17 Chlorine Cl	18 Argon Ar						
19 Potassium K	20 Calcium Ca	21 Scandium Sc	22 Titanium Ti	23 Vanadium V	24 Chromium Cr	25 Manganese Mn	26 Iron Fe	27 Cobalt Co	28 Nickel Ni	29 Copper Cu	30 Zinc Zn	31 Gallium Ga	32 Germanium Ge	33 Arsenic As	34 Selenium Se	35 Bromine Br	36 Krypton Kr									
37 Rubidium Rb	38 Strontium Sr	39 Yttrium Y	40 Zirconium Zr	41 Niobium Nb	42 Molybdenum Mo	43 Technetium Tc	44 Ruthenium Ru	45 Rhodium Rh	46 Palladium Pd	47 Silver Ag	48 Cadmium Cd	49 Indium In	50 Tin Sn	51 Antimony Sb	52 Tellurium Te	53 Iodine I	54 Xenon Xe									
55 Caesium Cs	56 Barium Ba	57 Lanthanum La	58-71 ●	72 Hafnium Hf	73 Tantalum Ta	74 Tungsten W	75 Rhenium Re	76 Osmium Os	77 Iridium Ir	78 Platinum Pt	79 Gold Au	80 Mercury Hg	81 Thallium Tl	82 Lead Pb	83 Bismuth Bi	84 Polonium Po	85 Astatine At	86 Radon Rn								
87 Francium Fr	88 Radium Ra	89 Actinium Ac	90-103 ■	104 Rutherfordium Rf	105 Dubnium Db	106 Seaborgium Sg	107 Bohrium Bh	108 Hassium Hs	109 Meitnerium Mt	110 Darmstadtium Ds	111 Roentgenium Rg	112 Copernicium Cn		114 Flerovium Fl		116 Livermorium Lv										
		58 Cerium Ce	59 Praseodymium Pr	60 Neodymium Nd	61 Promethium Pm	62 Samarium Sm	63 Europium Eu	64 Gadolinium Gd	65 Terbium Tb	66 Dysprosium Dy	67 Holmium Ho	68 Erbium Er	69 Thulium Tm	70 Ytterbium Yb	71 Lutetium Lu											
		90 Thorium Th	91 Protactinium Pa	92 Uranium U	93 Neptunium Np	94 Plutonium Pu	95 Americium Am	96 Curium Cm	97 Berkelium Bk	98 Californium Cf	99 Einsteinium Es	100 Fermium Fm	101 Mendelevium Md	102 Nobelium No	103 Lawrencium Lr											

## Key:

Metals

Non-metals

## Questions

For the following questions, **state** whether the element is a metal or non-metal.

1. Iron


2. Oxygen

3. Helium

4. hydrogen

5. Zinc

6. Mercury

7. Neon

8. Calcium


## Solids, liquids and gases in the periodic table

Temperature is a measure of heat energy, it is measured in **degrees Celsius**, the units for this is **°C**. Temperature is measured with a **thermometer**.

The **melting point** of an element is the temperature at which the element turns from a **solid** to a **liquid**.

The **boiling point** of an element is the temperature at which the element turns from a **liquid** to a **gas**.

*Colour in the elements by their state (solid, liquid or gas) at room temperature (25°C). KEEP SOLID AS WHITE and use 2 different colours for liquid and gas.*

1 Hydrogen -259 -253																	2 Helium -272 -269				
<div style="display: flex; align-items: center; justify-content: center;"> <div style="border: 1px solid black; padding: 5px; margin-right: 10px;">Key</div> <div style="border: 1px solid black; padding: 5px;">                 Atomic Number Name of Element Melting Point/°C Boiling Point/°C             </div> </div>																					
3 Lithium 181 1342	4 Beryllium 1287 2471*															5 Boron 2075 4000	6 Carbon †3825	7 Nitrogen -210 -196	8 Oxygen -219 -183	9 Fluorine -220 -188	10 Neon -249 -246
11 Sodium 98 883	12 Magnesium 650 1090															13 Aluminium 660 2519	14 Silicon 1414 3265	15 Phosphorus 44 280	16 Sulfur 115 445	17 Chlorine -101 -34	18 Argon -189 -186
19 Potassium 63 759	20 Calcium 842 1484	21 Scandium 1541 2836	22 Titanium 1668 3287	23 Vanadium 1910 3407	24 Chromium 1907 2672	25 Manganese 1246 2061	26 Iron 1538 2861	27 Cobalt 1495 2927	28 Nickel 1455 2913	29 Copper 1085 2562	30 Zinc 420 907	31 Gallium 30 2204	32 Germanium 938 2833	33 Arsenic *817 †616	34 Selenium 221 685	35 Bromine -7 59	36 Krypton -157 -153				
37 Rubidium 39 688	38 Strontium 777 1382	39 Yttrium 1522 3345	40 Zirconium 1855 4409	41 Niobium 2477 4744	42 Molybdenum 2623 4639	43 Technetium 2157 4265	44 Ruthenium 2333 4150	45 Rhodium 1964 3695	46 Palladium 1555 2963	47 Silver 962 2162	48 Cadmium 321 767	49 Indium 157 2072	50 Tin 232 2602	51 Antimony 631 1587	52 Tellurium 449 988	53 Iodine 114 184	54 Xenon -112 -108				
55 Caesium 28 671	56 Barium 727 1897	57 Lanthanum 920 3464	72 Hafnium 2223 4602	73 Tantalum 3017 5458	74 Tungsten 3422 5555	75 Rhenium 3185 5596	76 Osmium 3033 5012	77 Iridium 2446 4428	78 Platinum 1768 3825	79 Gold 1064 2856	80 Mercury -39 357	81 Thallium 304 1473	82 Lead 328 1749	83 Bismuth 271 1564	84 Polonium 254 962	85 Astatine 302	86 Radon -71 -62				

Key:     Solid     Liquid     Gas

### Questions

For each of the following elements or compounds, identify whether they are typically a solid, liquid, or gas at room temperature.

1. Oxygen


2. Iron

3. Mercury

4. Chlorine

1. Gold

2. Nitrogen

3. Bromine

4. Neon

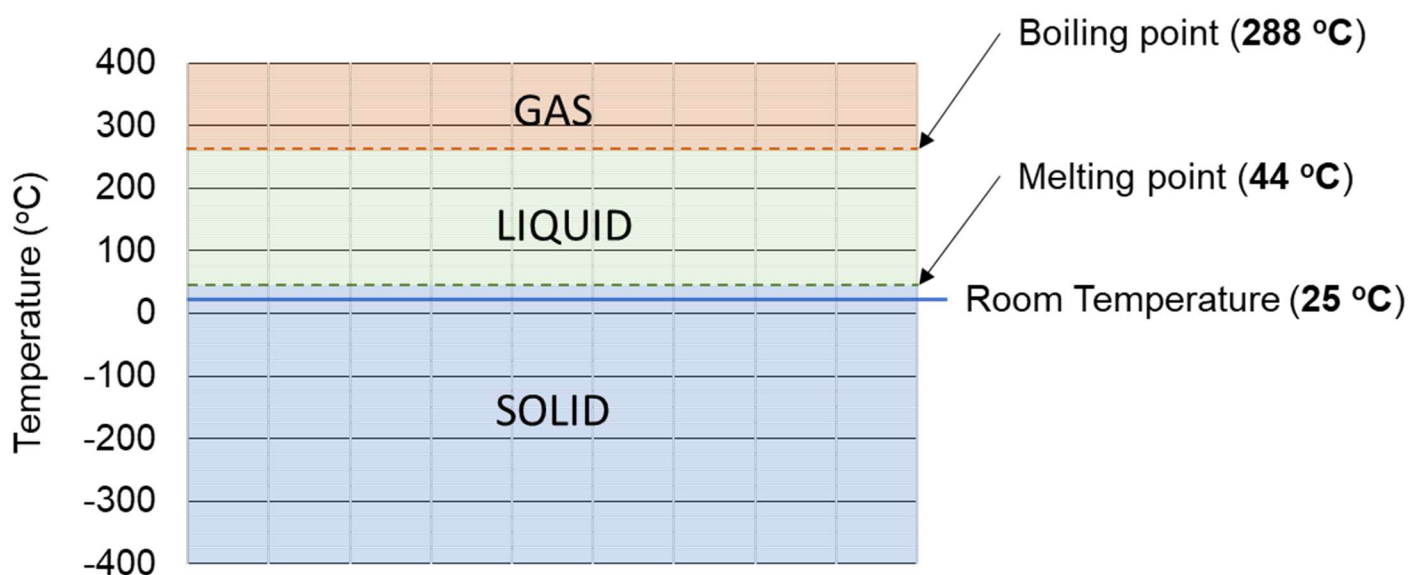

## Finding the state at room temperature (optional challenge)

Using the data booklet, we can find what the state of the element will be at room temperature (25 °C). This is important because we will most of the time observe and use elements at room temperature.

Using phosphorus (P) as an example:

The melting point of phosphorus is: **44 °C**.

The boiling point of phosphorus is: **280 °C**.



At room temperature phosphorus will be a **solid** because room temperature is below the melting point.

---

## Questions (optional challenge)

For the following questions, using just the melting point and boiling point, **state** whether the element is a solid, liquid or gas at room temperature.

You may use your data booklet and a whiteboard/blank paper to work them out.

1. Oxygen


2. Hydrogen

3. Iron

4. Boron

5. Tin

6. Iodine

7. Bromine

8. Mercury


## Groups and periods

The table organizes these elements in rows and columns, and here's the neat trick: elements in the same column have similar behaviours.

Rows in the periodic table are known as **periods**.

Columns in the periodic table are known as **groups**.

So, by looking at where an element sits on the table, we can get clues about how it might act. Think of it as our ultimate guide to the building blocks of our world.

When we number and name the groups of elements, we do not include the **transition metals**.

*Colour in the alkali metals, alkali earth metals, halogens and noble gases:*

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1 Hydrogen H							2 Helium He
3 Lithium Li	4 Beryllium Be	5 Boron B	6 Carbon C	7 Nitrogen N	8 Oxygen O	9 Fluorine F	10 Neon Ne
11 Sodium Na	12 Magnesium Mg	13 Aluminium Al	14 Silicon Si	15 Phosphorus P	16 Sulfur S	17 Chlorine Cl	18 Argon Ar
19 Potassium K	20 Calcium Ca	31 Gallium Ga	32 Germanium Ge	33 Arsenic As	34 Selenium Se	35 Bromine Br	36 Krypton Kr
37 Rubidium Rb	38 Strontium Sr	49 Indium In	50 Tin Sn	51 Antimony Sb	52 Tellurium Te	53 Iodine I	54 Xenon Xe
55 Caesium Cs	56 Barium Ba	81 Thallium Tl	82 Lead Pb	83 Bismuth Bi	84 Polonium Po	85 Astatine At	86 Radon Rn
87 Francium Fr	88 Radium Ra						

Key:  alkali metals  alkali earth metals  halogens  noble gases

## Questions

For each element below, state the number and name of the group they belong to:

Element	Group Number	Group Name
1. Lithium		
2. Magnesium		
3. Chlorine		
4. Argon		
5. Helium		
6. Strontium		
7. Sodium		
8. Iodine		
9. Hydrogen		
10. Xenon		

---

### Properties of groups 1, 2, 7 and 0/8

**Group 1** elements are known as the **alkali metals**.

**Properties:** **soft**, highly **reactive**, especially with water, with **low** melting points

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**Group 2** elements are known as the **alkali earth metals**.

**Properties:** **harder** than alkali metals, **less** reactive than alkali metals but still reactive, **higher** melting points than alkali metals.

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**Group 7** elements are known as the **halogens**.

**Properties:** **highly** reactive **non-metals** with **low** melting points.

---

**Group 0/8** elements are known as the **noble gases**.

**Properties:** colourless, odourless, **extremely low** reactivity.

# Atomic Structure

## Learning Intentions

- To learn about the structure of the atom.

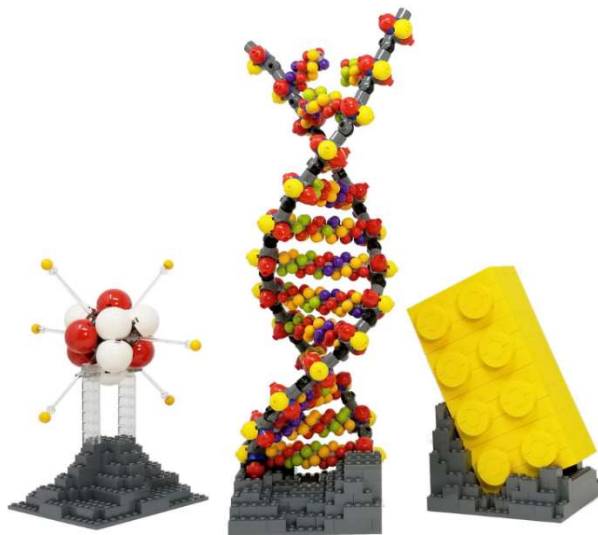
## Success Criteria

- I can state where the sub-atomic particles of an atom are located within the atom.
- I can state the names, charges and masses of each sub-atomic particle.

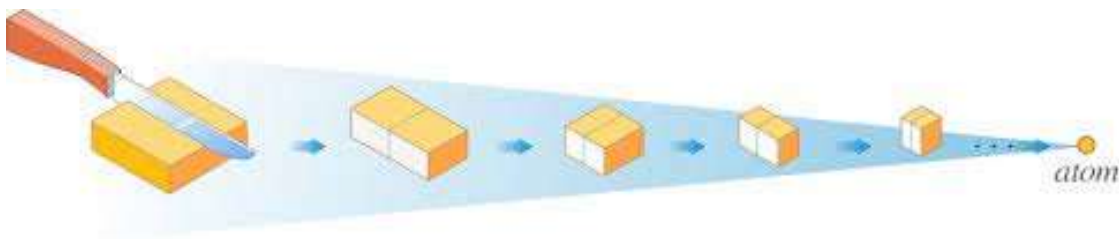
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## Introduction to the Atom

Atoms are the tiny **building blocks** of everything around us. Imagine a LEGO set; just as you can build vast and varied structures using different combinations of small LEGO pieces, everything in our **universe** is **made** up of different **combinations** of **atoms**.



The word "atom" comes from the ancient Greek word "atomos," which means "**indivisible**" or "**uncuttable**." The ancient Greeks believed that if you kept cutting matter into smaller and smaller pieces, you'd eventually reach a point where you couldn't cut it any further. They called this smallest piece "atomos."

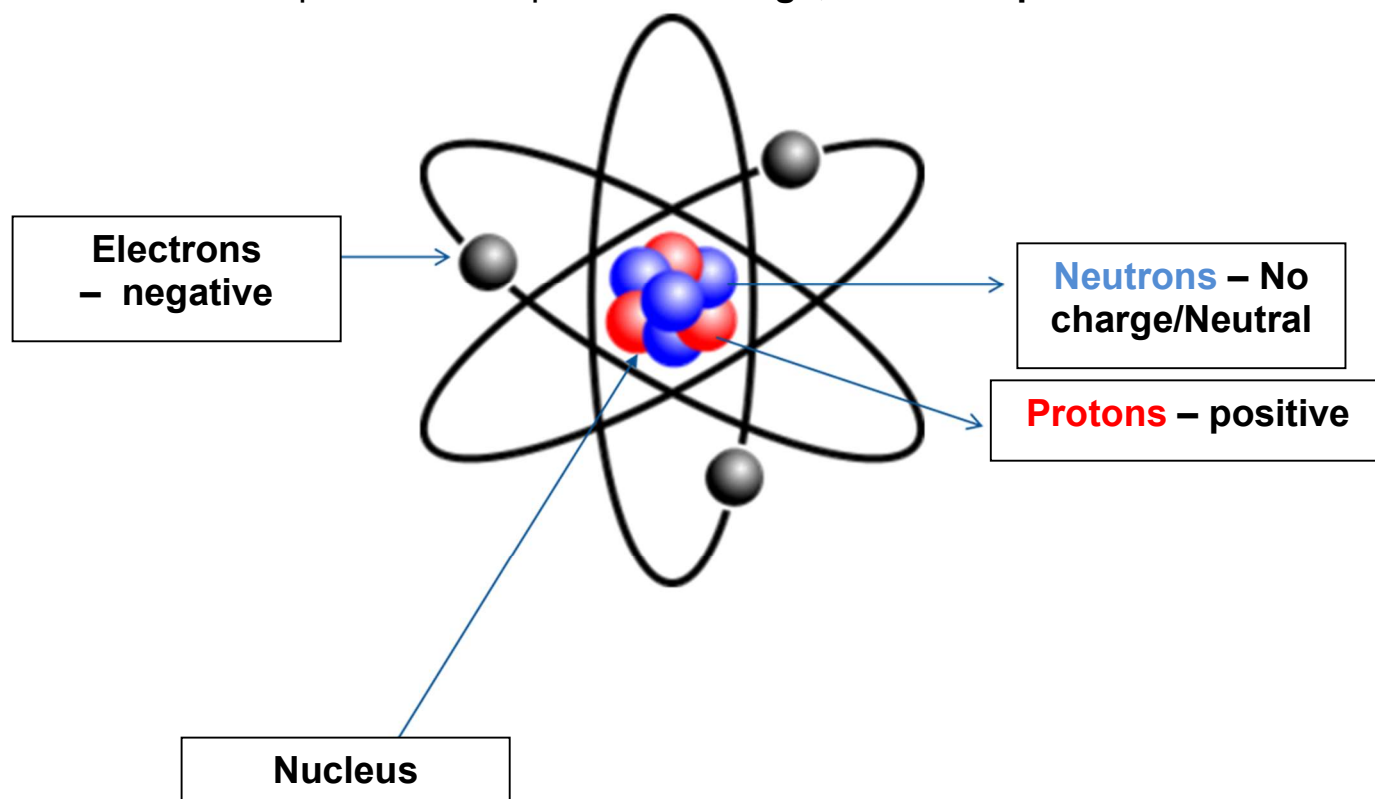


Today, we know atoms can be split into even tinier particles, but the name has stuck.

## Structure of the Atom

An atom itself is made up of a **nucleus**, which contains **protons** and **neutrons**, and **electrons** that orbit around this **nucleus**. Each smaller component of the atom is called a **sub-atomic particle**.

Each sub-atomic particle has a particular **charge**, **mass** and **position** in the atom.



Think of the nucleus as the sun in a solar system, and the electrons as the planets revolving around it.

*Fill in the table below about the charge, mass and position of each sub-atomic particle.*

Particle name	Mass (a.m.u*)	Charge	Where sub-particle is found in atom
<b>Proton</b>	1	+1	Inside the nucleus
<b>Electron</b>	0	-1	Outside the nucleus
<b>Neutron</b>	1	0 (neutral)	Inside the nucleus

a.m.u.\* = **atomic mass units**

## Atomic Number

### Learning Intentions

- To learn how the atomic structure relates to which element it is.

### Success Criteria

- I can state which sub-atomic particle relates to atomic number.
- Given the atom is neutral I can identify the number of electrons in an atom.

### Introduction to atomic number

Every atom is **unique** and can be identified by its **atomic number** (which can be found on pages 4 – 6 of the data booklet). The **atomic number** tells us the **number** of **protons** in the nucleus of an atom.

For example, **hydrogen** has an atomic number of **1** because it has one proton, while **helium** has an atomic number of **2** because it has two protons.

When an atom is **neutral**, where it has **equal numbers** of **positive** protons and **negative** electrons, the **atomic** number is also the number of **electrons**.

**Atomic Number:** Number of **protons** in the nucleus.

When **neutral**, atomic number = number of electrons also

### Questions

For the following elements with **neutral** atoms, find the atomic number, number of protons and number of electrons.

Element	Symbol	Atomic Number	Number of protons	Number of electrons
Hydrogen				
Helium				
Carbon				
Fluorine				
Neon				
Calcium				
Iron				
Gold				

## Mass number, isotopes and relative atomic mass

### Learning Intentions

- To learn how the atomic structure relates to mass number.
- To learn about isotopes and relative atomic mass.

### Success Criteria

- I can state which sub-atomic particles relate to mass number.
- I can use nuclide notation to identify the numbers of each sub-atomic particle.

### Introduction to mass number

The **mass number** is the total number of **protons** and **neutrons** in an atom's nucleus. Electrons are much lighter and don't significantly contribute to an atom's mass. So, if an atom has 2 protons and 2 neutrons, its mass number is 4.

If you are given the mass number and atomic number (number of protons) you can calculate the number of neutrons. To do this, you can subtract the mass number from the atomic number.

**Mass Number:** Total number of protons and neutrons in the nucleus.

$$\text{Mass number} = \text{protons} + \text{neutrons}$$

To find the number of neutrons given mass number and atomic number:

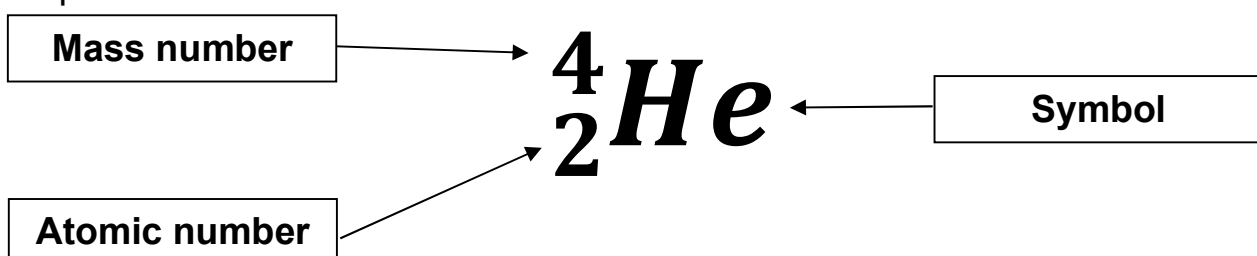
$$\text{Number of Neutrons} = \text{mass number} - \text{atomic number}$$

### Nuclide notation

Nuclide notation is a shorthand way to represent different atoms (or nuclides) and provide information about their atomic number and mass number.

The elements symbol is in the **centre**, the **atomic number** is on the **bottom left** and the mass number is on the **top left**.

Example:



## Sub-atomic particles from Nuclide notation

Nuclide notation can be used to find the number of protons, neutrons, and electrons. Again, we will assume that the atom is neutral (protons = electrons).

Example:

**Mass number**  
= protons +  
neutrons

Atomic number  
= number of  
**protons**



If there is nothing  
here, the atom is  
**neutral**

**Symbol**

*we can use our data booklet  
to find the atomic number  
from the symbol or vice  
versa*

### Questions

Complete the table below, filling out the atomic number, mass number, number of protons, neutrons, and electrons from the nuclide notation.

Nuclide Notation	Atomic Number	Number of protons	Mass Number	Number of neutrons	Number of electrons
${}^1_1\text{H}$	1	1	1	0	1
${}^2_1\text{H}$					
${}^4_2\text{He}$					
${}^7_3\text{Li}$					
${}^{12}_6\text{C}$					
${}^{14}_7\text{N}$					
${}^{16}_8\text{O}$					
${}^{19}_9\text{F}$					
${}^{23}_{11}\text{Na}$					
${}^{24}_{12}\text{Mg}$					

## Questions (extension)

Complete the table below, filling out the atomic number, mass number, number of protons, neutrons, and electrons from the nuclide notation like before. **However, this time you must use your data booklet to complete the nuclide notation.**

Nuclide Notation	Atomic Number	Number of protons	Mass Number	Number of neutrons	Number of electrons
$^1_1\text{H}$					
$^2_1$					
$^4_2$					
$^{10}_{\text{—}}\text{Ne}$					
$^{12}_6$					
$^{14}_{\text{—}}\text{N}$					
$^{16}_8$					
$^{19}_{\text{—}}\text{F}$					
$^{20}_{\text{—}}\text{Ne}$					
$^{23}_{11}$					
$^{40}_{\text{—}}\text{Ca}$					
$^{45}_{21}$					
$^{50}_{\text{—}}\text{Cr}$					
$^{52}_{24}$					
$^{55}_{\text{—}}\text{Mn}$					
$^{58}_{\text{—}}\text{Ni}$					
$^{75}_{33}$					

## Isotopes and relative atomic mass

### Learning Intentions

- To learn how to identify isotopes.
- To learn about relative atomic mass and use it to identify the most common isotope.

### Success Criteria

- I can state the definition of isotopes.
- I can identify isotopes using nuclide notations.
- I can explain what the relative atomic mass is.
- I can identify the most common isotope using relative atomic mass.
- I can calculate the relative atomic mass.

### Introduction to Isotopes

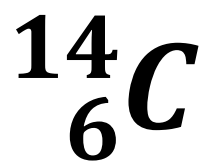
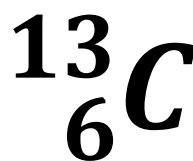
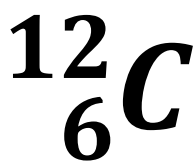
An element is defined by its atomic number (the number of protons), but the number of neutrons in its atoms can vary.

**Isotopes:** Atoms of the same **element** that have the **same** number of **protons** but **different** numbers of **neutrons**.\*

\*This means that while they have the same **atomic number** (which determines the element), but they have **different mass numbers**.

For example, there are 3 isotopes of carbon:

Nuclide  
notation:



### Number of

Protons:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Neutrons:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Electrons:

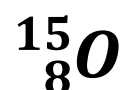
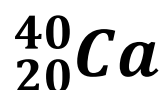
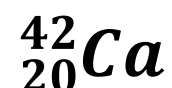
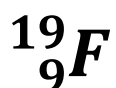
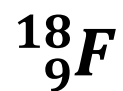
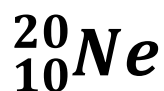
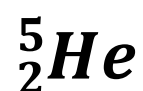
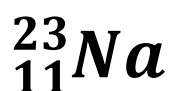
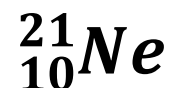
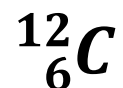
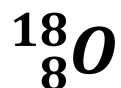
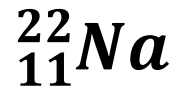
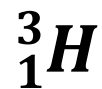
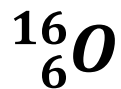
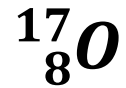
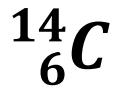
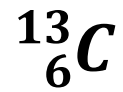
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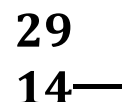
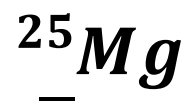
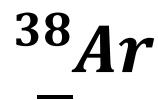
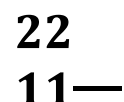
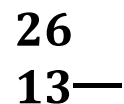
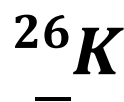
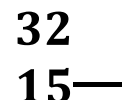
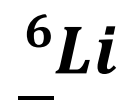
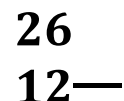
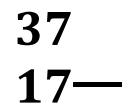
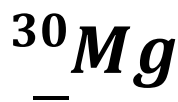
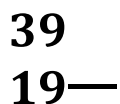
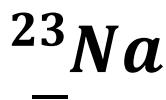
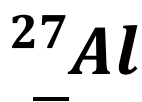
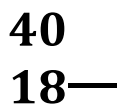
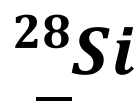
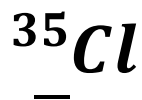
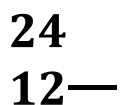
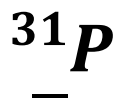
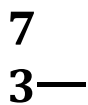
## Match the Isotope

Using a ruler, match the isotopes by drawing a line between them. There may be more than one line.



### Match the Isotope (challenge)

Using a ruler, match the isotopes by drawing a line between them. There may be more than one line. You will need to complete the nuclide notation before you begin matching them.



## Relative atomic mass (R.A.M.)

Relative atomic mass represents the **average mass** of the atoms of an element, considering all its different isotopes.

It's measured against the mass of the carbon-12 atom, which is set as a standard.

This average is crucial because elements can exist in various isotopes, each with a different mass.

Using carbon as an example:

Isotope:	${}^{12}_6\text{C}$	${}^{13}_6\text{C}$	${}^{14}_6\text{C}$
Natural Abundance (%)	98.9	1.1	0.000000001

If we were to average the mass of these isotopes, the relative atomic mass would be **12.01**.

Since we mostly have carbon-12, the average is closest to it. This tells us that carbon-12 is the most common isotope, even if we did not have the percentages.

---

The natural abundance is always referring to a sample. For example, the carbon atoms in a lump of coal.

To illustrate what this means, let's imagine we had 1,000,000 (a million) carbon atoms. Using the percentages in this sample of coal we would have:

Isotope	Mass (a.m.u)	Number of atoms
Carbon-12	12	989,000
Carbon-13	13	11,000
Carbon-14	14	0.001 (essentially 0 in practical terms)

Samples contain far too many atoms to think about them atom-by-atom. So instead of thinking about the mass of each atom and adding them up, we just find the average of these numbers, which is 12.01.

By using the relative atomic mass chemists can make accurate calculations in experiments and reactions. *We will come back to these calculations later.*

## Isotope questions (identifying the most common isotope)

Identify the most common isotope based on the given nuclide notation and relative atomic mass:

### 1. Oxygen

Isotopes :  ${}^{15}_8\text{O}$ ,  ${}^{16}_8\text{O}$ ,  ${}^{17}_8\text{O}$ ,  ${}^{18}_8\text{O}$

R.A.M: 15.999

Which isotope is most common: \_\_\_\_\_

### 2. Carbon

Isotopes :  ${}^{12}_6\text{C}$ ,  ${}^{13}_6\text{C}$

R.A.M: 12.011

Which isotope is most common: \_\_\_\_\_

### 3. Hydrogen

Isotopes :  ${}^1_1\text{H}$ ,  ${}^2_1\text{H}$ ,  ${}^3_1\text{H}$

R.A.M: 1.008

Which isotope is most common: \_\_\_\_\_

### 4. Nitrogen

Isotopes :  ${}^{14}_7\text{N}$ ,  ${}^{15}_7\text{N}$

R.A.M: 14.007

Which isotope is most common: \_\_\_\_\_

### 5. Chlorine

Isotopes :  ${}^{37}_{17}\text{Cl}$ ,  ${}^{35}_{17}\text{Cl}$

R.A.M: 35.453

Which isotope is most common: \_\_\_\_\_

**6. Boron**

Isotopes :  $^{10}_5\text{B}$ ,  $^{11}_5\text{B}$

R.A.M: 10.811

Which isotope is most common: \_\_\_\_\_

**7. Lithium**

Isotopes :  $^6_3\text{Li}$ ,  $^7_3\text{Li}$

R.A.M: 6.94

Which isotope is most common: \_\_\_\_\_

**8. Neon**

Isotopes :  $^{20}_{10}\text{Ne}$ ,  $^{21}_{10}\text{Ne}$ ,  $^{22}_{10}\text{Ne}$

R.A.M: 20.180

Which isotope is most common: \_\_\_\_\_

**9. Potassium**

Isotopes :  $^{39}_{19}\text{K}$ ,  $^{40}_{19}\text{K}$ ,  $^{41}_{19}\text{K}$

R.A.M: 39.098

Which isotope is most common: \_\_\_\_\_

**10. Magnesium**

Isotopes :  $^{24}_{12}\text{Mg}$ ,  $^{26}_{12}\text{Mg}$

R.A.M: 25.000

Given the provided isotopes and the relative atomic mass, what does this suggest about the proportion of each isotope in the sample?

\_\_\_\_\_

\_\_\_\_\_

### Optional challenge – Isotope questions (calculating relative atomic mass)

The relative atomic mass (r.a.m.) of a sample can be calculated given the following equation:

$$r.a.m. = \frac{(mass\ of\ isotope\ X \times \%\ of\ X) + (mass\ of\ isotope\ Y \times \%\ of\ Y)}{100}$$

Calculate the relative atomic mass of each of the following samples using the equation above.

1) Element: Chlorine (Cl)

- Isotope X:  $^{35}\text{Cl}$ 
  - Mass of X: 35.0 amu
  - % of X: 75.8%
- Isotope Y:  $^{37}\text{Cl}$ 
  - Mass of isotope Y: 37 amu
  - % of Y: 24.2%


2) Element: Carbon (C)

- Isotope X:  $^{12}\text{C}$ 
  - Mass of X : 12.0 amu
  - % of X: 98.9%
- Isotope Y:  $^{13}\text{C}$ 
  - Mass of isotope Y: 12.0 amu
  - % of Y: 1.1%


3) Element: Boron (B)

- Isotope X:  $^{10}\text{B}$ 
  - Mass of X : 10.0 amu
  - % of X: 19.9%
- Isotope Y:  $^{11}\text{B}$ 
  - Mass of isotope Y: 11.0 amu
  - % of Y: 80.1%


4) Element: Lithium (Li)

- Isotope X:  $^6\text{Li}$ 
  - Mass of X : 6.0 amu
  - % of X: 7.6%
- Isotope Y:  $^7\text{Li}$ 
  - Mass of isotope Y: 7.0 amu
  - % of Y: 92.4%


# Electron Arrangements

## Learning Intentions

- To learn about electron arrangements and how they relate to each element.

## Success Criteria

- I can use the data booklet to find the electron arrangements.
- I can draw electron energy level diagrams.
- I can state the 2,8,8 rule.

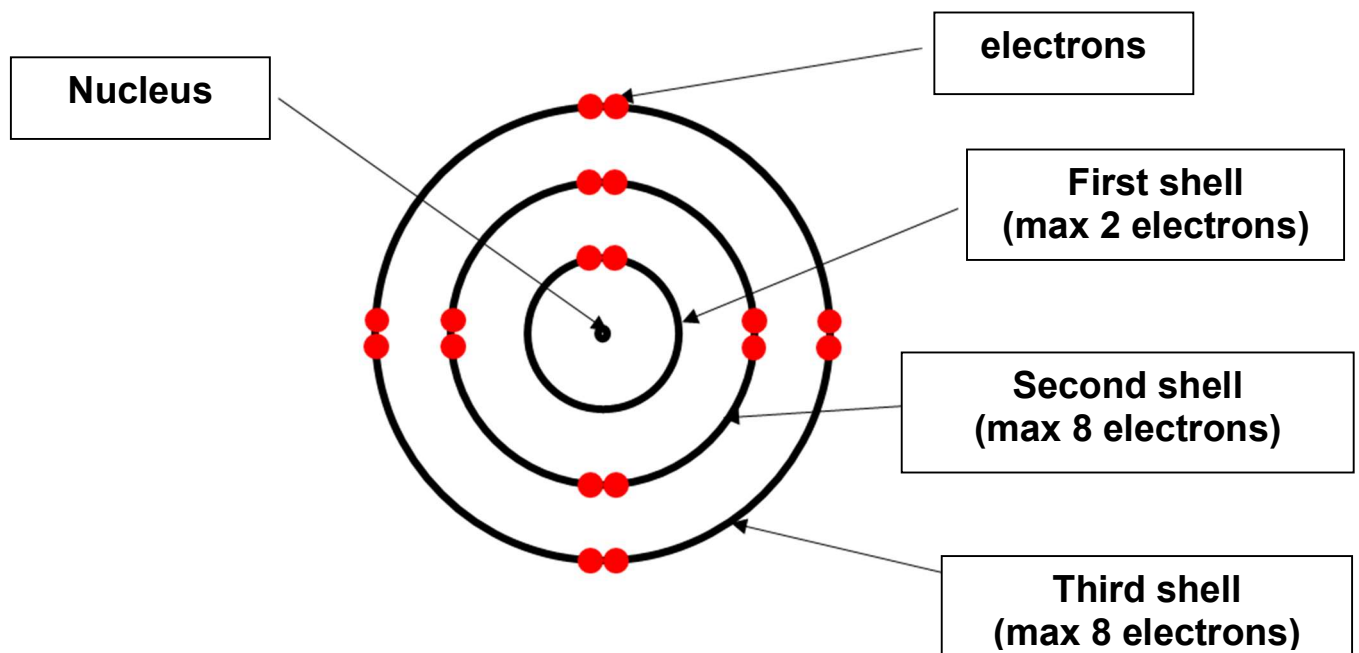
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## Introduction to electron arrangements

Atoms consist of a nucleus (containing protons and neutrons) and electrons that move around the nucleus in specific regions called **energy levels** or **shells**. The arrangement of electrons in these shells is known as the **electron arrangement**.

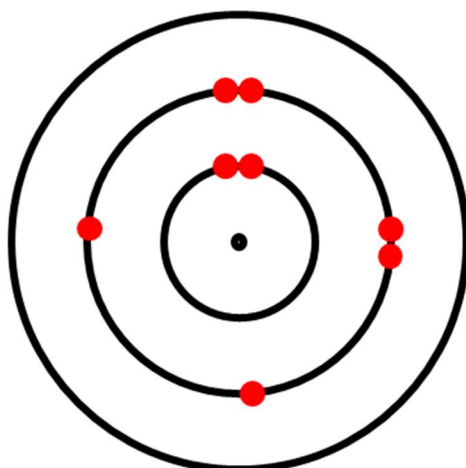
**Shells/Energy Levels:** Electrons occupy spaces called **shells** around the **nucleus**. These shells can hold a **specific** number of electrons:

- The **first** shell (closest to the nucleus) can hold up to **2** electrons.
- The **second** and **third** shells can each hold up to **8** electrons.



**Electron arrangement:** This refers to the distribution of electrons in the shells. This can be found on page 6 of your data booklet.

For example, oxygen has 8 electrons. Its electron configuration is 2,6, meaning 2 electrons in the first shell and 6 in the second. A diagram for this is shown below



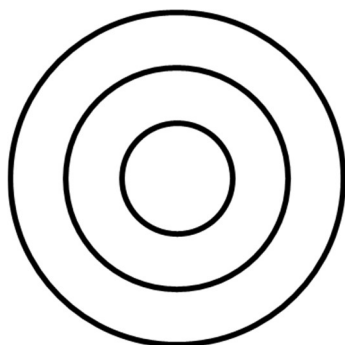
Oxygen

Electron configuration: 2,8

The electrons are filled from the inside out. Each shell must have the correct maximum number of electrons (2,8,8).

*Your teacher will show you the correct order for filling the shells with 8 electrons.*

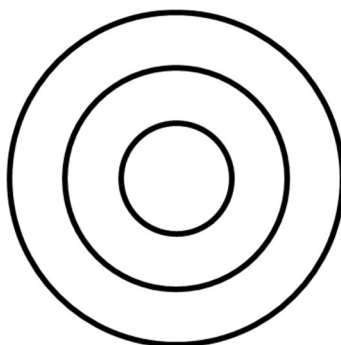
*Fill out the following electron shell diagrams with your teacher.*



Carbon

Electron arrangement

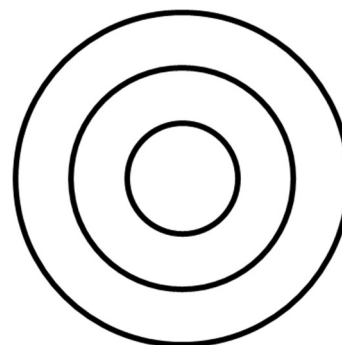
\_\_\_\_\_



Fluorine

Electron arrangement

\_\_\_\_\_



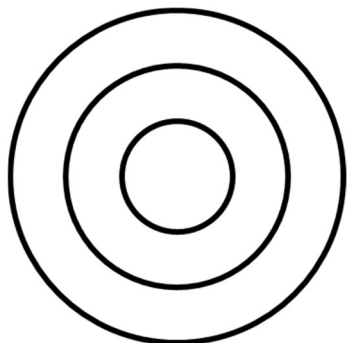
Neon

Electron arrangement

\_\_\_\_\_

## Electron Arrangement Questions

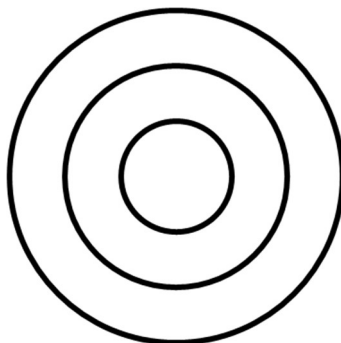
Fill out the following the diagrams and complete the information below it.



**Hydrogen**

Electron arrangement

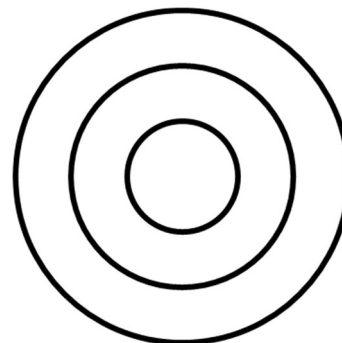
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**Helium**

Electron arrangement

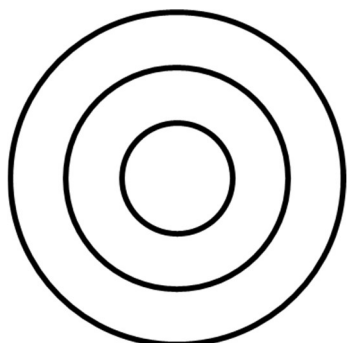
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**Beryllium**

Electron arrangement

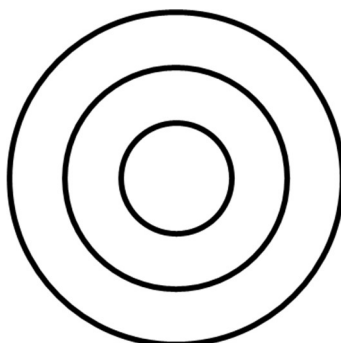
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**Boron**

Electron arrangement

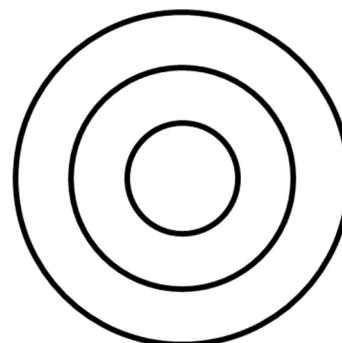
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**Nitrogen**

Electron arrangement

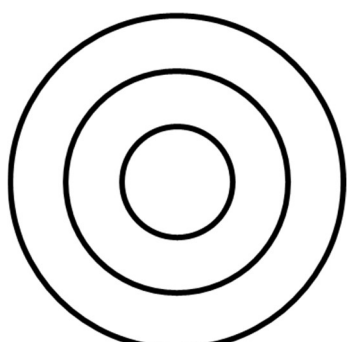
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**Sodium**

Electron arrangement

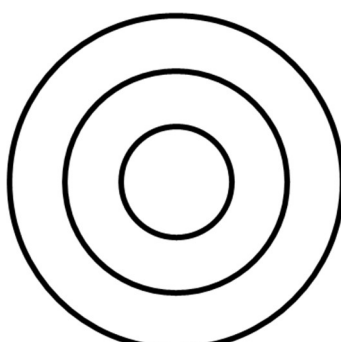
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**Aluminium**

Electron arrangement

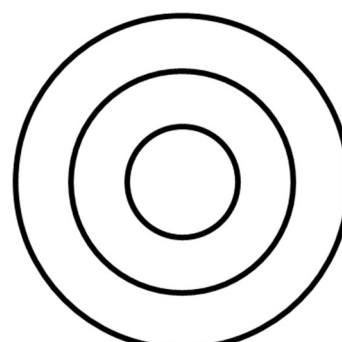
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**Phosphorus**

Electron arrangement

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**Chlorine**

Electron arrangement

---

## Electron Arrangements and Ions

### Learning Intentions

- To learn about ions and their electron arrangements.

### Success Criteria

- I can state the definition of an ion.
- I can identify if an ion will become positive or negative.
- I can use the 2,8,8 rule to find the charge of an ion.
- I can write the electron arrangement for an ion given its charge.
- I can identify isoelectronic ions.

---

### Introduction to Ions

An **ion** is an atom or group of atoms that has **gained** or **lost** one or more electrons, resulting in a net **positive** or **negative charge**.

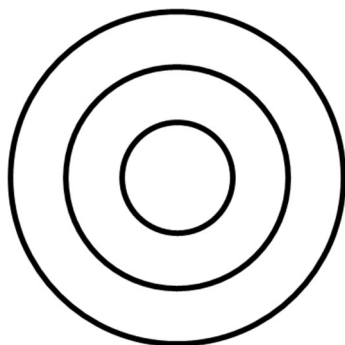
Ions are formed when atoms seek to achieve a full outer shell, making them more **stable**.

- If an atom's outer shell is not full, it might either borrow or give away electrons to achieve a full shell, turning the atom into an ion in the process.

**Atoms** are **neutral**, they have the **same** number of protons and electrons. **Ions** are **charged** because they have a **different** number of protons and electrons.

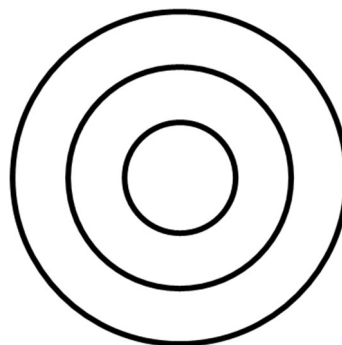
There are two main types of ions:

- **Positive ions** are formed when an atom **loses** electrons. For instance, sodium (Na) has a single electron in its third shell. By giving away this electron, sodium achieves a full second shell and becomes a positively charged ion, represented as  $\text{Na}^+$ .



**Sodium atom (Na)**  
Electron arrangement

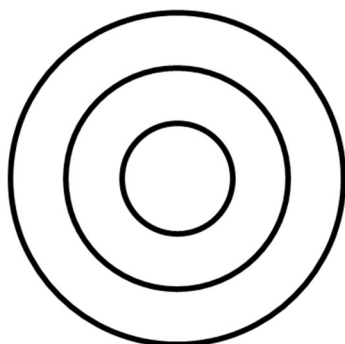
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**Sodium ion ( $\text{Na}^+$ )**  
Electron arrangement

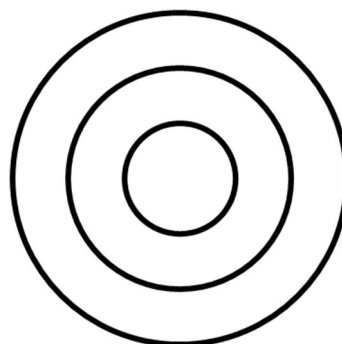
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- **Negative ions** are formed when an atom **gains** electrons. Chlorine (Cl), for example, has seven electrons in its third shell. To complete this shell, chlorine can borrow an electron, turning it into a negatively charged ion, represented as  $\text{Cl}^-$ .



**Chlorine atom (Cl)**  
Electron arrangement

---



**Chlorine ion ( $\text{Cl}^-$ )**  
Electron arrangement

---

With a full shell, ions will have the **same** electron arrangement as the nearest **noble gas** on the periodic table to that element. Remember, the noble gases are very **unreactive** and stable.

## Using the 2,8,8 rule to find the charge

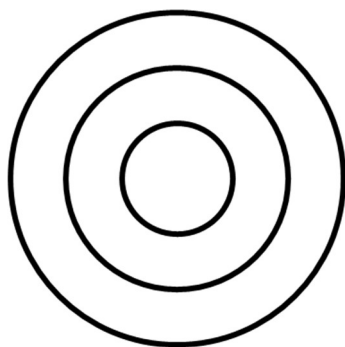
The 2,8,8 rule is particularly useful as it provides insights into the behaviour of atoms.

- Atoms with 1, 2, or 3 electrons in their outer shell might find it more favourable to **lose** these **electrons**, becoming **positive** ions.
  - Atoms losing 2/3 electrons become 2+/3+ charge, e.g.  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$
- Conversely, atoms with 5, 6, or 7 electrons in their outer shell often tend to **gain** additional electrons to achieve a **full** shell, thus becoming **negative** ions.
  - Atoms gaining 2/3 electrons become 2-/3- charge, e.g.  $\text{O}^{2-}$ ,  $\text{N}^{3-}$
- Atoms that already have a **full** outer shell, like the noble gases, are inherently **stable** and typically don't form ions.

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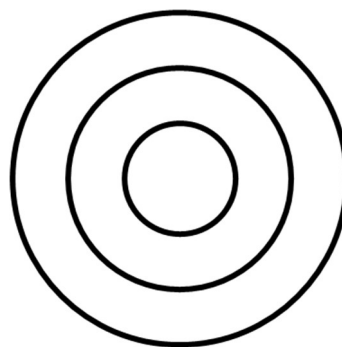
## Questions

Fill out the following electron shell diagrams for the following atoms and ions of each element. Fill out the symbol for the ion and



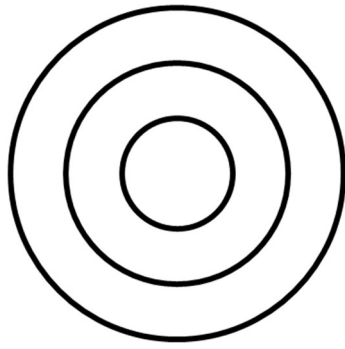
**Lithium atom (Li)**  
Electron arrangement

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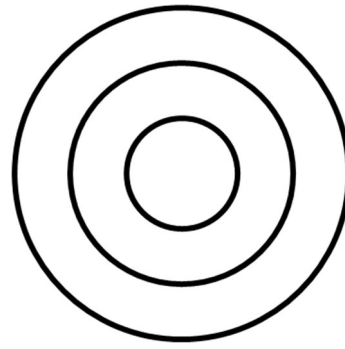
**Lithium ion (\_\_\_)**  
Electron arrangement

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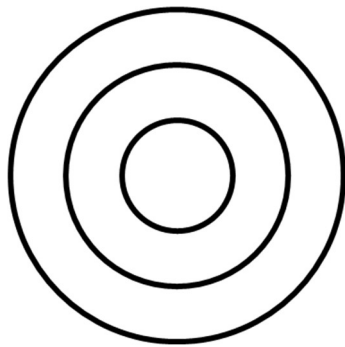
**Beryllium atom (Be)**  
Electron arrangement

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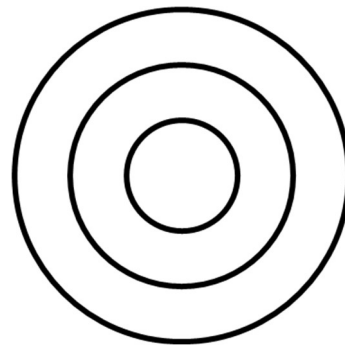
**Beryllium ion (Be<sup>2+</sup>)**  
Electron arrangement

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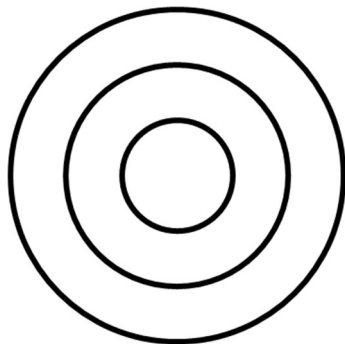
**Boron atom (B)**  
Electron arrangement

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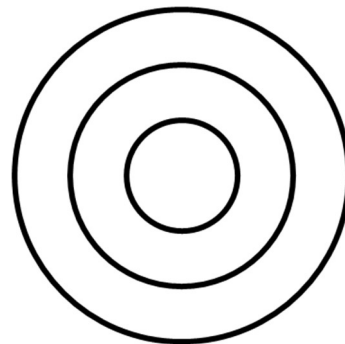
**Boron ion (B<sup>3+</sup>)**  
Electron arrangement

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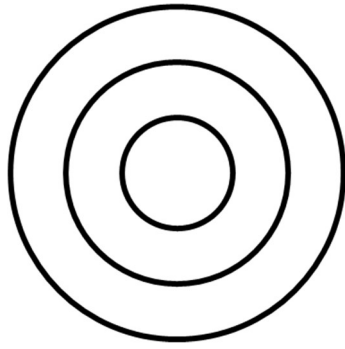
**Nitrogen atom (N)**  
Electron arrangement

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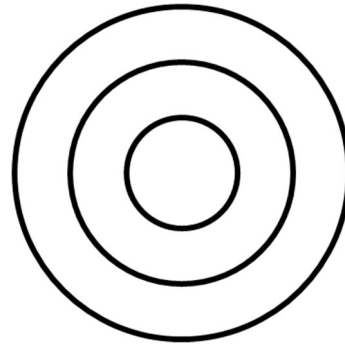
**Nitrogen ion (N<sup>3-</sup>)**  
Electron arrangement

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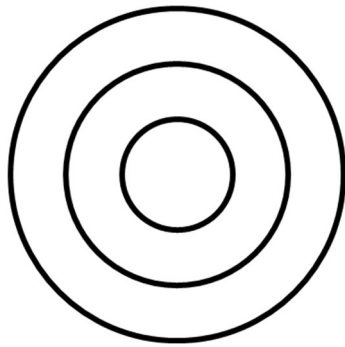
**Oxygen atom (O)**  
Electron arrangement

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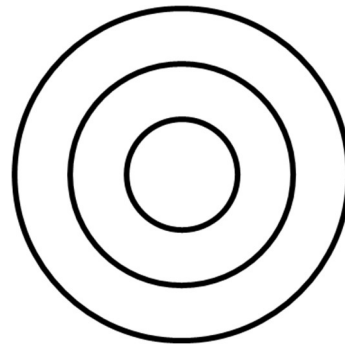
**Oxygen ion (\_\_\_)**  
Electron arrangement

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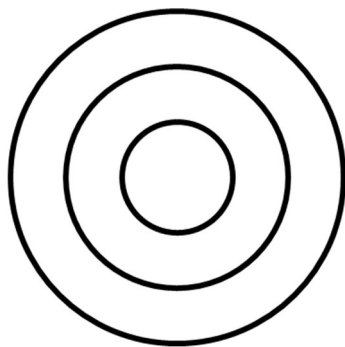
**Fluorine atom (F)**  
Electron arrangement

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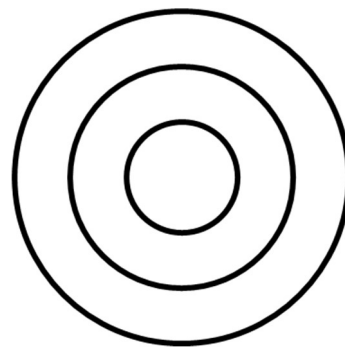
**Fluorine ion (\_\_\_)**  
Electron arrangement

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**Sulfur atom (S)**  
Electron arrangement

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**Sulfur ion (\_\_\_)**  
Electron arrangement

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## Questions (electron arrangements of ions)

Complete the following table

Nuclide Notation	Number of protons	Mass Number	Number of neutrons	Number of electrons	Electron arrangement
${}^1_1\text{H}^+$	1	1	0		
${}^4_2\text{He}$					
${}^7_3\text{Li}^+$					
${}^{14}_7\text{N}^{3-}$					
${}^{16}_8\text{O}^{2-}$					
${}^{19}_9\text{F}^-$					
${}^{23}_{11}\text{Na}^+$					
${}^{24}_{12}\text{Mg}^{2+}$					
${}^{32}_{16}\text{S}^{2-}$					
${}^{35}_{17}\text{Cl}^-$					
${}^{41}_{20}\text{Ca}^{2+}$					
${}^{80}_{35}\text{Br}^-$					

Do you notice pattern with the electron arrangement of ions?

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Which group in the periodic table do ions have the same electron arrangements?

**Explain** why this is significant.

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## **PHET Atom builder (laptop required - (google: PHET atom builder))**

*Follow the tasks below and tick the box once you have completed each task.*

### **Part 1: Basic Atomic Structure**

- Task 1.1:** Open the "Build an Atom" simulation.
- Task 1.2:** Drag 1 proton onto the nucleus. Note the element's name.
- Task 1.3:** Add 1 electron. Observe the atom's charge.
- Task 1.4:** Keep adding protons up to 5, noting the element's name after each addition.

### **Part 2: Neutrons and Isotopes**

- Task 2.1:** Start with an atom having 3 protons and 3 electrons.
- Task 2.2:** Add 1 neutron. Note any changes in the atom's name or symbol.
- Task 2.3:** Continue adding neutrons up to 5. Observe the atom's mass number.

### **Part 3: Ions**

- Task 3.1:** Begin with a neutral helium atom (2 protons, 2 electrons).
- Task 3.2:** Remove 1 electron to form a cation. Note the charge.
- Task 3.3:** Add back 3 electrons to form an anion. Observe the charge.

### **Part 4: Challenge Tasks**

- Task 4.1:** Create an atom with a mass number of 7 and a +1 charge. Identify the element.
- Task 4.2:** Construct a neutral carbon isotope. Determine its mass number.
- Task 4.3:** Build a negative ion of oxygen. Note its electron configuration.

### **Part 5: Periodic Table Exploration**

- Task 5.1:** Navigate to the "Periodic Table" tab.
- Task 5.2:** Hover over elements to see their atomic details.
- Task 5.3:** Pick an element and replicate it in the "Build an Atom" section.

### **Part 6: Test Your Knowledge**

- Task 6.1:** Click on the "Game" tab.
- Task 6.2:** Complete at least 5 challenges, building or identifying atoms as instructed.

## Questions (challenge)

**Isoelectronic** refers to different atomic or ionic species that have the same number of electrons and hence the **same electronic arrangement**.

- Which of the following pairs of ions are isoelectronic, meaning they have the same number of electrons?
  - $\text{Na}^+$  and  $\text{Mg}^{2+}$
  - $\text{O}^{2-}$  and  $\text{F}^-$
  - $\text{N}^{3-}$  and  $\text{O}^{2-}$
  - $\text{Ca}^{2+}$  and Ar
- Which of the following pairs of ions are isoelectronic?
  - $\text{K}^+$  and  $\text{Cl}^-$
  - $\text{S}^{2-}$  and  $\text{Cl}^-$
  - $\text{Mg}^{2+}$  and Ne
  - $\text{Li}^+$  and  $\text{H}^-$
- Which ion is not isoelectronic with Ne?
  - $\text{Li}^+$
  - $\text{O}^{2-}$
  - $\text{F}^-$
  - $\text{Mg}^{2+}$
- Which pair of ions do not have the same electron arrangement?
  - $\text{P}^{3-}$  and  $\text{S}^{2-}$
  - $\text{Al}^{3+}$  and Ne
  - $\text{K}^+$  and Ar
  - $\text{Ca}^{2+}$  and Ne
- Which ion is not isoelectronic with Ar?
  - $\text{K}^+$
  - $\text{Cl}^-$
  - $\text{Ca}^{2+}$
  - $\text{O}^{2-}$

