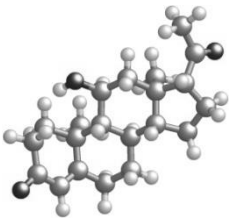

Chem!stry

Name: …… **( )**

Class: ……

Date: …… **/** …… **/** ……

Secondary Two Science – Atomic Structure and Chemical Bonding

Concepts: Change, Models and Systems

Students should be able to:

(a) Describe the formation of ions by electron loss / gain in order to obtain the electronic configuration of a noble gas.

(b) Describe the formation of ionic bonds between metals and non-metals, *e.g.* Na*Cl* and $MgCl_2$.

(c) State that ions are arranged in a giant crystal lattice structure held by electrostatic attraction, *e.g.* Na*Cl* (students will not be required to draw diagrams of ionic lattices).

(d) Deduce the formulae of other ionic compounds from diagrams of their lattice structures, limited to binary compounds.

(e) Describe the formation of a covalent bond by the sharing of a pair of electrons in order to gain the electronic configuration of a noble gas.

(f) Describe, using 'dot-and-cross' diagrams, the formation of covalent bonds between non-metallic elements, *e.g.* H_2, O_2, H_2O, CH_4 and CO_2.

(g) Deduce the arrangement of electrons in other covalent molecules.

Essential Questions:

(a) How are electrons arranged in an atom?

(b) How can I use the Periodic Table to determine the electronic configuration of an atom?

(c) How do we tell the charge of an ion given the element?

(d) Why will different types of elements react to give different types of bonding?

(e) How might we represent the types of bonding in a diagram?

(f) How can we infer the formula of a substance based on 'dot-and-cross" diagrams and vice versa?

All matter is essentially composed of three different particles – electrons, neutrons and protons – which combine together in different numbers to create the 118 known chemical elements. Most of these elements can, in turn, combine together in different quantities to create the wide variety of diverse substances (compounds) that we encounter in our everyday lives. Not all of these elements are useful to chemists. For example, the elements in Group 18 (the noble gases) are almost completely unreactive while many of the very heavy elements are unstable and consequently radioactive, their nuclei flying apart in a matter of seconds.

To illustrate this further, consider a cell in your body. It contains different organelles such as the mitochondria, nucleus and ribosomes. These structures are, in turn, composed of molecules of different compounds such as amino acids, carbohydrates, DNA and lipids. These molecules are composed of atoms of the different elements, and the atoms are composed of electrons, neutrons and protons. Although 118 chemical elements are known to exist, approximately 99% of the human body is composed of only six elements; oxygen, carbon, hydrogen, nitrogen, calcium and phosphorus. Another 0.85% of the human body is composed of another five elements; potassium, sulfur, sodium, chlorine and magnesium. The rest of the human body is composed of slightly more than one dozen trace elements, including iron and zinc. The compounds that exist in the human body can be classified as either ionic or covalent, depending upon how the atoms are bonded together.

• More to explore. Use a QR Code reader on your iPad to investigate more information about the chemical elements, and build atoms using an interactive animation.

• Video: How small is an atom?	• Video: What are atoms made of?	• Interactive Animation: Build an atom.

• Enduring understandings…

→ All of the natural world around us is composed of three particles – electrons, protons and neutrons – arranged to form the atoms of 118 different chemical elements. In turn, the atoms of these elements bond together to form millions of different compounds.

→ Chemical reactions involve the movement of just a small number of electrons, and yet the changes in the properties of the chemicals are profound.

1. What are some generalisations about systems?

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2. Why can an atom be considered to be a system?

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3. What are some generalisations about models?

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4. Why do scientists use a model of the atom to understand the natural world?

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5. What are some generalisations about change?

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6. Why is change an important concept in chemistry?

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Ionic Bonding – Bonding Between a Metallic Element and a Non-metallic Element

7. In the spaces provided below, draw the electronic configurations of helium, neon and argon.

• Helium	• Neon	• Argon

8. What do the electronic configurations of the noble gases all have in common? Why are noble gases unreactive?

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9. In the spaces provided below, draw electronic configurations of sodium (a metallic element) and fluorine (a non-metallic element). Use dots (•) to represent the electrons of sodium and crosses (×) to represent the electrons of fluorine.

• Sodium	• Fluorine

10. Predict whether sodium and fluorine are reactive or unreactive elements. Explain your answer.

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11. How can sodium and fluorine cooperate and re-arrange their valence electrons so that both atoms can obtain the electronic configurations of noble gases?

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12. In the spaces provided below, draw the electronic configurations of sodium a fluorine after they have reacted to obtain the electronic configurations of a noble gas. Use dots (•) to represent the electrons of sodium and crosses (×) to represent the electrons of fluorine.

• Sodium Ion	• Fluoride Ion

13. The products of the reaction are charged particles called ions. The oppositely charged ions are attracted towards each other by a strong electrostatic force of attraction. How many electrons and protons does the sodium ion contain? What is the charge on a sodium ion? How many electrons and protons does a fluoride ion contain? What is the charge on a fluoride ion?

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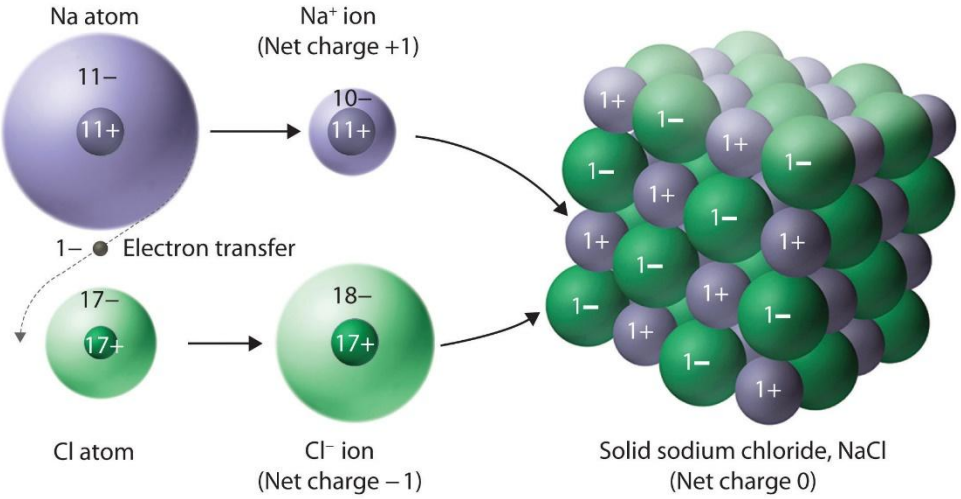
Note: Ionic bonding occurs in compounds that are composed of a *metal* and a *non-metal*. The metal *transfers* its valence electrons to the non-metal. Both the metal and the non-metal obtain the electronic configurations of the *noble gas* closest to them in the Periodic Table. As a consequence of the electron transfer, the metal forms a *positively* charge ion called a *cation*, while the non-metal forms a *negatively* charged ion called an *anion*. Strong electrostatic forces of attraction between the oppositely charged ions result in the formation of a crystal lattice.



14. Draw a dot-and-cross diagram to clearly show the bonding in magnesium oxide. Include the charge on the magnesium ion, the charge on the oxide ion and a key / legend in you answer.

15. Draw a dot-and-cross diagram to clearly show the bonding in sodium oxide. Include the charge on the sodium ion, the charge on the oxide ion and a key / legend in you answer.

16. Draw a dot-and-cross diagram to clearly show the bonding in magnesium chloride. Include the charge on the magnesium ion, the charge on the chloride ion and a key / legend in you answer.

17. Draw a dot-and-cross diagram to clearly show the bonding in aluminium chloride. Include the charge on the aluminium ion, the charge on the chloride ion and a key / legend in you answer.

18. Draw a dot-and-cross diagram to clearly show the bonding in aluminium oxide. Include the charge on the aluminium ion, the charge on the oxide ion and a key / legend in you answer.

19. Draw a dot-and-cross diagram to clearly show the bonding in magnesium nitride. Include the charge on the magnesium ion, the charge on the nitride ion and a key / legend in you answer.

Covalent Bonding – Bonding Between Two or More Non-metallic Elements

20. In the spaces provided below, draw electronic configurations of two fluorine atoms (fluorine is a non-metallic element). Use dots (•) to represent the electrons of one fluorine atom and crosses (×) to represent the electrons of the second fluorine atom.

• Fluorine Atom One	• Fluorine Atom Two

21. Is it possible for both fluorine atoms to obtain the electronic configurations of noble gases by *transferring* electrons form the valence shell of one atom to the other? What problems arise when this happens?

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22. In the space provided below, draw the two fluorine atoms close together *sharing a pair of electrons*. Use dots (•) to represent the electrons of one fluorine atom and crosses (×) to represent the electrons of the second fluorine atom. By *sharing* (instead of transferring) electrons, both of the fluorine atoms can obtain a noble gas electronic configuration. The pair of electrons that are shared between the two atoms is referred to as a *covalent bond*.

• A Diatomic Molecule of Fluorine – F_2

Note: Covalent bonding occurs between the atoms of *non-metallic elements*. The atoms may be of the same element or of different elements. The atoms come close together, so that their valence shells overlap. The atoms then *share* a pair(s) of electrons in order to obtain the electronic configuration of the noble gas that is closest to them in the Periodic Table. The shared pair of electrons is referred to as a *covalent bond*. It is the mutual electrostatic force of attraction between the positively charged nuclei of the two atoms and the negatively charged shared pair of electrons that holds the atoms together. A small group of non-metallic atoms that are held together by covalent bonds is referred to as a *molecule*. The molecules are *neutral*, *i.e.* they are *not ions* and they *do not carry any overall charge*.

23. Draw a dot-and-cross diagram to clearly show the bonding in hydrogen chloride, HC*l*.

24. Draw a dot-and-cross diagram to clearly show the bonding in water, H_2O.

25. Draw a dot-and-cross diagram to clearly show the bonding in methane, CH_4.

26. Draw a dot-and-cross diagram to clearly show the bonding in nitrogen, N_2.

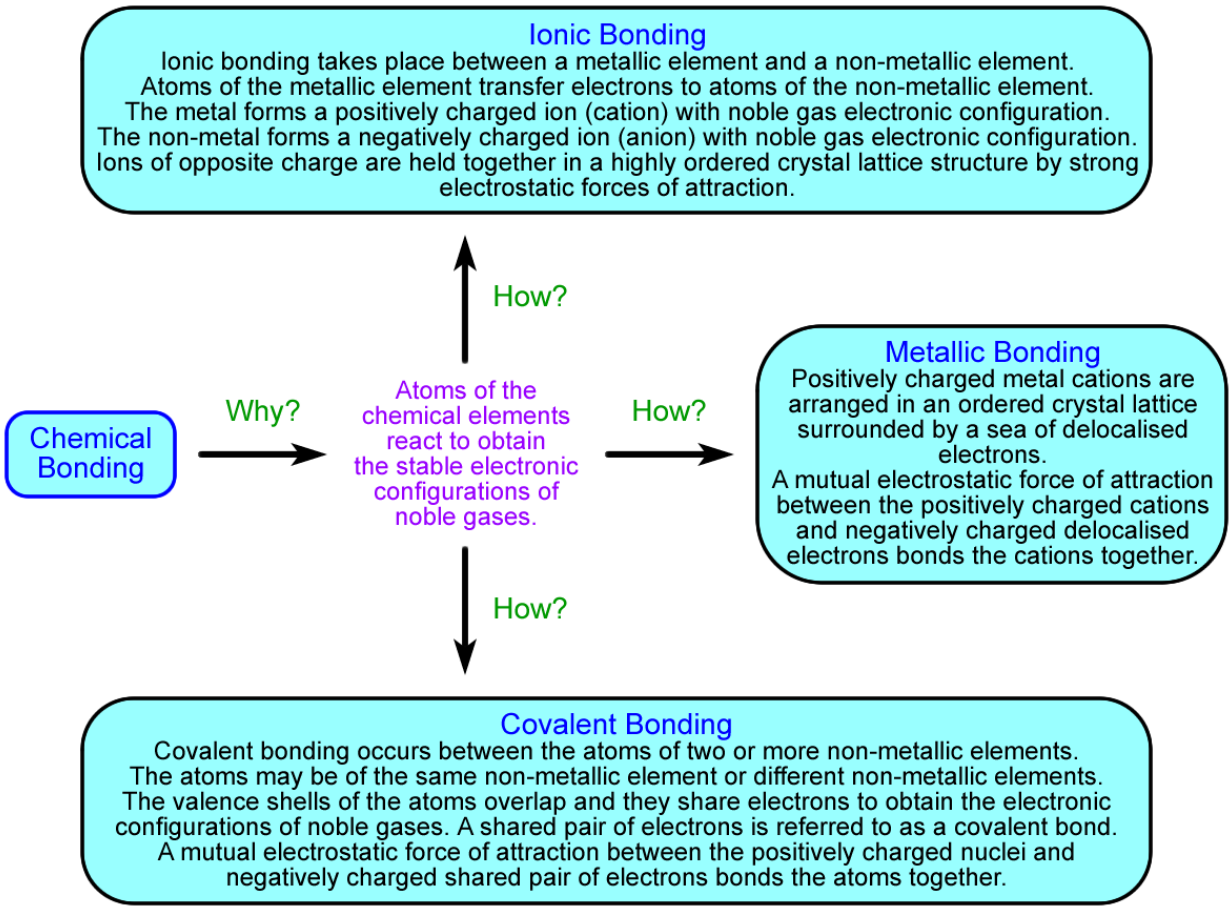
27. Draw a dot-and-cross diagram to clearly show the bonding in carbon dioxide, CO_2.

• Interactive Animation: Build a molecule.

Self-checklist on Chemical Bonding

	Aspect of chemical bonding:	Yes, I understand	No, I need more help
1.	*Prior knowledge from atomic structure:* I am able to draw the electronic configurations of the first 20 chemical elements (when given an element's atomic number or allowed to reference the *Periodic Table*).	☐	☐
2.	*Prior knowledge from atomic structure:* I know that the *Noble gases* (Group 18) have a complete valence electron shell, and this makes them chemically stable.	☐	☐
3.	I understand that atoms lose / gain / share electrons to obtain the electronic configuration of a Noble gas. Once an atom has obtained the electronic configuration of a Noble gas it becomes chemically stable.	☐	☐
4.	I know that *ionic bonding* occurs when a metal reacts with a non-metal. The metal atoms form positively charged ions (called *cations*) and the non-metal atoms form negatively charged ions (called *anions*).	☐	☐
5.	I know that during *ionic bonding*, atoms of metals transfer their valence electrons to atoms of non-metals so that both obtain the electronic configurations of Noble gases.	☐	☐
6.	I know that in ionic compounds, the positive ions (cations) and negative ions (anions) are arranged in a *giant crystal lattice*. Each positive ion is surrounded by negative ions, and each negative ion is surrounded by positive ions.	☐	☐
7.	I am able to represent ionic compounds using dot-and-cross diagrams. The diagrams show the correct number of ions, the charge on the ions, and need only show the valence electron shell of each ion (drawing the inner electron shells is not required).	☐	☐
8.	I know that *covalent bonding* occurs when a *non-metal* reacts with another *non-metal*. Atoms of the non-metallic elements share electrons to form neutral covalent molecules (no charged ions are formed).	☐	☐
9.	I know that during covalent bonding, the valence shells of two or more non-metallic atoms *overlap*. The atoms *share* electrons in order to obtain the electronic configuration of a Noble gas. A shared pair of electrons is a *covalent bond*.	☐	☐
10.	I am able to represent covalent compounds and elements using dot-and-cross diagrams. The diagrams show the correct number of atoms, their valence electron shells overlapping to share electrons, and each atom having the electronic configuration of a Noble gas (drawing the inner electron shells is not required).	☐	☐
11.	I am able to state the formulae of ionic and covalent compounds based upon the number of atoms or ions of the different chemical elements that are present in the dot-and-cross diagram.	☐	☐

Summary



- Scan the QR Code below for the answers to this assignment.

http://www.chemist.sg/chemical_bonding/notes_chemical_bonding/notes_on_bonding_ans.pdf