



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.

Column 1	Column 2	TRANSITION METALS										Column 3	Column 4	Column 5	Column 6	Column 7	Column 8		
1 Hydrogen H																			2 Helium He
3 Lithium Li	4 Beryllium Be																		10 Neon Ne
11 Sodium Na	12 Magnesium Mg																		18 Argon Ar
19 Potassium K	20 Calcium Ca	21 Scandium Sc	22 Titanium Ti	23 Vanadium V	24 Chromium Cr	25 Manganese Mn	26 Iron Fe	27 Cobalt Co	28 Nickel Ni	29 Copper Cu	30 Zinc Zn	31 Gallium Ga	32 Germanium Ge	33 Arsenic As	34 Selenium Se	35 Bromine Br	36 Krypton Kr		
37 Rubidium Rb	38 Strontium Sr	39 Yttrium Y	40 Zirconium Zr	41 Niobium Nb	42 Molybdenum Mo	43 Technetium Tc	44 Ruthenium Ru	45 Rhodium Rh	46 Palladium Pd	47 Silver Ag	48 Cadmium Cd	49 Indium In	50 Tin Sn	51 Antimony Sb	52 Tellurium Te	53 Iodine I	54 Xenon Xe		
55 Caesium Cs	56 Barium Ba	57 Lanthanum La	58-71 Lanthanides	72 Hafnium Hf	73 Tantalum Ta	74 Tungsten W	75 Rhenium Re	76 Osmium Os	77 Iridium Ir	78 Platinum Pt	79 Gold Au	80 Mercury Hg	81 Thallium Tl	82 Lead Pb	83 Bismuth Bi	84 Polonium Po	85 Astatine At	86 Radon Rn	
87 Francium Fr	88 Radium Ra	89 Actinium Ac	90-103 Actinides	104 Rutherfordium Rf	105 Dubnium Db	106 Seaborgium Sg	107 Bohrium Bh	108 Hassium Hs	109 Meitnerium Mt	110 Darmstadtium Ds	111 Roentgenium Rg	112 Copernicium Cn	114 Flerovium Fl		116 Livermorium Lv				
		58 Cerium Ce	59 Praseodymium Pr	60 Neodymium Nd	61 Promethium Pm	62 Samarium Sm	63 Europium Eu	64 Gadolinium Gd	65 Terbium Tb	66 Dysprosium Dy	67 Holmium Ho	68 Erbium Er	69 Thulium Tm	70 Ytterbium Yb	71 Lutetium Lu				
		90 Thorium Th	91 Protactinium Pa	92 Uranium U	93 Neptunium Np	94 Plutonium Pu	95 Americium Am	96 Curium Cm	97 Berkelium Bk	98 Californium Cf	99 Einsteinium Es	100 Fermium Fm	101 Mendelevium Md	102 Nobelium No	103 Lawrencium Lr				

Key: Atomic Number, Name of Element, Symbol

Elements below the dark line are metals.

WATCH - TWIG: The Periodic Table 1: <http://twigfil.ms/2uJMORY>

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

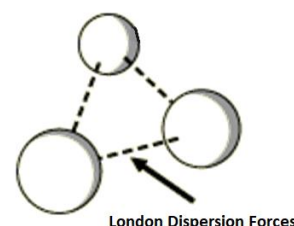
The first 20 elements of the periodic table can be divided into 5 groups based on their bonding and structure, as shown below.

Group 5		Group 4		Group 3		Group 2			Group 1
H -259 -253 gas									He -270 -269 gas
Li 180 1340 solid	Be 1280 2500 solid	B 2030 3700 solid	C 3500 3900 solid	N -210 -196 gas	O -219 -183 gas	F -220 -188 gas			Ne -249 -246 gas
Na 98 883 solid	Mg 650 1110 solid	Al 660 2400 solid	Si 1410 2500 solid	P 44 280 solid	S 119 445 solid	Cl -101 -34 gas			Ar -189 -186 gas
K 63 760 solid	Ca 850 1440 solid								

Key: symbol, m.pt. (°C), b.pt. (°C), state

1. Monatomic Gases

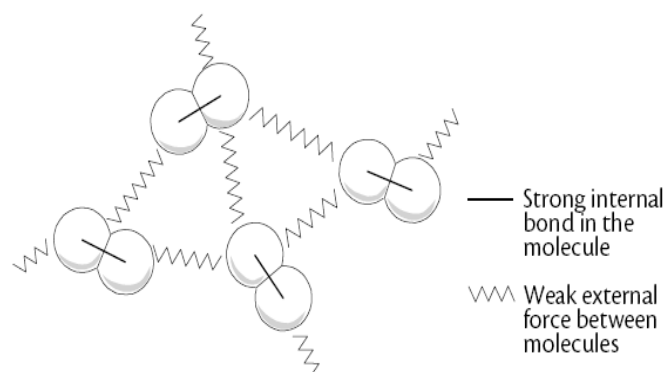
These are the Noble Gases, Helium, Neon and Argon. They are completely unreactive and exist as single atoms (monatomic) held together only by weak intermolecular forces (called London Dispersion Forces).

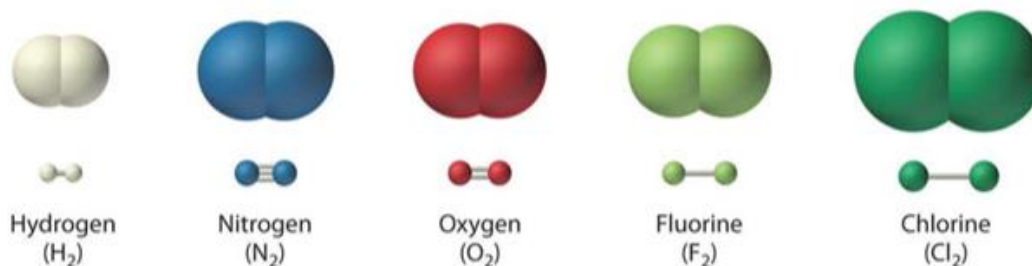


WATCH - TWIG: Noble Gases: <http://twigfil.ms/2uUDG00>

2. Covalent Molecular Gases

Hydrogen, Nitrogen, Oxygen, Fluorine and Chlorine all exist as diatomic molecules (H₂, N₂ 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).

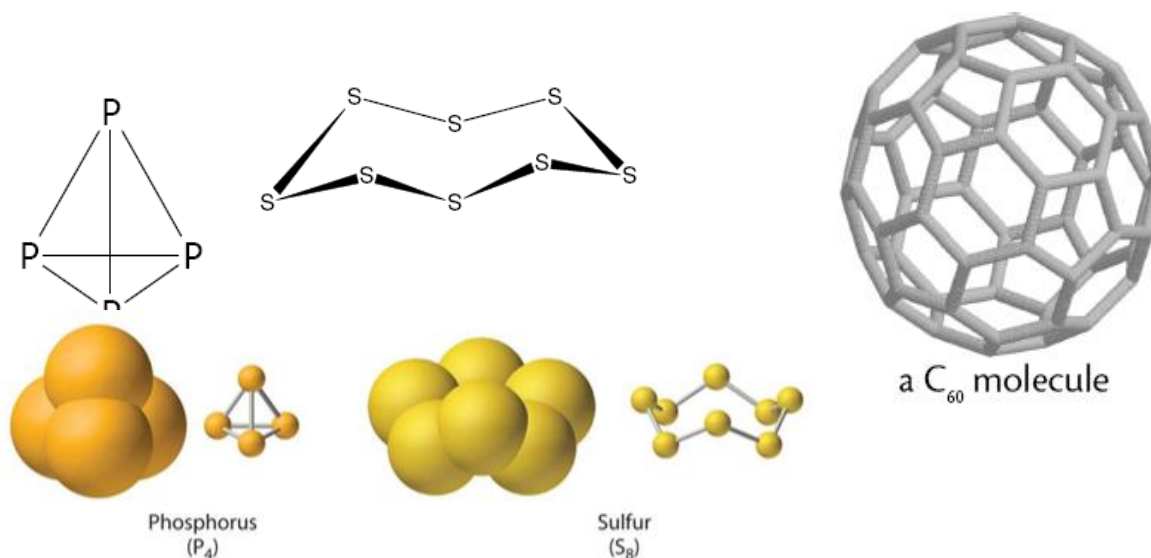




WATCH - TWIG: Covalent Bonding: <http://bit.ly/2u3VLvm>

3. Covalent Molecular Solids

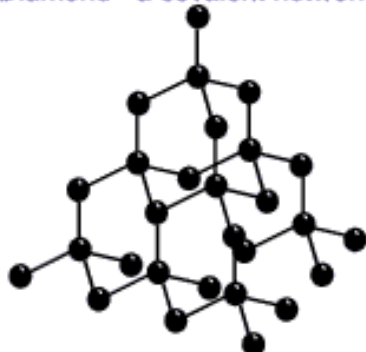
Phosphorous, sulfur and carbon (fullerene) exist as molecules but larger than diatomic: P₄, S₈ and C₆₀. All are solid at room temperatures, but still have low melting points compared with covalent networks. The strength of London Dispersion Forces increases as the number of electrons in a molecule increases, therefore larger molecules tend to have higher melting points.



4. Covalent Networks

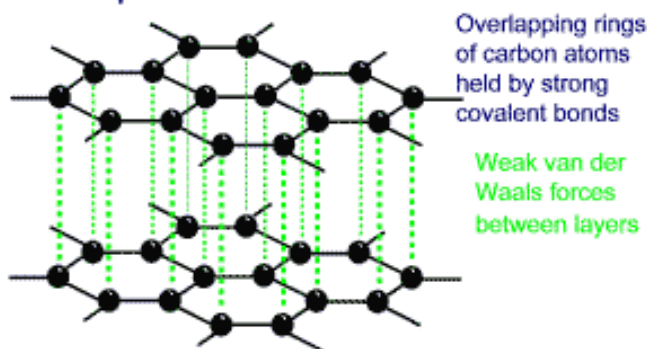
Boron, silicon, carbon (diamond) and carbon (graphite) exist as covalent networks. All atoms are held together by strong covalent bonds, therefore have very high melting points. All are solid at room temperature.

Diamond - a covalent network



Strong covalent bonds throughout - based on the tetrahedron

Graphite - a covalent network



SPECIAL CASE: FORMS OF CARBON

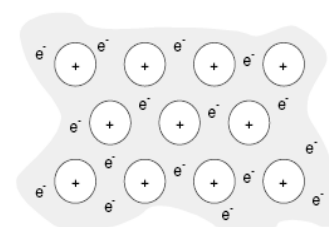
Carbon can exist in a number of different forms. It can exist as a covalent network in graphite and diamond but also as large covalent molecules called Fullerenes. These ball-like structures consists of 60 carbon atoms joined together in one molecule, C_{60} .

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

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
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 Sulphur 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						

Covalent molecular gases

metallic

monatomic

Covalent network

Covalent molecular solids

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 – H₂, N₂, O₂, F₂, Cl₂, P₄, S₈ and fullerenes (eg C₆₀)
 - 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
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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) *Monatomic 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 S₈ molecular solid whereas phosphorus exists as a P₄ molecular solid. A sulphur molecule has the larger number of electrons therefore more energy will be required to break the London Dispersion Forces.*