Higher Chemistry: Unit 1 – Chemical Changes and Structure

Part A – Periodicity and Bonding

Lesson 1 – Bonding and Structure in the First 20 Elements

Learning Outcomes

By the end of this lesson you should know:

1. How elements are arranged in the periodic table in terms of atomic number, groups and periods.

2. How the first 20 elements can be categorised by the type of chemical bonding and structure they contain:
   - monatomic
   - covalent molecular
   - covalent network
   - metallic

Success Criteria

You will have been successful in this lesson if you:

1. Read and learn the notes given

2. Watch the links provided

3. Complete Exercise 1.1 and check your answers.

There is also a further reading section to help you gain more depth of understanding for this section.

MS Teams will be monitored throughout the week by a chemistry teacher. If you need help or clarification with either the task or the content of the lesson, just ask.

Links to Prior Knowledge

You may wish to revise the following to help you understand this lesson:

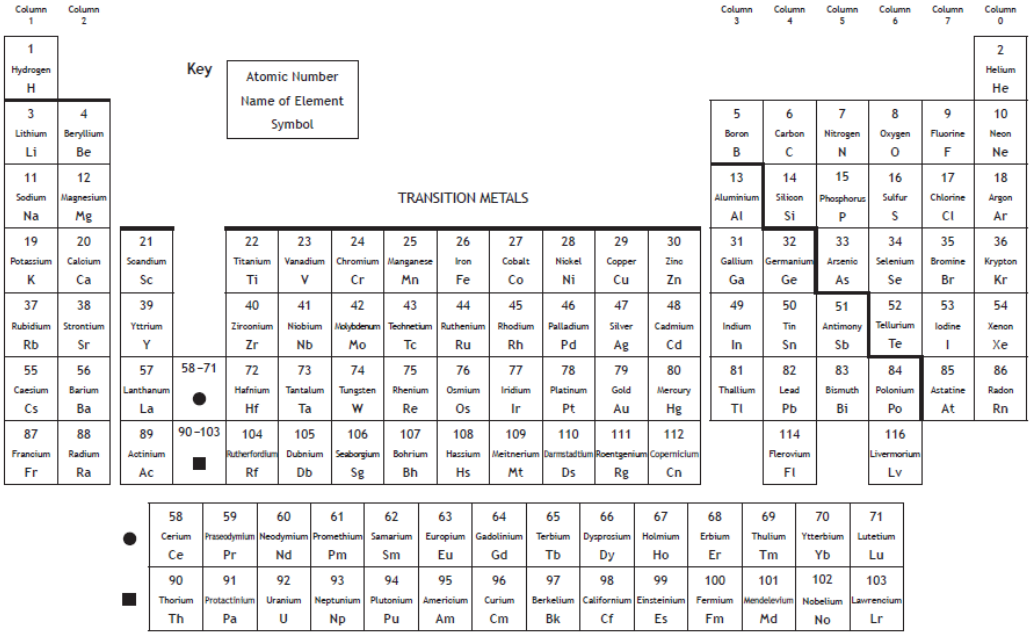
- National 5 chemistry – bonding, structure and properties

For reference, the periodic table is given in the data booklet. Download or print a copy of the Higher Chemistry Data Booklet from MS Teams or from the SQA website -
https://www.sqa.org.uk/sqa/files_ccc/ChemistryDataBooklet_NewH_AH-Sep2016.pdf

Notes

The Periodic Table

The Periodic Table lists all known elements in order of atomic number (the number of protons in each atom of the element). The table starts at the top left with hydrogen, atomic number 1. Each element has a unique name, symbol and atomic number.



Elements below the dark line are metals.

WATCH - TWIG: The Periodic Table 1: http://twigfil.ms/2uUMORY

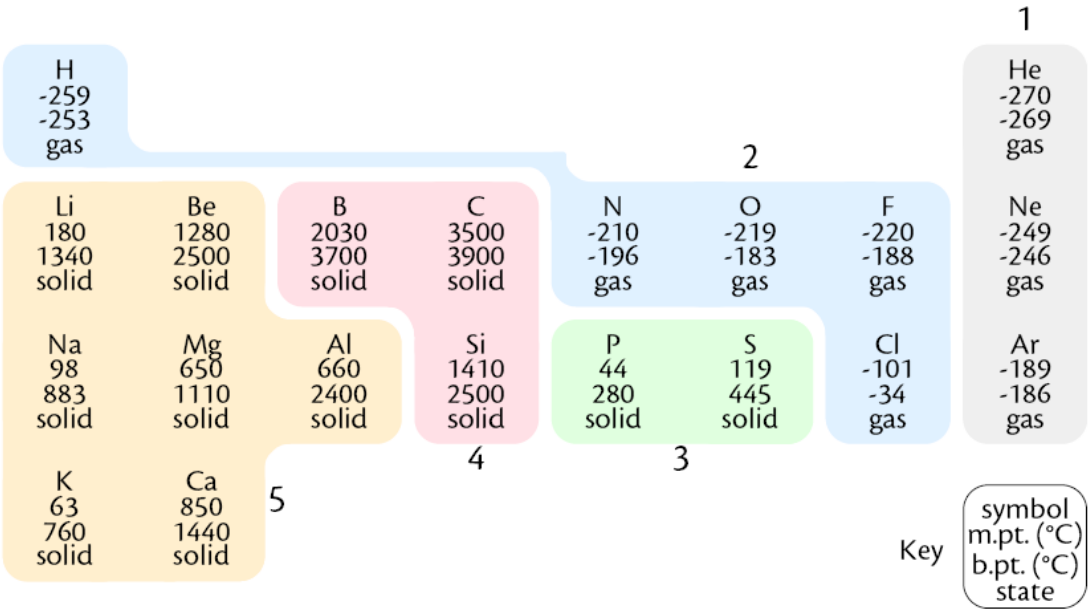
The elements are organised in such a way that patterns can be identified. This is often referred to as "Periodicity". For example:

- Metal elements are found on the left hand side of the table and non-metals are on the right.
- Elements in the same column are called a "group". Elements in a group display similar chemical properties because they have the same number of electrons in their outer shell. For example the alkali metals are all very reactive elements that contain just one electron on their outer shells
- A Row of elements are called a "period". Elements in the same period have the same number of electron shells. For example hydrogen and helium in period 2 only have 1 electron shell.

WATCH - TWIG: The Periodic Table 2: http://bit.ly/2ud8Diw

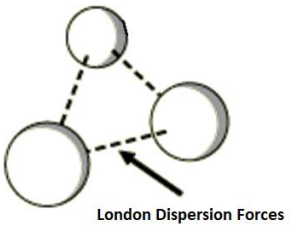
Bonding and Structure of the First 20 elements

The first 20 elements of the periodic table can be divided into 5 groups based on their bonding and structure, as shown below.



1. Monatomic Gases

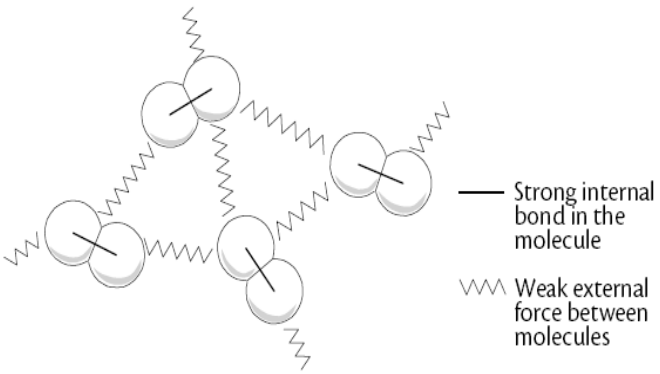
These are the Noble Gases, Helium, Neon and Argon. They are completely unreactive and exist as single atoms (monatomic) held together only by weak intermolecular forces (called London Dispersion Forces).

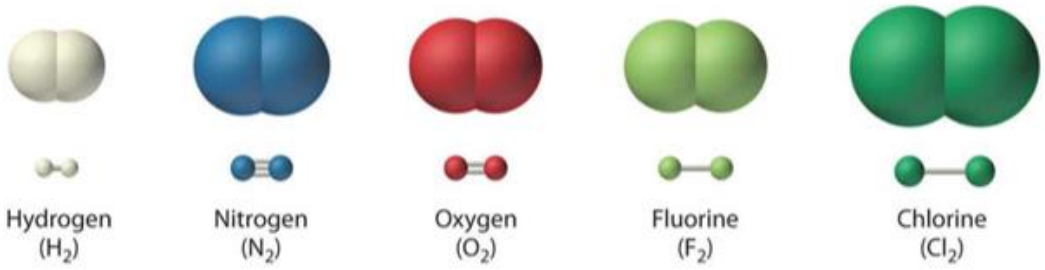


WATCH - TWIG: Noble Gases: http://twigfil.ms/2uUDG00

2. Covalent Molecular Gases

Hydrogen, Nitrogen, Oxygen, Fluorine and Chlorine all exist as diatomic molecules (H_2, N_2 etc) and are all gases at room temperature. Atoms are held to each other by strong covalent bonds, but molecules held together by weak London Dispersion Forces (same as monatomic gases).

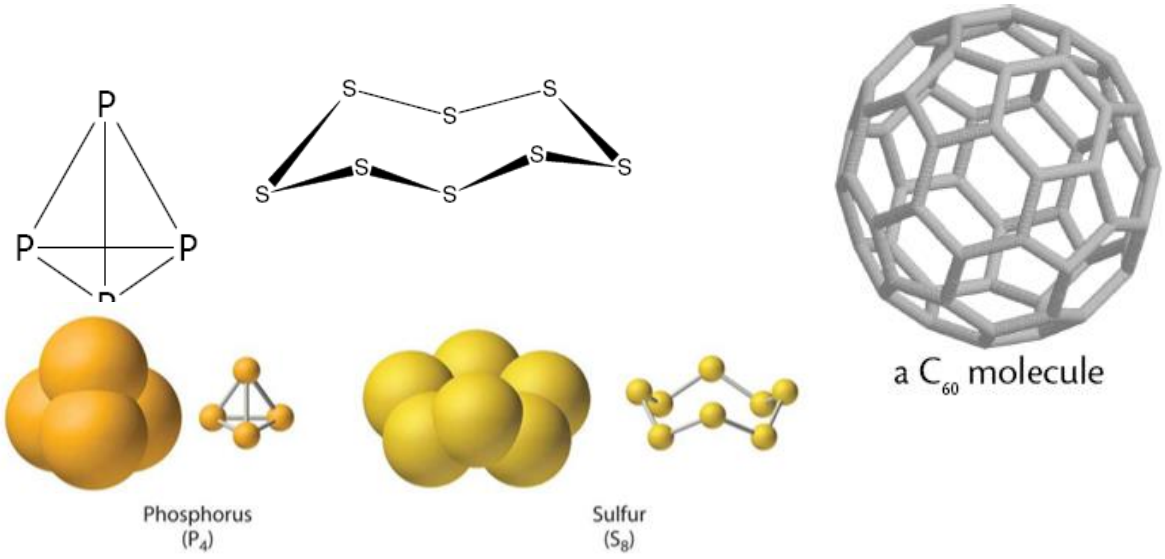




WATCH - TWIG: Covalent Bonding: http://bit.ly/2u3VLvm

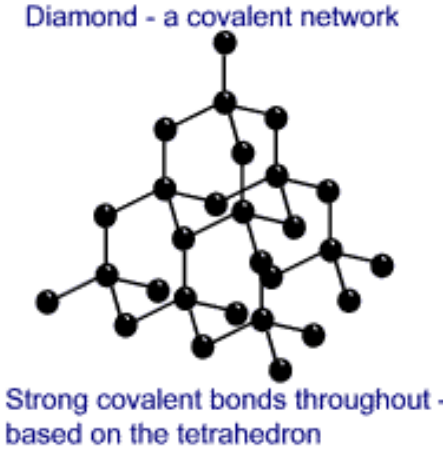
3. Covalent Molecular Solids

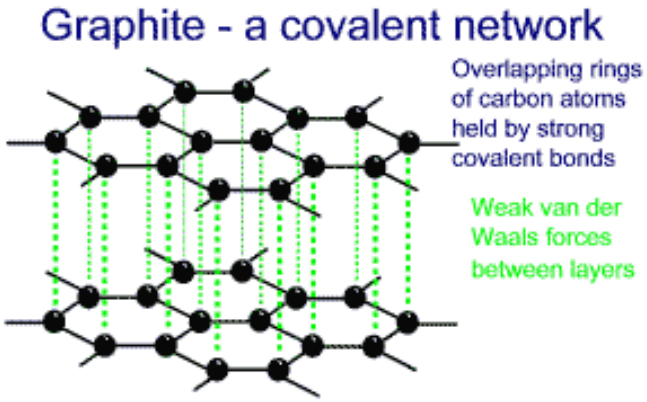
Phosphorous, sulfur and carbon (fullerene) exist as molecules but larger than diatomic: P_4, S_8 and C_{60}. All are solid at room temperatures, but still have low melting points compared with covalent networks. The strength of London Dispersion Forces increases as the number of electrons in a molecule increases, therefore larger molecules tend to have higher melting points.



4. Covalent Networks

Boron, silicon, carbon (diamond) and carbon (graphite) exist as covalent networks. All atoms are held together by strong covalent bonds, therefore have very high melting points. All are solid at room temperature.





SPECIAL CASE: FORMS OF CARBON

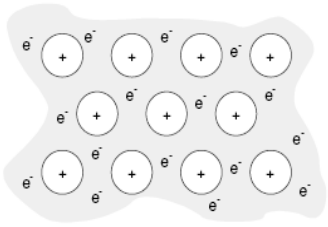
Carbon can exist in a number of different forms. It can exist as a covalent network in graphite and diamond but also as large covalent molecules called Fullerenes. These ball-like structures consists of 60 carbon atoms joined together in one molecule, C_{60}.

WATCH - TWIG: Carbon Introduction: http://twigfil.ms/2uUBtSb

WATCH - TWIG: Carbon: Buckminsterfullerene http://bit.ly/2u4ut7S

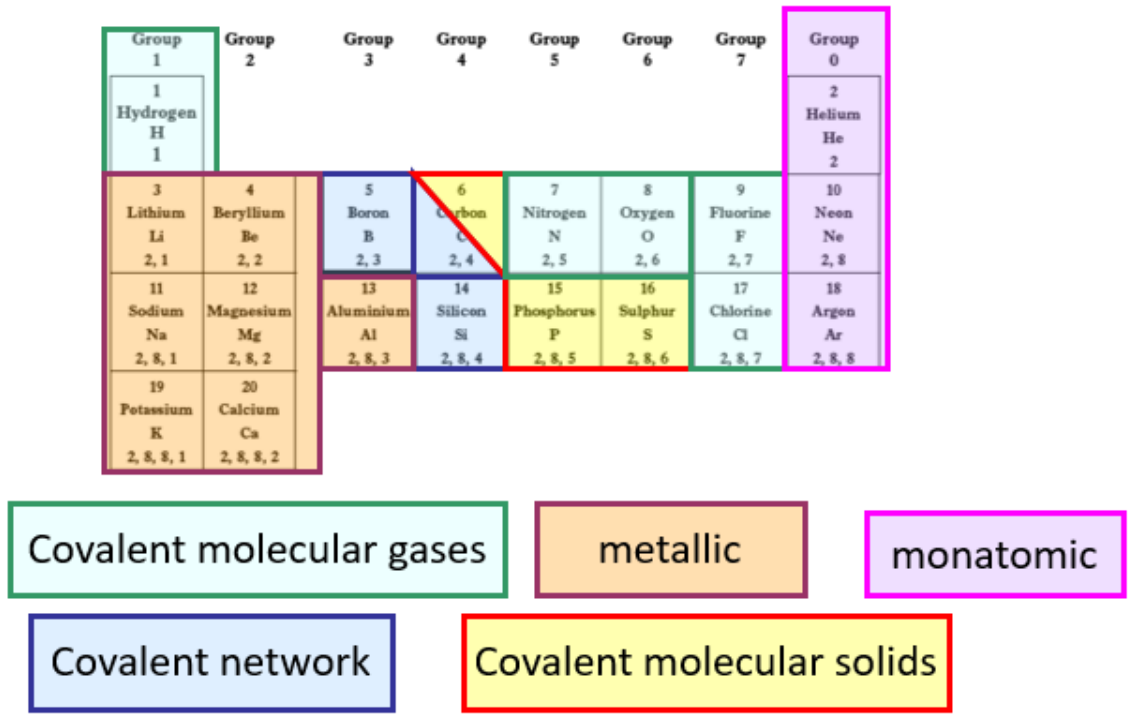
5. Metals

Li, Be, Na, Mg, Al, K, Ca have a typical metallic structure. They exist as giant lattices of **positively charged ions** and **delocalised electrons.** Metal elements conduct electricity because they contain delocalised electrons.



WATCH - TWIG: Metallic Bonding: http://bit.ly/2uYhVw9

SUMMARY



Learning Outcomes

You should now know:

1. Elements are arranged in the periodic table in order of increasing atomic number.

2. The periodic table allows chemists to make accurate predictions of physical properties and chemical behaviour for any element, based on its position. Features of the table are:
   - groups: vertical columns within the table contain elements with similar chemical properties resulting from a common number of electrons in the outer shell
   - periods: rows of elements arranged with increasing atomic number, demonstrating an increasing number of outer electrons and a move from metallic to non-metallic characteristics

3. The first 20 elements in the periodic table are categorised according to bonding and structure:
   - metallic (Li, Be, Na, Mg, Al, K, Ca)
   - covalent molecular — H_2, N_2, O_2, F_2, Cl_2, P_4, S_8 and fullerenes (eg C_{60})
   - covalent network — B, C (diamond, graphite), Si
   - monatomic (noble gases)

Further Reading

To learn more about the first 20 elements. Follow the links below:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zxc99j6/revision/1

Read pages 1-5

Evans2 chem web: https://www.evans2chemweb.co.uk/login/index.php#

Username: snhs password: giffnock

Select any teacher → revision material → CfE Higher → Periodicity

Questions

Complete Exercise 1.1 and check your answers

Exercise 1.1 - Bonding in the First 20 Elements

1. The first 20 elements of the Periodic Table are shown below

1 Hydrogen H 1							2 Helium He 2
3 Lithium Li 2,1	4 Beryllium Be 2,2	5 Boron B 2,3	6 Carbon C 2,4	7 Nitrogen N 2,5	8 Oxygen O 2,6	9 Fluorine F 2,7	10 Neon Ne 2,8
11 Sodium Na 2,8,1	12 Magnesium Mg 2,8,2	13 Aluminium Al 2,8,3	14 Silicon Si 2,8,4	15 Phosphorus P 2,8,5	16 Sulfur S 2,8,6	17 Chlorine Cl 2,8,7	18 Argon Ar 2,8,8
19 Potassium K 2,8,8,1	20 Calcium Ca 2,8,8,2						

For each of the elements identify them as belonging to one of the following:

(a) Monatomic gases.
(b) Covalent networks.
(c) Covalent molecular gases.
(d) Metallic lattice.
(e) Covalent molecular solids.

2. The table below shows the types of bonding considered to exist among the elements.

Molecular gas	Closely packed molecules	Atomic gas	Covalent network	Lattice of positive ions with mobile electrons

Which structure best describes the normal state of

(a) fluorine
(b) sodium
(c) phosphorus
(d) neon
(e) boron

3. Sulfur and phosphorus are adjacent to one another in the Periodic Table, however, sulfur has a higher melting point.

(a) Using the data booklet give the melting points of both sulfur and phosphorus.

(b) By discussing the structure of both sulfur and phosphorus, explain why sulfur has a higher melting point than phosphorus.

Exercise 1.1 – ANSWERS

1. *(a) Monotomic gases: He, Ne and Ar*

   (b) Covalent networks: B, C and Si (carbon graphite and carbon diamond)

   (c) Covalent molecular gases: H, N, O, F and Cl

   (d) Metallic lattices: Li, Be, Na, Mg, Al, K and Ca

   (e) Covalent molecular solids: P, S and C (carbon in the form of fullerene)

2. *(a) Fluorine – Molecular gas*

   (b) Sodium – Lattice of positive ions with mobile electrons

   (c) Phosphorus – Closely packed molecules

   (d) Neon – Atomic gas

   (e) Boron – Covalent network

3. *(a) Sulfur = 115°C / Phosphorus = 44°C*

   (b) Sulfur exists as a S_8 molecular solid whereas phosphorus exists as a P_4 molecular solid. A sulphur molecule has the larger number of electrons therefore more energy will be required to break the London Dispersion Forces.