Name:

Chemical Bonding	Objectives
5. Chemical Bonding: Chemical Formulas	-understand that compounds can be represented by chemical formulas -relate the stability of noble gasses to their electron configurations -describe bonding and valency in terms of the attainment of a stable electronic structure -state the octet rule -explain its limitations -use the octet rule to predict the formulas of simple binary compounds of the first 36 elements (excluding d-block elements) and the hydroxides, carbonates of these elements (where such exist). -relate the uses of helium and argon to their chemical unreactivity
Ionic Bonding	-define ion, positive ion, negative ion -appreciate the minute size of ions -explain ionic bonding in terms of electron transfer -represent ionic bonds using dot and cross diagrams -describe the structure of a sodium chloride crystal having reviewed models -associate ionic substances with their characteristics -outline two uses of ionic materials in everyday life
Covalent Bonding	-define molecule -appreciate the minute size of molecules -explain covalent bonding in terms of the sharing of pairs of electrons (Single, double and triple covalent bonds) -represent covalent bonds in molecules using dot and cross diagrams -distinguish between polar and non-polar covalent bonding -test a liquid for polarity using a charged plastic rod -give examples of polar and non-polar materials in everyday life (two examples in each case) -associate covalent substances with their characteristics -test the solubility of ionic and covalent substances in different solvents
Electronegativity	-define electronegativity -recognise the trends in electronegativity values down a group and across a period -explain the general trends in electronegativity values • down a group • across a period. -relate differences in electronegativity to polarity of bonds -predict bond type using electronegativity differences
Shapes of Molecules and Intermolecular Forces	-describe the shapes of simple molecules -use appropriate modeling techniques to illustrate molecular shape

Defn: A **compound** is a substance that is made up of two or more different elements combined together chemically.

The Octet Rule: When bonding occurs, atoms tend to reach an electron arrangement with eight electron in the outermost energy level.

Exceptions to the octet rule:

1. Transition Metals usually do not obey the octet rule.
2. Hydrogen, Lithium and Beryllium tend to achieve two electrons in the outermost energy level instead of eight.

<u>Ionic Bonding:</u>

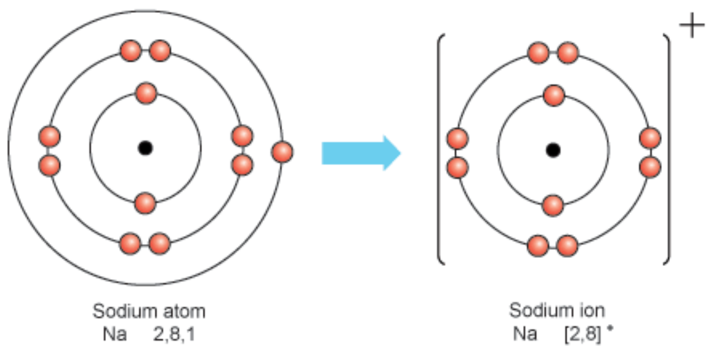
Defn: An **ion** is a charged atom or group of atoms.

Elements in Group I of the Periodic Table form ions with a charge of +1 as they lose their 1 outermost electron.

Elements in Group II of the Periodic Table form ions with a charge of +2 as they lose their 2 outermost electrons.

Elements in Group III of the Periodic Table form ions with a charge of +3 as they lose their 3 outermost electrons.

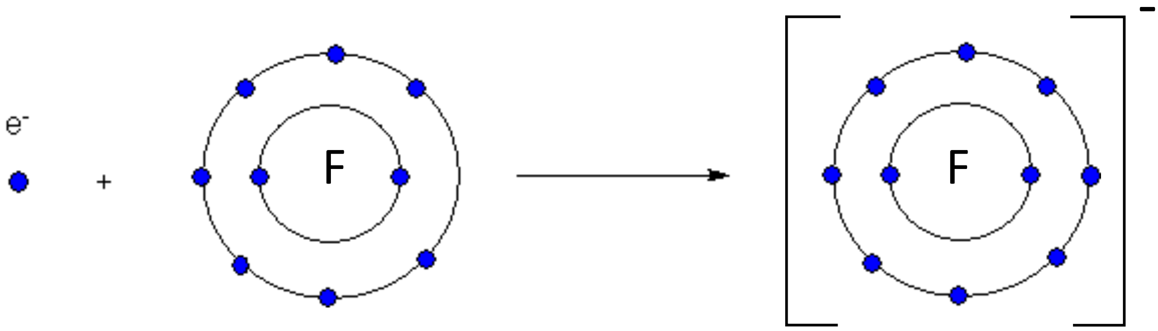
These positive ions are called **cations**.



Elements in Group VI of the Periodic Table form ions with a charge of -2 as they gain 2 electrons.

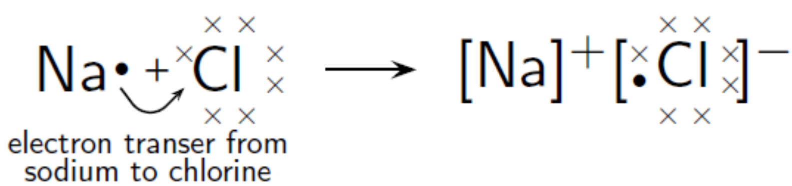
Elements in Group VII of the Periodic Table form ions with a charge of -1 as they gain 1 electron.

These negative ions are called **anions**.



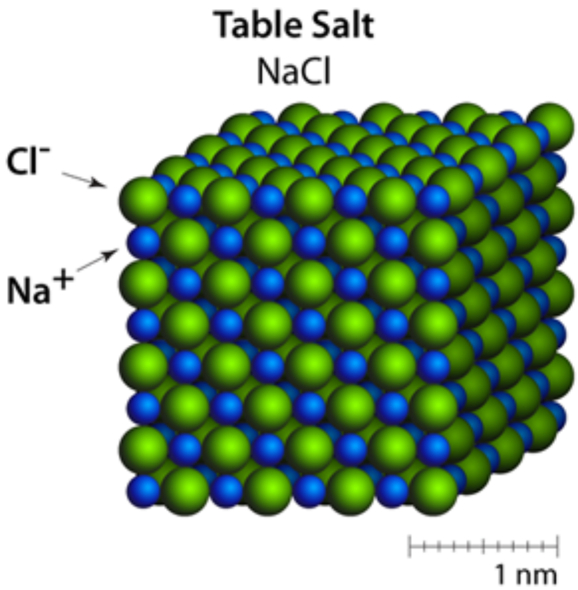
Defn: An ionic **bond** is the force of attraction between oppositely charged ions in a compound. Ionic bonds are always formed by the complete transfer of electrons from one atom to another.

To show the ionic bonding in a compound, use a **dot-and-cross diagram**:



Note: The charges in an ionic compound always cancel each other out to be neutral overall.

Crystal Structure of Sodium Chloride:



Notes:

The three-dimensional arrangement of ions is called a **crystal lattice**.

Each sodium ion is surrounded by 6 chloride ions.

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Writing Formulas of Ionic Compounds:

Note: In the formula and the name of any ionic compound, the *positive* ion goes *first*.

Example: Write the formula for the compound Aluminium Oxide.

This compound, from its name, is made up of Aluminium, Al, and Oxygen, O.

Al is in Group III, so it forms a +3 ion.   O is in Group VI so it forms a -2 ion.

The LCM of 3 and 2 is 6. We need to have a +6 charge and a -6 charge so that the compound is neutral overall.

So we need 2 Al^{3+} and we need 3 O^{2-}.

Our formula is $\mathbf{Al_2O_3}$.

Complex Ions (Group Ions)

A complex ion is an ion made up of two or more different atoms.

There are a number of complex ions whose *names, formulas and charges* you need to know by heart:

Name	Formula	Charge
Hydroxide ion	OH^-	One Negative Charge
Carbonate ion	CO_3^{2-}	Two Negative Charges

Example: Write the chemical formula for the ionic compound Calcium Hydroxide.

This compound is made up of Calcium, Ca, and the complex ion, Hydroxide, OH^-.

Calcium is in Group II, so it forms a +2 ion. Hydroxide is a -1 complex ion.

The LCM of 2 and 1 is 2. We need to have a +2 charge and a -2 charge to be neutral overall.

So, we need only one Ca^{2+} ion. We need two OH^- ions, which we write like $(OH)_2$.

Our formula is **$Ca(OH)_2$**.

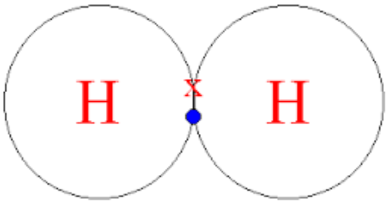
Covalent Bonding:

Covalent bonding involves electrons being *shared* between atoms, rather than electrons being fully transferred.

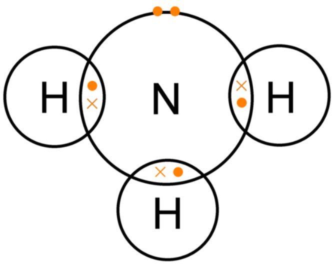
Def^n: A **molecule** is a group of atoms joined together. It is the smallest particle of an element or compound that can exist independently.

We can show covalent bonding using dot-and-cross diagrams:

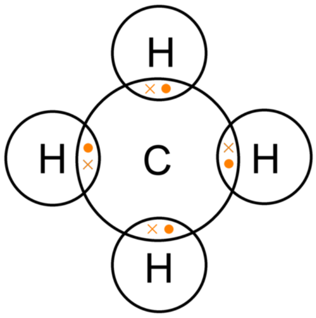
Hydrogen, H_2



Ammonia, NH_3



Methane, CH_4



Def^n: The **valency** of an element is defined as the number of atoms of hydrogen which the element will combine with.

Example: Carbon belongs to Group 4 of the Periodic Table so it has 4 outer electrons. To achieve an outer shell of 8 electrons (Octet Rule) it would need to bond with 4 hydrogen atoms. Therefore Carbon's valency is 4.

Different properties between ionic and covalent compounds:

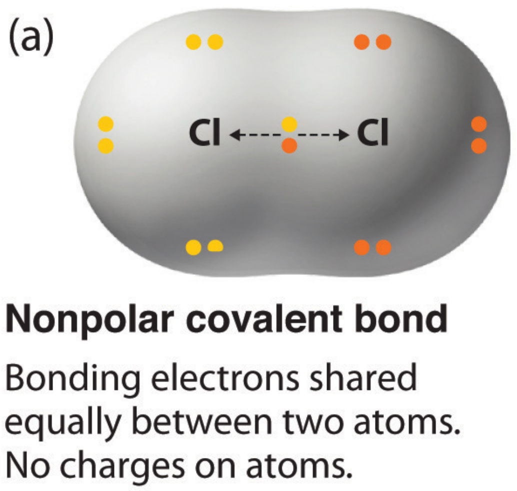
	Ionic	**Covalent**
1.	Contain a network of ions in the crystal	Contain individual molecules
2.	Ususally hard and brittle	Usually soft
3.	High melting and boiling points	Low melting and boiling points
4.	Ususally solid at room temperature	Usually liquids, gases, or soft solids at room temperature
5.	Conduct electricity when molten or dissolved in water	Do not conduct electricity

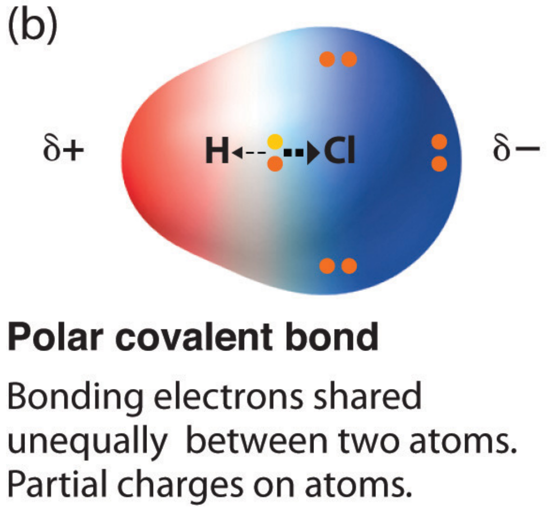
Electronegativity:

Def^n: **Electronegativity** is the relative attraction that an atom in a molecule has for the shared pair of electrons in a covalent bond.

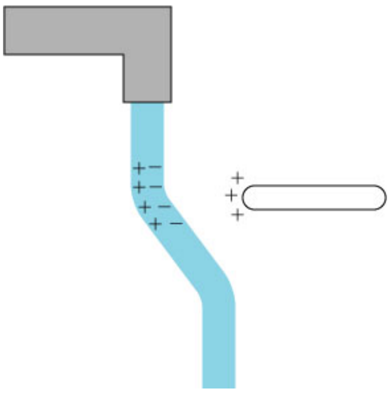
In covalent bonds, the electrons are not always equally shred. One atom in the molecule has a greater "pull" on the electrons in the bond – this atom with the greater "pull" is the more electronegative atom. This leads to having two main types of bond in a covalent molecule:

(a) Non-polar covalent: The atoms in the molecule all share electrons equally.
(b) Polar covalent: The atoms in the molecule do not share the electrons equally. This causes one end of the bond to be slightly positive (δ+) and the other ened to be slightly negative (δ-).





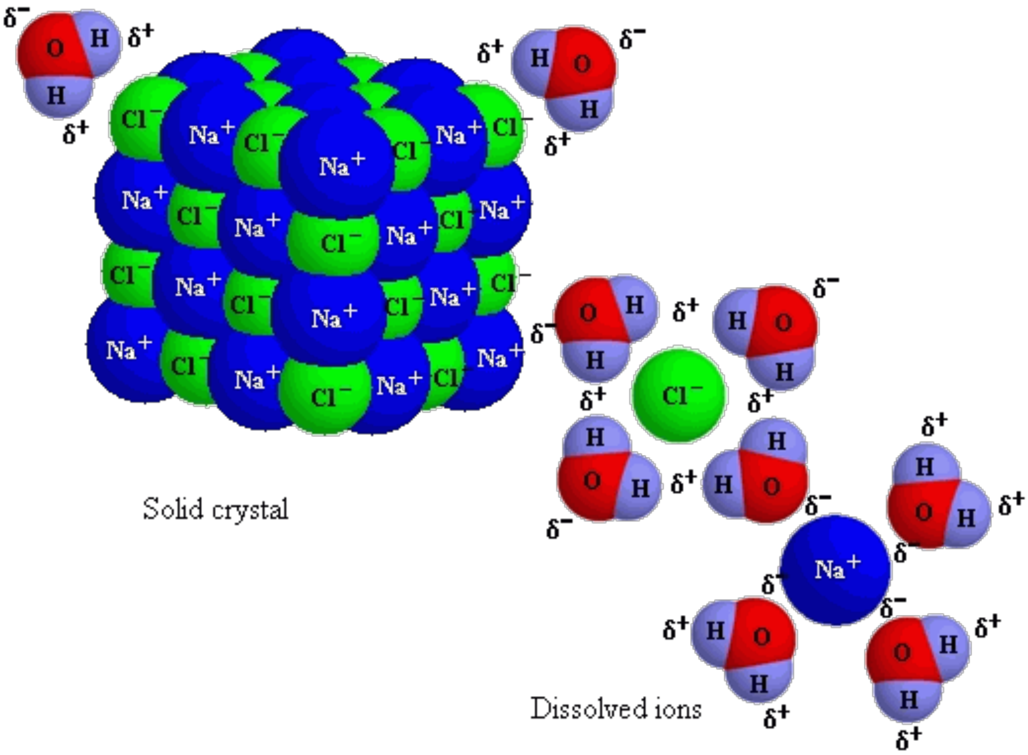
We can prove that water is polar, by placing a charged plastic rod near a thin stream of water (from a burette). We see that whether the plastic rod has a positive or negative charge, the water is always attracted to (and never repelled from) the rod.



Explanation: If the rod is positively charged, the water molecules will spin so that the negative end of the molecule is facing the rod, causing an attraction. Likewise, if the rod is negatively charged, the water molecules will spin so that the positive end of the molecule will face the rod, causing attraction.

Dissolving Ionic Compounds in Water:

We will look at the example of dissolving NaCl, Sodium Chloride (Table Salt) in water:



Ionic compounds are made up of positively and negatively charged ions.

When these ions are put in water, the water molecules arrange themselves around the ions so that the crystal is "pulled apart", or dissolved.

The negative (oxygen) end of the water will surround the positive ions (Na^+) in the crystal.

The postive (hydrogen) end of the water will surround the negative ions (Cl^-) in the crystal.

Using Electronegativity Values to Predict the Type of Bonding in a Molecule:

For this you need the Electronegativity Tables (Log Tables, Page 81). These table give us a number for each element, letting us know exactly how electronegative that element is.

To see what type of bonding is occuring in a molecule:

1. Find the electonegativity values (from the Log Tables) of the elements in the molecule.
2. Subtract the two values (if you get a negative answer, ignore the minus).
3. Compare your answer with the table on the right to get the type of bonding in the molecule.

Value	**Bonding**
0 - 0.4	Non-Polar Covalent
0.4 - 1.7	Polar Covalent
Over 1.7	Ionic

Example: What type of bonding occurs in a molecule of HCl (Hydrogen Chloride)?

From the tables, the Electronegativity Value for H is 2.20.

From the tables, the Electronegativity Value for Cl is 3.16.

3.16 – 2.2 = 0.96

Since 0.96 is between 0.4 and 1.7, the type of bonding in HCl is **Polar Covalent.**

Dissolving Compounds in Water:

A good rule to remember when trying to make a solution up is "LIKE DISSOLVES LIKE". This means that a polar solute will only dissolve in a polar solvent, and a non-polar solute will only dissolve in a non-polar solvent.

As water is a highly polar molecule, only polar and ionic substances can dissolve in it.

The more polar the substance, the more easily it will dissolve in water.

If a compound has Hydrogen Bonding, it will dissolve even more easily in water.

Non-polar compounds will NOT dissolve in water. Non-polar solvents are usually dissolved in *cyclohexane*, a non-polar solvent.