

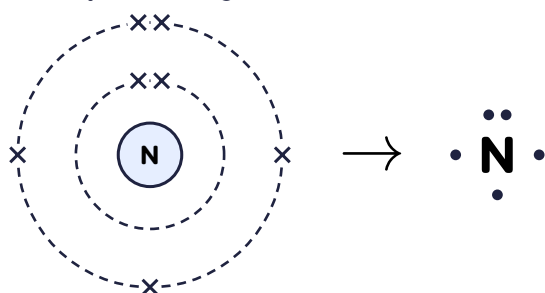
Lewis diagrams and ions

Name _____ Class _____ Mark _____ / 37

What you are practising

I can draw a Lewis diagram for an atom from its electron arrangement, and use it to show the ion the atom forms.

Worked example: nitrogen



Bohr diagram, 2, 5

Lewis diagram

Nitrogen has the electron arrangement 2, 5. Only the outer shell takes part in reactions, so a Lewis diagram keeps only those 5 outer electrons.

The symbol N stands for the nucleus and the inner shell.

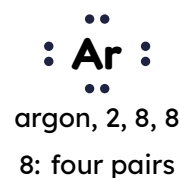
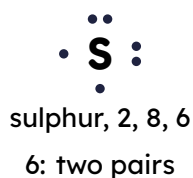
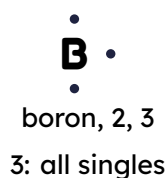
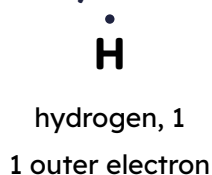
The rules

1. Write the electron arrangement. The last number is the number of outer (valence) electrons.
2. Write the symbol. It stands for the nucleus and all the inner shells.
3. Place the outer electrons at N, E, S and W, one at a time.
4. Pair them up only once all four places have one electron. This is the same rule you use for Bohr diagrams.

Check: the number of dots = the number of outer electrons. For groups 1 to 7 this is the group number. Group 8 (0) has a full outer shell of 8 (helium has 2).

In a Lewis diagram a **dot** is one of the atom's own electrons. A **cross** is an electron the atom has gained from another atom. You will need crosses when you draw negative ions.

Examples to check your rules against



1 Draw the atoms**[12]**

Complete the table. Find the group on your periodic table. One mark for each complete, correct row.

Element	Z	Electron arrangement	Group	Outer electrons	Lewis diagram
lithium (Li)	3				
beryllium (Be)	4				
carbon (C)	6				
nitrogen (N)	7				
oxygen (O)	8				
fluorine (F)	9				
neon (Ne)	10				
sodium (Na)	11				
magnesium (Mg)	12				
aluminium (Al)	13				
chlorine (Cl)	17				
calcium (Ca)	20				

2 Spot the pattern

[4]

(a) Lithium and sodium are both in group 1. What do their Lewis diagrams have in common? [1]

(b) Complete the sentence. [1]

The number of dots in a Lewis diagram is the same as the number of _____ electrons.
For groups 1 to 7 this is the same as the _____ number.

(c) Neon's Lewis diagram has four pairs: its outer shell is full. Explain why an atom with a full outer shell does not react. [2]

3 Fix the diagram

[6]

Each Lewis diagram below has one mistake. Say what is wrong, then draw the correct diagram in the box. Two marks each.

a



chlorine, 2, 8, 7

What is wrong?

Correct diagram

b



magnesium, 2, 8, 2

What is wrong?

Correct diagram

c



carbon, 2, 4

What is wrong?

Correct diagram

Atoms to ions

When an atom loses or gains electrons it becomes an **ion**.

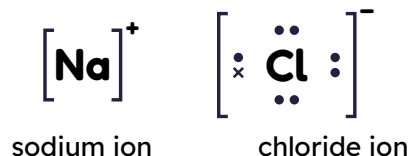
Charge = number of protons – number of electrons.

A charge of +2 is written as 2+ at the top right of the symbol.

Draw an ion in square brackets with its charge at the top right.

A **metal** ion has lost its outer electrons, so no dots are shown.

A **non-metal** ion has a full outer shell of 8. Show the gained electrons as crosses.



4 From atom to ion

[8]

Complete the table. The first row is done for you. One mark for each complete, correct row.

Atom	Arrangement	Loses or gains? How many?	Protons	Electrons in the ion	Charge	Lewis diagram of the ion
chlorine (Cl)	2, 8, 7	gains 1	17	18	–1	$\left[\begin{array}{c} \cdot\cdot \\ \times \text{Cl} \cdot\cdot \\ \cdot\cdot \end{array} \right]^-$
sodium (Na)						
potassium (K)						
magnesium (Mg)						
calcium (Ca)						
aluminium (Al)						
fluorine (F)						
oxygen (O)						
sulphur (S)						

5 Explain**[5]**

(a) A sodium atom loses one electron but a chlorine atom gains one. Explain why. Say where each atom's outer electrons are, how strongly the nucleus attracts them, and what each atom ends up with. **[3]**

(b) The ions Na^+ , Mg^{2+} and Al^{3+} all have the same electron arrangement. What is it, and which noble gas has the same arrangement? **[2]**

Arrangement

Noble gas

6 Who is right?**[2]****Ana**

A sodium atom has 11 protons and 11 electrons. It loses one electron, so it has 11 protons and 10 electrons. The charge is +1.

Ben

Sodium loses one electron. Something has been taken away, so the charge goes down. The sodium ion has a charge of -1.

Who is right? Explain the mistake the other person made.

Part 1 debrief

I can draw a Lewis diagram from an electron arrangement.

I can work out the charge on an ion.

I can draw a Lewis diagram for an ion.

1 = not yet 2 = with help 3 = on my own 4 = could teach it

1	2	3	4
1	2	3	4
1	2	3	4

1.7

Ions, formulae, equations

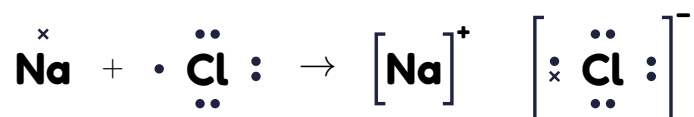
Name _____ Class _____ Mark _____ / 41

What you are practising

I can use ion charges to write the formula of a compound, and balance an equation by changing only the numbers in front of each formula.

7 How sodium chloride forms**[4]**

Here sodium's outer electron is drawn as a cross so you can follow it.



Complete the sentences. One mark for each line.

A sodium atom _____ one electron and becomes a _____ ion, Na^+ .

A chlorine atom _____ that electron and becomes a _____ ion, Cl^- .

The ions are held together because _____

Sodium chloride is a huge network of ions. The ratio of Na to Cl is _____.

Ions to formulae

In a compound the positive and negative charges cancel out: the total charge is zero.

Write the metal first. A small number after a symbol shows there is more than one of that ion.

This is what the ion jigsaw showed: every tab filled.

 Na^+ and Cl^-

$(+1) + (-1) = 0$, so one of each: **NaCl**

 Mg^{2+} and Cl^-

One Cl^- is not enough. $(+2) + (-1) + (-1) = 0$, so two Cl^- : **MgCl_2**

8 Write the formulae**[15]**

Write the formula of the compound each pair of ions makes. One mark for each.

	Na^+	K^+	Mg^{2+}	Ca^{2+}	Al^{3+} Level 3
Cl^-					
O^{2-}					
S^{2-}					

9 Explain**[2]**

Why is calcium chloride CaCl_2 and not CaCl ?

How to balance: one step at a time

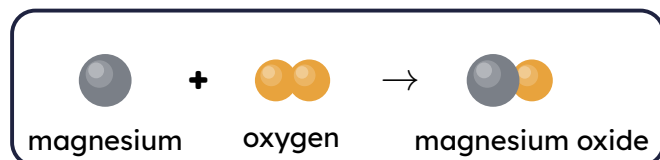
1. Write the formulae. Never change them.
2. **Start row:** count each type of atom on the left (L) and right (R).
3. Find an element that does not match. Fix it with a number in front of the **compound with the most atoms in its formula** first (for example H_2O or MgO).
4. Leave elements on their own (Mg , Na , Li , H_2 , O_2 , Cl_2) until last: changing them does not upset anything else.
5. After every change, write a new row and count again. Stop when every L matches its R.

Write 1 in a box if no number is needed.

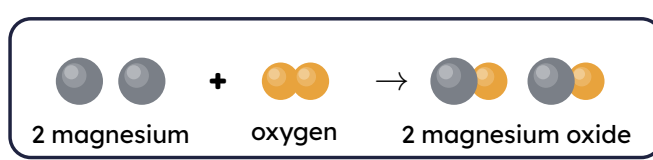
10 Why equations need balancing

[4]

When you burned magnesium, the mass went up. Oxygen atoms from the air joined the magnesium atoms. Atoms are not made or destroyed in a reaction, so the same atoms must be on both sides of the equation.



One of each: $\text{Mg} + \text{O}_2 \rightarrow \text{MgO}$



Balanced: $2 \text{Mg} + \text{O}_2 \rightarrow 2 \text{MgO}$

We cannot change MgO into MgO_2 ; that would be a different substance. We change the numbers in front instead.

(a) Fill in the counts in the step table. The changes are given. One mark for each row.

[3]

Step	What I changed	Mg		O	
		L	R	L	R
Start	count the atoms				
1	2 in front of MgO				
2	2 in front of Mg				

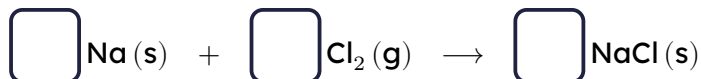
(b) Your magnesium oxide was heavier than the magnesium ribbon. Use the balanced equation to explain why.

[1]

11 Balance with a step table: (a)

[2]

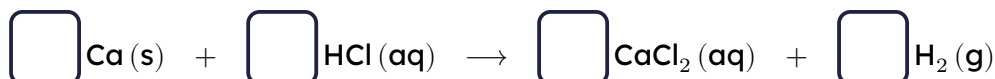
Balance each equation with a step table, then fill in the boxes. Use as many rows as you need. One mark for the boxes, one for the table.



Step	What I changed	Na		Cl	
		L	R	L	R
Start	count the atoms				
1					
2					
3					

11 Balance with a step table: (b)

[2]



Hint: calcium chloride is CaCl_2 (question 8). Do not change it.

Step	What I changed	Ca		H		Cl	
		L	R	L	R	L	R
Start	count the atoms						
1							
2							
3							

11 Balance with a step table: (c)

[2]

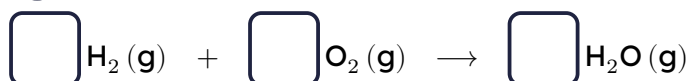


This is the reaction from the alkali metals demo.

Step	What I changed	Li		H		O	
		L	R	L	R	L	R
Start	count the atoms						
1							
2							
3							

11 Balance with a step table: (d)

[2]

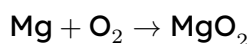


Step	What I changed	H		O	
		L	R	L	R
Start	count the atoms				
1					
2					
3					

12 Who is right?

[2]

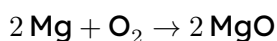
Sam



Now there are 2 oxygen atoms on each side, so it balances.

Who is right? What rule did the other person break?

Priya



I put a 2 in front of MgO, then a 2 in front of Mg.

13 On your own

[6]

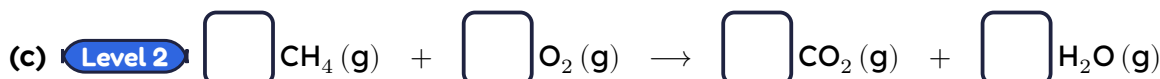
Fill in the boxes. Use a step table in the space at the side if it helps.



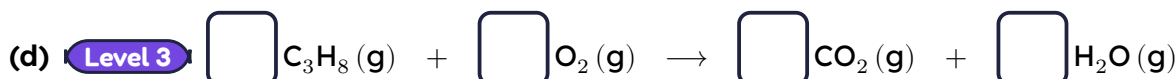
[1]



[1]



[2]



[2]

Part 2 debrief

I can use ion charges to write a formula.

I can balance an equation without changing a formula.

1 = not yet 2 = with help 3 = on my own 4 = could teach it

1	2	3	4
1	2	3	4

Answers**1 Draw the atoms****[12]**

Element	Z	Electron arrangement	Group	Outer electrons	Lewis diagram
lithium (Li)	3	2, 1	1	1	$\cdot \text{Li}$
beryllium (Be)	4	2, 2	2	2	$\cdot \text{Be} \cdot$
carbon (C)	6	2, 4	4	4	$\cdot \overset{\cdot}{\underset{\cdot}{\text{C}}} \cdot$
nitrogen (N)	7	2, 5	5	5	$\cdot \overset{\cdot}{\underset{\cdot}{\text{N}}} \cdot$
oxygen (O)	8	2, 6	6	6	$\cdot \overset{\cdot}{\underset{\cdot}{\text{O}}} \cdot$
fluorine (F)	9	2, 7	7	7	$\cdot \overset{\cdot}{\underset{\cdot}{\text{F}}} \cdot$
neon (Ne)	10	2, 8	8 (0)	8	$:\overset{\cdot}{\underset{\cdot}{\text{Ne}}}: \cdot$
sodium (Na)	11	2, 8, 1	1	1	$\cdot \text{Na}$
magnesium (Mg)	12	2, 8, 2	2	2	$\cdot \text{Mg} \cdot$
aluminium (Al)	13	2, 8, 3	3	3	$\cdot \overset{\cdot}{\underset{\cdot}{\text{Al}}} \cdot$
chlorine (Cl)	17	2, 8, 7	7	7	$\cdot \overset{\cdot}{\underset{\cdot}{\text{Cl}}} \cdot$
calcium (Ca)	20	2, 8, 8, 2	2	2	$\cdot \text{Ca} \cdot$

[4]

- [6]**

[6]

1.4–1.7 C · Electrons to equations · 12/16

4 From atom to ion

[8]

Atom	Arrange- ment	Loses or gains? How many?	Protons	Electrons in the ion	Charge	Lewis diagram of the ion
chlorine (Cl)	2, 8, 7	gains 1	17	18	-1	$\left[\begin{array}{c} \times \ddot{\text{Cl}} : \\ : \end{array} \right]^{-}$
sodium (Na)	2, 8, 1	loses 1	11	10	+1	$[\text{Na}]^{+}$
potassium (K)	2, 8, 8, 1	loses 1	19	18	+1	$[\text{K}]^{+}$
magnesium (Mg)	2, 8, 2	loses 2	12	10	+2	$[\text{Mg}]^{2+}$
calcium (Ca)	2, 8, 8, 2	loses 2	20	18	+2	$[\text{Ca}]^{2+}$
aluminium (Al)	2, 8, 3	loses 3	13	10	+3	$[\text{Al}]^{3+}$
fluorine (F)	2, 7	gains 1	9	10	-1	$\left[\begin{array}{c} \times \ddot{\text{F}} : \\ : \end{array} \right]^{-}$
oxygen (O)	2, 6	gains 2	8	10	-2	$\left[\begin{array}{c} \times \ddot{\text{O}} : \\ : \times \end{array} \right]^{2-}$
sulphur (S)	2, 8, 6	gains 2	16	18	-2	$\left[\begin{array}{c} \times \ddot{\text{S}} : \\ : \times \end{array} \right]^{2-}$

5 Explain

[5]

(a) Sodium's one outer electron is in the third shell, far from the nucleus, so it is only weakly attracted and is easily lost. [1] Chlorine has 7 outer electrons, one missing from a full shell, and its nucleus pulls strongly on electrons, so it gains one. [1] Both end up with a full outer shell. [1]

(b) 2, 8 [1] neon [1]

6 Who is right?

[2]

Ana is right. [1] Ben forgot that electrons are negative. Losing a negative electron leaves more protons than electrons, so the charge is +1, not -1. [1]

Answers**7 How sodium chloride forms****[4]**

A sodium atom **loses** one electron and becomes a **positive** ion. [1]

A chlorine atom **gains** that electron and becomes a **negative (chloride)** ion. [1]

The ions are held together because **the positive and negative ions attract each other (electrostatic attraction)**. [1]

The ratio of Na to Cl is **1:1**. [1]

8 Write the formulae**[15]**

	Na ⁺	K ⁺	Mg ²⁺	Ca ²⁺	Al ³⁺ Level 3
Cl ⁻	NaCl	KCl	MgCl ₂	CaCl ₂	AlCl ₃
O ²⁻	Na ₂ O	K ₂ O	MgO	CaO	Al ₂ O ₃
S ²⁻	Na ₂ S	K ₂ S	MgS	CaS	Al ₂ S ₃

9 Explain**[2]**

A calcium ion has a charge of 2+ and a chloride ion has a charge of 1-. [1] Two chloride ions are needed to cancel the 2+, so the formula has two Cl: CaCl₂. [1]

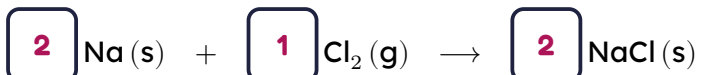
10 Why equations need balancing**[4]****(a) [3]**

Step	What I changed	Mg		O	
		L	R	L	R
Start	count the atoms	1	1	2	1
1	2 in front of MgO	1	2	2	2
2	2 in front of Mg	2	2	2	2

(b) The oxygen atoms from the air are now part of the magnesium oxide, so the product has the mass of the magnesium plus the oxygen. [1]

11 (a)

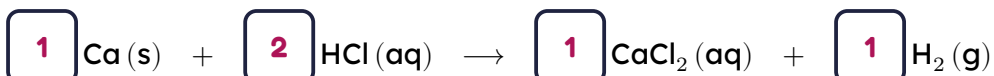
[2]



Step	What I changed	Na		Cl	
		L	R	L	R
Start	count the atoms	1	1	2	1
1	2 in front of NaCl	1	2	2	2
2	2 in front of Na	2	2	2	2

11 (b)

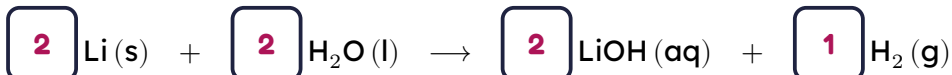
[2]



Step	What I changed	Ca		H		Cl	
		L	R	L	R	L	R
Start	count the atoms	1	1	1	2	1	2
1	2 in front of HCl	1	1	2	2	2	2

11 (c)

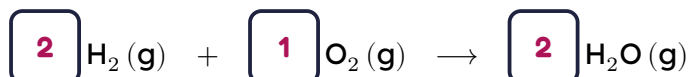
[2]



Step	What I changed	Li		H		O	
		L	R	L	R	L	R
Start	count the atoms	1	1	2	3	1	1
1	2 in front of LiOH	1	2	2	4	1	2
2	2 in front of H ₂ O	1	2	4	4	2	2
3	2 in front of Li	2	2	4	4	2	2

11 (d)

[2]



Step	What I changed	H		O	
		L	R	L	R
Start	count the atoms	2	2	2	1
1	2 in front of H ₂ O	2	4	2	2
2	2 in front of H ₂	4	4	2	2

12 Who is right?

[2]

Priya is right. [1] Sam changed the formula MgO into MgO₂. You must only change the numbers in front; changing a formula makes a different substance. [1]

13 On your own

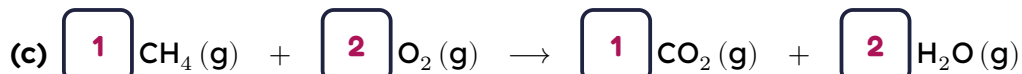
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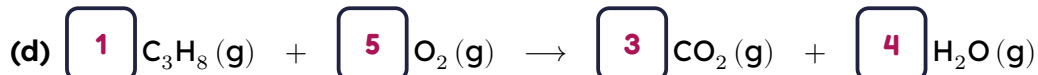
[1]



[1]



[2]



[2]

How to revise this

Look at a question you got wrong. Cover the answer, write it again from memory, then check. Repeat only the ones you missed. For Lewis diagrams, cover the table and redraw from the electron arrangement. For equations, redo the count table until every row matches.