Lesson 5: Electronic Configurations

*Read through the lesson notes. You can write them out, print them or save them.

*Once you have tried to understand the lesson answer the questions that follow at the end.

*The answers to the question sheet(s) will be posted later and this will allow you to self-evaluate your learning.

Learning Intentions

-Learn how to write spectroscopic notation for the first 36 elements.

-Learn how to draw orbital box notation for the first 36 elements.

Background

-Leading on from lesson 4 in which we learned about orbitals and quantum numbers, this lesson explores a more accurate way of representing the electron arrangements of atoms.

Early on in National 5 chemistry, we used the Bohr model of the atom to write electron arrangements. However, from lesson 4, we now know that the Bohr model is not entirely accurate and therefore we can use the knowledge that we have gained to write electron arrangements in a more accurate manner.

(i) Spectroscopic Notation

To write the electron arrangement in the form called spectroscopic notation, it is important to know and understand the aufbau principle (which we learned about in lesson 4). It is also useful to have a copy of the Periodic Table from your data booklet handy (page 8). The spectroscopic notation has been written for the first seven elements together with their electron arrangement as taught at National 5.

Hydrogen (electron arrangement: 1) spectroscopic notation: $1s^1$

Helium (electron arrangement: 2) spectroscopic notation: $1s^2$

Lithium (electron arrangement: 2,1) spectroscopic notation: $1s^2\ 2s^1$

Beryllium (electron arrangement: 2,2) spectroscopic notation: $1s^2\ 2s^2$

Boron (electron arrangement: 2,3) spectroscopic notation: $1s^2\ 2s^2\ 2p^1$

Carbon (electron arrangement: 2,4) spectroscopic notation: $1s^2\ 2s^2\ 2p^2$

Nitrogen (electron arrangement: 2,5) spectroscopic notation: $1s^2\ 2s^2\ 2p^3$

Key Point 1

You may have noticed that the rules for writing spectroscopic notation are:

- ➔ Write the number of the shell
- ➔ Write the letter of the orbital
- ➔ Write the number of electrons in that orbital

e.g. Sodium (electron arrangement: 2,8,1) spectroscopic notation: $1s^2\ 2s^2\ 2p^6\ 3s^1$

For sodium, we see that the electron arrangement 2,8,1 indicates that a sodium atom has a total of 11 electrons. This is indeed true, however, it does not take into account that these electrons are also distributed into subshells (orbitals). Therefore, the spectroscopic notation is more accurate as it indicates the number of electrons that will be found in certain orbitals. Note also that the spectroscopic notation indicates that sodium has 11 electrons.

Key Point 2

For Advanced Higher Chemistry, we normally don't use the electron arrangement form as taught at National 5. This is used as a building block to understand spectroscopic notation. You are expected to know the spectroscopic notation for the elements up to krypton (atomic number 36).

Krypton (electron arrangement 2,8,18,8)

spectroscopic notation: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$

Writing the spectroscopic notation of an element should not be a task that you memorise. You should be able to give the spectroscopic notation of an element by using the aufbau principle and page 8 of the data booklet.

Key Point 3

vanadium (electron arrangement 2,8,11,2)

spectroscopic notation: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$

By carefully looking at the aufbau principle, we see that electrons fill the 4s orbital before the 3d orbitals.

On some occasions, a shorthand version of spectroscopic notation is used, e.g.

Calcium: [Ar] $4s^2$

Instead of $\underbrace{1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6}$ $4s^2$

This part is the spectroscopic notation of argon and is abbreviated to: [Ar]

Vanadium: [Ar] $4s^2\ 3d^3$ ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2 3d^3$)

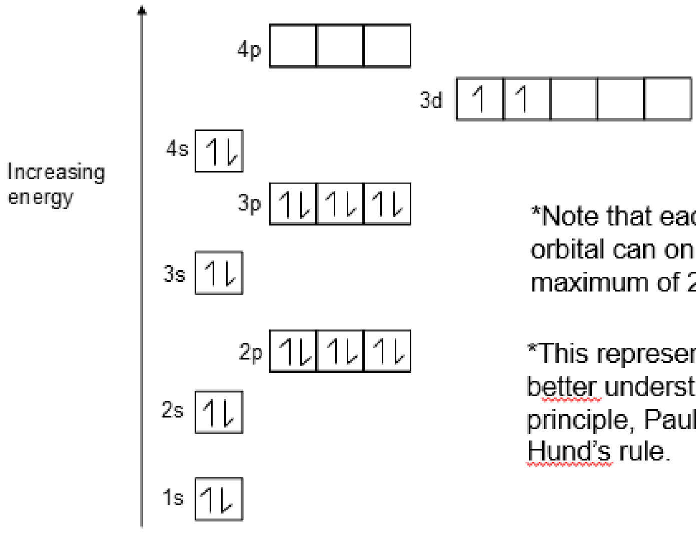
*It is important to note, if you are asked to give spectroscopic notation then ALWAYS give the full notation. If a question requires shorthand notation, it will be clearly stated.

(ii) Orbital Box Notation

Orbital box notation is an extension of spectroscopic notation in that it represents the electrons as arrows drawn inside a box to indicate a specific orbital. This is visually useful as it can help to understand the Pauli exclusion principle and also Hund's rule.

In the example below, the spectroscopic notation of titanium is written first with the orbital box notation written secondly.

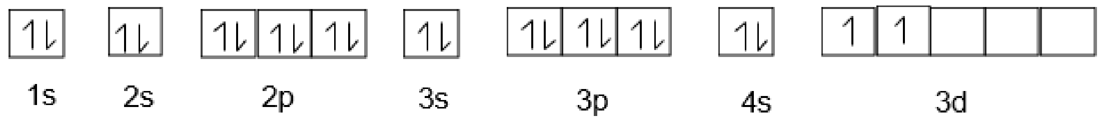
Titanium ($1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$)



*Note that each individual orbital can only hold a maximum of 2 electrons.

*This representation can be used to gain a better understanding of the Aufbau principle, Pauli exclusion principle and Hund's rule.

Note also that the orbital box notation is not always written vertically (although this highlights the relative energies of the orbitals) but can be written horizontally.



Additional Resources

-Watch the clip on Youtube:

→ Crash course chemistry #5 (6 minutes – 7 minutes 30 seconds)

https://www.youtube.com/watch?v=rcKilE9CdaA

-Read Scholar Sections 2.5 and 2.6

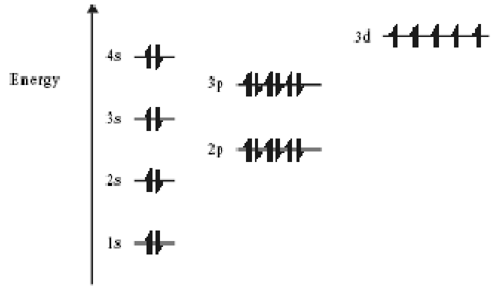
-Read BrightRed textbook pages 15 and 16

-Answer the Question from Sheets 1.7 and 1.8 and check the answers when you have completed them.

-If there are any questions regarding this lesson or the questions from sheets 1.7 and 1.8 then please leave a post on Microsoft Teams.

1.7 Electronic Configuration (I)

1. The electron configuration of an atom of element Y in the ground state can be represented as follows:



(a) Identify element Y.

(b) Draw a similar diagram to represent the electron configuration of

(i) magnesium
(ii) scandium
(iii) fluorine

(c) The electron configuration of an atom or ion may also be expressed in another form, e.g. $1s^2\ 2s^2\ 2p^1$ for boron.
Give the electron configuration for

(i) manganese ii) iron iii) chlorine
iv) phosphorus v) neon vi) silicon
vii) titanium viii) oxygen ix) bromine

2. The electronic configuration can be represented using a *shorthand method as illustrated for calcium below.

$[Ar]\ 4s^2$

(a) Write a similar representation for the following elements

(i) potassium
(ii) manganese
(iii) zinc

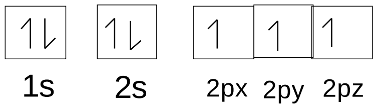
(b) Give the names of the following elements that have been represented by their electronic configuration in *shorthand form.

(i) $[Ne]\ 3s^23p^1$ (ii) $[Ne]\ 3s^23p^5$ (iii) $[Ar]\ 4s^23d^7$

*Remember, if you are asked to give spectroscopic notation then it is important to give the full notation. If a question requires shorthand notation, it will be clearly stated.

1.8 Electronic configuration (II)

1. The electron configuration for nitrogen is:



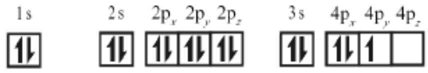
(a) What is the significance of *x*, *y* and *z* in the 2p sublevel?

(b) (i) Describe the shape of the s and p orbitals.

(ii) Describe the position of the p orbitals relative to each other.

(c) Why is the 2p*z* electron for nitrogen not placed in the 2p*x* or 2p*y* orbital?

(d) Phosphorus is in the same group as nitrogen but has 15 electrons. A pupil wrote the following configuration for phosphorus:



Explain the two mistakes in the student's answer.

2. There are three statements that you have come across in your study of electrons and atomic orbitals. These statements are:

(1) The Aufbau principle

(2) Hund's rule of maximum

principle

(3) The Pauli exclusion principle

multiplicity

(a) The electronic configuration for boron is given by (i) and not (ii).

Explain why (ii) is wrong and identify which of the above statements justifies your choice.

(b) The electronic configuration for carbon is given by (iii) and not (iv). Explain why (iv) is wrong and identify which of the above statements justifies your choice.

(c) The electronic configuration for nitrogen is given by (v) and not (vi).

Explain why (vi) is wrong and identify which of the above statements justifies your choice.