

AQA Chemistry

GCSE Student calculation sheet

C3.5

Name Class Date

Formulae of covalent compounds

Specification references

- C2.1.4 Covalent bonding
- MS 5b

Aims

This worksheet gives you practice in drawing a range of molecules in two dimensions. You will look at the different models used to represent covalent compounds: displayed formulae, dot and cross diagrams, and ball and stick models. You will also look at how the empirical formula for a covalent compound can be worked out from a model or diagram.

Learning outcomes

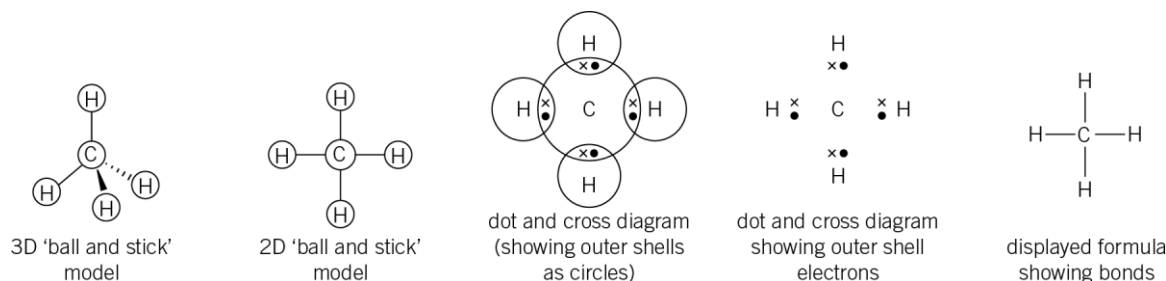
After completing this worksheet, you should be able to:

- recognise a covalent compound from its diagram showing bonds
- draw dot and cross diagrams and ball and stick diagrams for H_2 , N_2 , HCl , H_2O , NH_3 , and CH_4
- draw dot and cross diagrams and ball and stick diagrams for unfamiliar small molecules.

Setting the scene

When non-metals react together, their atoms share pairs of electrons to form molecules. We call this covalent bonding.

Molecules are three-dimensional but we need to be able to represent their structure on paper in two dimensions. There are a number of different ways in which we can do this. Some of these are shown below for the molecule methane, CH_4 .



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Worked example

Draw a dot and cross diagram for ammonia, NH_3 , and use this to draw the displayed formula for ammonia.

Step 1

First, use the Periodic Table to determine the number of electrons in the outer shell of each atom in the compound:

nitrogen is in Group 5 and so has five electrons in its outer shell

hydrogen has one electron in its outer shell

Step 2

Then determine how many electrons each atom needs to gain in order to achieve the stable electronic configuration of a noble gas, which has eight electrons in the outer shell:

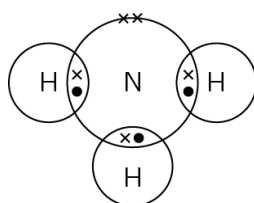
nitrogen has five electrons in its outer shell, so needs to gain three electrons from sharing

each hydrogen atom has one electron in its outer shell, so needs to gain one electron from sharing

Step 3

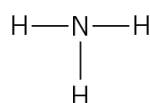
Each electron that an atom needs to gain corresponds to a shared pair of electrons or a covalent bond with a neighbouring atom. We can show this shared pair of electrons as a dot and cross between the two atoms concerned. The dot and cross tell us which electron is contributed from which atom. Any electrons that are not paired up are shown as a *non-bonding* or *lone pair* on the ring of the atom to which they belong.

So, a dot and cross diagram for ammonia, NH_3 , would look like:



Step 4

In a displayed formula, each shared pair of electrons is represented as a single line, or bond, between the atoms. Therefore, the displayed formula for ammonia is:



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Questions

You will need to look at a Periodic Table when answering these questions.

- 1 Complete the table to show the number of electrons in the outer shell of some common atoms, and hence the number of electrons they need to gain in order to achieve the stable electronic configuration of a noble gas.

Atom	Number of electrons in outer shell	Number of electrons need to gain
carbon		
oxygen		
chlorine		
sulfur		
phosphorus		

(5 marks)

- 2 a Draw dot and cross diagrams for the following simple covalent molecules. Remember to include any non-bonding or lone pairs of electrons as well as the shared pairs of electrons.

i hydrogen

(1 mark)

ii water

(1 mark)

iii hydrogen chloride, HCl

(1 mark)

iv trichloromethane, CHCl₃.

(1 mark)

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b Draw the displayed formulae of each of the molecules in **i–iv**. (4 marks)

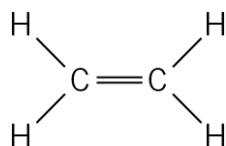
3 In some molecules, more than one pair of electrons is shared between two atoms. In these cases, the molecules contain a double (two shared pairs of electrons) or a triple (three shared pairs of electrons) covalent bond.

a For each of the molecules below, state the molecular formula and draw a dot and cross diagram.

Use the displayed formula to help you.

i carbon dioxide $\text{O}=\text{C}=\text{O}$ (2 marks)

ii ethene



(2 marks)

iii nitrogen



(2 marks)

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iv hydrogen cyanide. $\text{H}-\text{C}\equiv\text{N}$ (2 marks)

b Draw the dot and cross diagram and displayed formula for the molecule ethyne, C_2H_2 . (2 marks)

Student follow up

1 Carbon can be found in a large number of compounds. A compound that contains carbon is called an organic compound.

a i State the number of electrons in the outer shell of a carbon atom.

..... (1 mark)

ii Predict the number of covalent bonds a carbon atom forms.

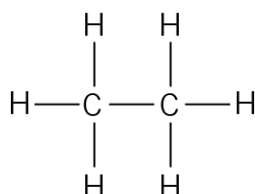
..... (1 mark)

b A common class of organic compounds is the hydrocarbons.

i What is a hydrocarbon?

..... (1 mark)

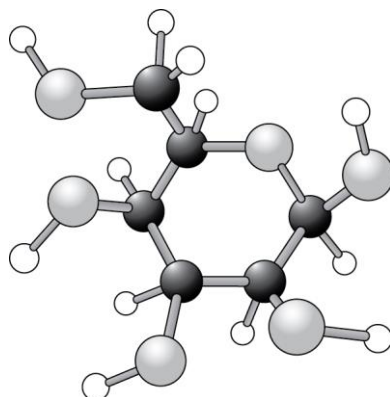
ii Ethane, C_2H_6 , is an example of a hydrocarbon. The displayed formula for ethane is shown in the diagram below.



Draw a dot and cross diagram for ethane. (2 marks)

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- c Glucose is another common compound that contains carbon. The picture below shows a molecular model of glucose. Black balls represent carbon atoms, shaded balls represent oxygen atoms, and white balls represent hydrogen atoms.



State the molecular formula of glucose.

.....

(1 mark)

Maths skills links

You may also need to visualise and represent 2D and 3D forms when studying electronic structure and organic chemistry.