

Dot-and-Cross Diagrams

Simulation: edtechsims.com/dot-and-cross-diagrams

Name: _____ Class: _____ Date: _____



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Part A: Electronic Configurations

A1 Complete Table 1.

[8]

Element	Proton number	Electronic configuration	Valence electrons	To get a noble gas configuration, it...	Ion formed
Sodium, Na	11	2.8.1	1	Loses 1 electron	Na ⁺
Magnesium, Mg	12				
Calcium, Ca	20				
Oxygen, O	8	2.6	6	Gains 2 (or shares 2)	O ²⁻
Chlorine, Cl	17				
Nitrogen, N	7				
Carbon, C	6				
Hydrogen, H	1				

Table 1

Part B: Ionic Compounds

On the sim: Open the Builder and choose ionic compounds. Build NaCl, MgO and MgCl₂, transferring electrons from the metal to the non-metal.

Fig. 1 shows the dot-and-cross diagram of sodium chloride, with all shells shown. (× = electrons from Na, • = electrons from Cl)

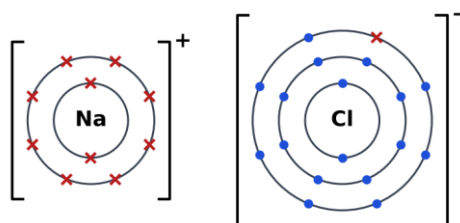


Fig. 1

B1 Complete the rules for drawing ionic dot-and-cross diagrams.

[4]

The metal atom _____ its valence electrons and the non-metal atom _____ them. Each ion is drawn inside _____, with its _____ written at the top right.

B2 Complete Table 2.

[6]

Compound	Electrons lost by each metal atom	Cation	Anion	Ratio of cation : anion	Formula
Sodium chloride	1	Na ⁺	Cl ⁻	1 : 1	NaCl
Magnesium oxide					
Magnesium chloride					
Sodium oxide					
Calcium fluoride					
Potassium sulfide					

Table 2

B3 Draw dot-and-cross diagrams, showing all shells, for magnesium oxide and calcium fluoride. [4]

Magnesium oxide, MgO

Calcium fluoride, CaF₂

Part C: Covalent Molecules

On the sim: In the Builder, choose Covalent molecules. Build H_2O , NH_3 , CO_2 and N_2 , placing shared pairs in the overlap between atoms.

C1 Complete the sentences.

[3]

In a covalent bond, a pair of electrons is _____ between two non-metal atoms. A double bond contains _____ shared pairs. Electrons in the outer shell that are not shared are called _____ (non-bonding electrons).

C2 Complete Table 3.

[10]

Molecule	Number of shared pairs in the molecule	Type(s) of bond	Lone pairs on the central atom
H_2	1	Single	0 (on each H)
Cl_2			
HCl			
H_2O	2	Single	2 (on O)
NH_3			
CH_4			
O_2			
N_2			
CO_2			
C_2H_4			

Table 3

C3 Draw dot-and-cross diagrams, showing all shells, for water, ammonia, carbon dioxide and nitrogen.

[8]

Water, H_2O

Ammonia, NH_3

Carbon dioxide, CO_2

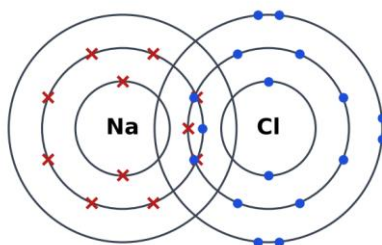
Nitrogen, N_2

Part D: Spot the Mistake

On the sim: Open the Spot the Mistake tab and try the diagrams there. Then find the mistake in each diagram below.

D1 A student's diagram of sodium chloride.

[2]



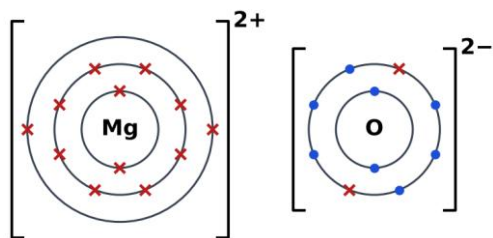
Mistake and correction:

.....

.....

D2 A student's diagram of magnesium oxide.

[2]



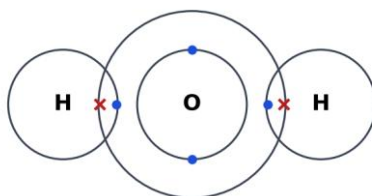
Mistake and correction:

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D3 A student's diagram of water.

[2]



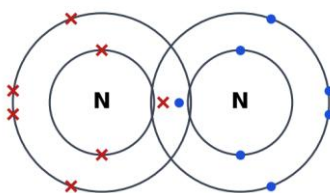
Mistake and correction:

.....

.....

D4 A student's diagram of nitrogen.

[2]



Mistake and correction:

.....

.....

Part E: Practice Questions

E1 Aluminium (2.8.3) reacts with oxygen (2.6) to form aluminium oxide.

(a) State the charges on the two ions formed. [2]

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(b) Deduce the formula of aluminium oxide. Explain your answer using the charges. [2]

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E2 Explain why the formula of water is H_2O and not HO , in terms of electrons. [2]

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E3 Compare how the bonds form in magnesium chloride and in hydrogen chloride. [3]

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Answer Key: Dot-and-Cross Diagrams

Part A: Electronic Configurations

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Calcium, Ca	20	2.8.8.2	2	Loses 2	Ca ²⁺
Oxygen, O	8	2.6	6	Gains 2 (or shares 2)	O ²⁻
Chlorine, Cl	17	2.8.7	7	Gains 1 (or shares 1)	Cl ⁻
Nitrogen, N	7	2.5	5	Shares 3	—
Carbon, C	6	2.4	4	Shares 4	—
Hydrogen, H	1	1	1	Shares 1	—

Table 1

Part B: Ionic Compounds

On the sim: Open the Builder and choose Ionic compounds. Build NaCl, MgO and MgCl₂, transferring electrons from the metal to the non-metal.

Fig. 1 shows the dot-and-cross diagram of sodium chloride, with all shells shown. (× = electrons from Na, • = electrons from Cl)

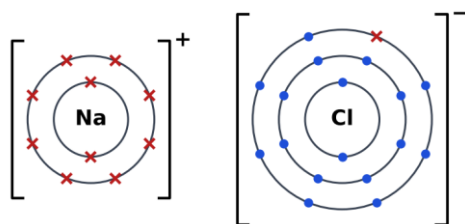


Fig. 1

B1 Complete the rules for drawing ionic dot-and-cross diagrams.

[4]

The metal atom **loses** its valence electrons and the non-metal atom **gains** them. Each ion is drawn inside **square brackets**, with its **charge** written at the top right.

B2 Complete Table 2.

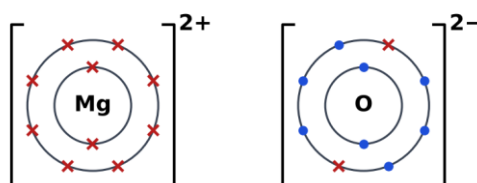
[6]

Compound	Electrons lost by each metal atom	Cation	Anion	Ratio of cation : anion	Formula
Sodium chloride	1	Na ⁺	Cl ⁻	1 : 1	NaCl
Magnesium oxide	2	Mg ²⁺	O ²⁻	1 : 1	MgO
Magnesium chloride	2	Mg ²⁺	Cl ⁻	1 : 2	MgCl ₂
Sodium oxide	1	Na ⁺	O ²⁻	2 : 1	Na ₂ O
Calcium fluoride	2	Ca ²⁺	F ⁻	1 : 2	CaF ₂
Potassium sulfide	1	K ⁺	S ²⁻	2 : 1	K ₂ S

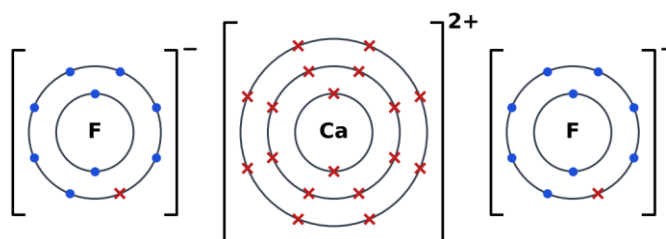
Table 2

B3 Draw dot-and-cross diagrams, showing all shells, for magnesium oxide and calcium fluoride. [4]

Magnesium oxide, MgO



Calcium fluoride, CaF₂



or one Ca²⁺ ion with a big two in front of F⁻ ion

Part C: Covalent Molecules

On the sim: In the Builder, choose Covalent molecules. Build H₂O, NH₃, CO₂ and N₂, placing shared pairs in the overlap between atoms.

C1 Complete the sentences.

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In a covalent bond, a pair of electrons is **shared** between two non-metal atoms. A double bond contains **two** shared pairs. Electrons in the outer shell that are not shared are called **lone pairs** (non-bonding electrons).

C2 Complete Table 3.

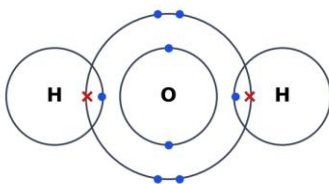
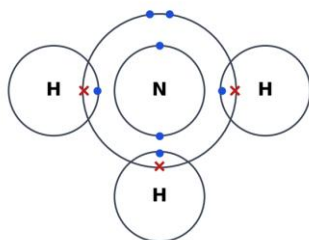
[10]

Molecule	Number of shared pairs in the molecule	Type(s) of bond	Lone pairs on the central atom
H ₂	1	Single	0 (on each H)
Cl ₂	1	Single	3 (on each Cl)
HCl	1	Single	3 (on Cl)
H ₂ O	2	Single	2 (on O)
NH ₃	3	Single	1 (on N)
CH ₄	4	Single	0 (on C)
O ₂	2	Double	2 (on each O)
N ₂	3	Triple	1 (on each N)
CO ₂	4	Two double	0 (on C); 2 on each O
C ₂ H ₄	6	One C=C double, four C–H single	0 (on each C)

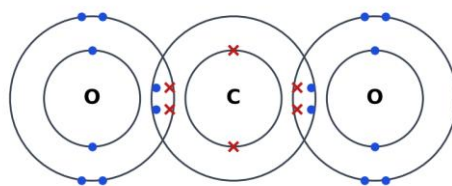
Table 3

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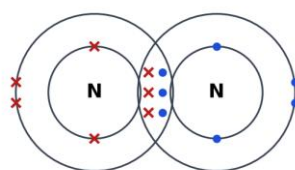
[8]

Water, H₂O

Ammonia, NH₃


Carbon dioxide, CO₂



Nitrogen, N₂

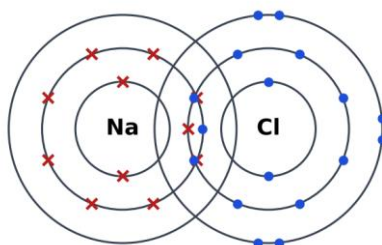


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On the sim: Open the Spot the Mistake tab and try the diagrams there. Then find the mistake in each diagram below.

D1 A student's diagram of sodium chloride.

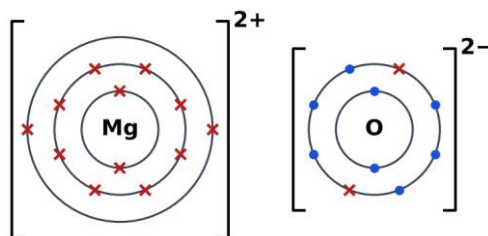
[2]



Electrons are shared, as in a covalent bond. NaCl is ionic: Na transfers 1 electron to Cl, forming Na⁺ [2.8] and Cl⁻ [2.8.8] in separate brackets with charges.

D2 A student's diagram of magnesium oxide.

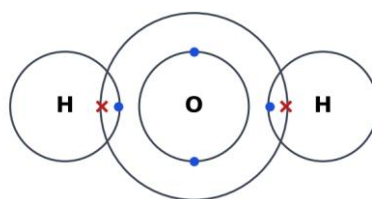
[2]



Mg²⁺ still shows its outer shell with 2 electrons. Those 2 electrons have been transferred to O, so Mg²⁺ should have only 2 shells (2.8).

D3 A student's diagram of water.

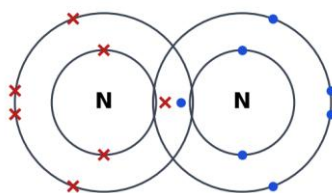
[2]



The 4 non-bonding electrons (2 lone pairs) on oxygen are missing; O has only 4 electrons in its outer shell instead of 8.

D4 A student's diagram of nitrogen.

[2]



Only one shared pair is shown, so each N has 6 outer electrons. N_2 has a triple bond (3 shared pairs), with one lone pair on each N.

Part E: Practice Questions

E1 Aluminium (2.8.3) reacts with oxygen (2.6) to form aluminium oxide.

(a) State the charges on the two ions formed.

[2]

Al^{3+} and O^{2-}

(b) Deduce the formula of aluminium oxide. Explain your answer using the charges.

[2]

Al_2O_3 . Two Al^{3+} give +6 and three O^{2-} give -6, so the charges balance.

E2 Explain why the formula of water is H_2O and not HO , in terms of electrons.

[2]

Oxygen has 6 valence electrons and needs 2 more for an octet, so it forms two covalent bonds. Each hydrogen forms only one bond, so two H atoms are needed.

E3 Compare how the bonds form in magnesium chloride and in hydrogen chloride.

[3]

In $MgCl_2$, electrons are transferred: Mg loses 2 electrons (one to each Cl), forming Mg^{2+} and Cl^- ions held by electrostatic attraction. In HCl , H and Cl each contribute one electron to a shared pair (covalent bond); no ions form.