CHEMISTRY STRUCTURE OF MATERIALS

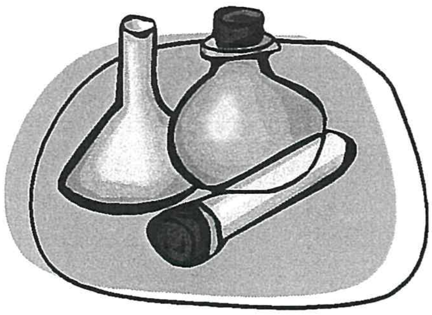
➢ When describing the structure of materials or the way that various atoms "stick" together in different types of compound, it is very important to use correct language to convey a precise understanding of the way in which a myriad of materials are "glued" together.

- There are THREE main types of chemical bond: Metallic; Ionic and Covalent. The type of bonding which "glues" different materials, depends on the types of atom that are involved. While there are only three types of chemical bond there are actually FOUR categories that are used to classify bonding: Metallic; Ionic; Covalent Molecular and Covalent Network.

- The fundamental reason why different atoms bond differently is that they all have varying numbers of protons in their nucleus as well as differing numbers of electrons which orbit at variable radii. We use a model for electron orbit that arranges electrons into "SHELLS" which reflect the various radii of orbit. The more electrons that an atom has the further will be the radii of orbit of the valence electrons as we go from one row or PERIOD of the periodic table to another. We rationalise the behaviour of atoms in chemical reactions that lead to bonds being formed, in terms of their "desire" to achieve "FULL SHELLS" and become "ISOELECTRONIC" with their nearest inert gas. Both the model and this rationalisation are, of course, a bit simplistic.

- Whether atoms are involved in bonding that requires electron transfer (REDOX: IONIC BOND) or delocalisation (METALLIC BOND) or even "sharing" (COVALENT) really depends on the strength of electro-proton attraction between the protons in the nucleus of the atom and the outermost or "VALENCE" electrons. If there are relatively few valence electrons, as is the case with metals, and these are at distance from the nucleus, they will not be attracted as strongly and will be more easily lost or delocalised. To bring about the removal or delocalisation of these electrons, only a small amount of energy known, as IONISATION ENERGY, will be required, which means that it is more likely to occur.

- Atoms that have relatively more valence electrons and protons in their nuclei (NON-METALS) will have much higher ionisation energies. The valence electrons experience more electro-proton attraction and are harder to remove, hence they will not be lost in chemical reaction. These types of element (***non-metals***) may accept electrons in a redox reaction involving an element that is more able to release them (***metals***) or may SHARE electron fields with another element that has strong electro-proton attraction (COVALENT BOND). The valence shells of these elements (***both non-metals***) can overlap so that parts of their electron fields are shared due to the mutual attraction of the nucleus of one atom for the electron field of the other and vice versa.



METALLIC BONDING

➢ Metal elements are by definition not compounds. Metals will often react by losing electrons (Oxidation) due to their low *ionisation energy to form compounds, if they come in contact with a non-metal element.

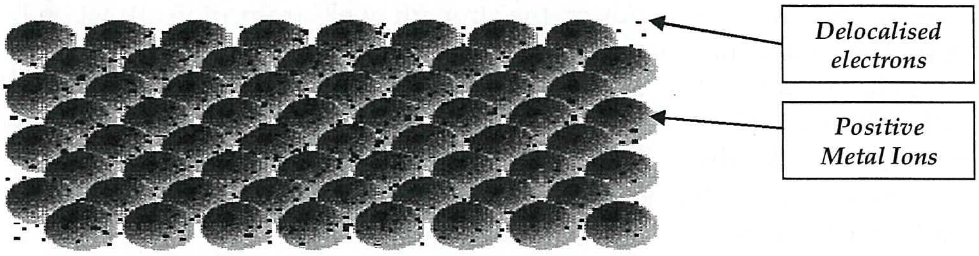
• If the element is isolated then the low ionisation energy allows the valence electrons of the metal atoms freedom to move from one atom to another within the block. As a loosely held **valence** electron leaves one atom it is said to be **DELOCALISED**. This means that the charge balance in the atom is changed and it is transformed momentarily into a ***metal ion*** with a positive charge dependent on the number of electrons that are delocalised.

** **Ionisation energy is the energy required to remove an electron from an atom. The valence electrons, being further from the nucleus, are the easiest ones to ionise! They are less under the influence of the electrostatic attraction of the protons in the nucleus.***

• While one atom may delocalise its electron/s at any instant, others may do likewise and electrons from neighbouring atoms may move into the locality of the original. In this way electrons can move from one region to another within the block, the total **charge balance is maintained** as electrons are not lost, yet the electrons are mobile and this gives rise to all of the characteristic properties of metals.

THE GLUE :

• The force that holds metal atoms together is: The force of ***electrostatic attraction*** between the lattice of ***positively charged metal ions*** and the ***"sea" of delocalised electrons***.



PROPERTIES EXPLAINED :

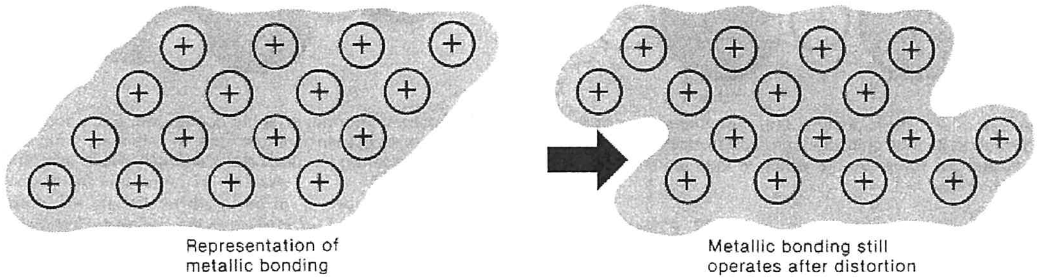
• Metals have **LUSTRE** (shiny): The "sea" of delocalised electrons that move throughout the metal will reflect light giving the sheen that we describe as lustre.

• Metals are good conductors of **ELECTRICITY**: The "sea" of delocalised electrons that exists and moves in the spaces between the lattice of metal ions is capable of transferring an electric current very effectively.

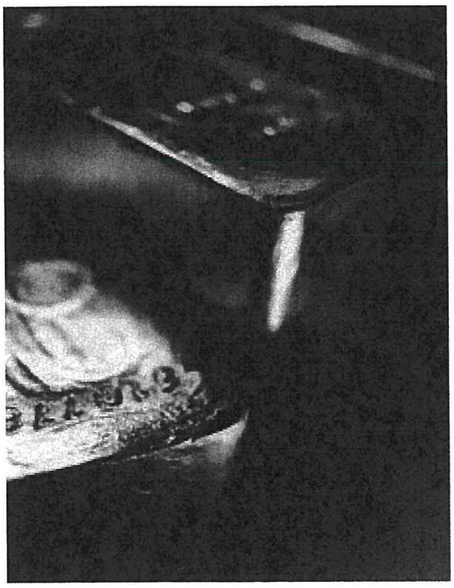
• Metals are good conductors of **HEAT**: In the solid phase the "sea" of delocalised electrons can move to transfer thermal energy while the ions can vibrate in their fixed position to do likewise. In the liquid phase both the ions and the electrons can do so.

• Metals generally have **HIGH MELTING** and **BOILING POINTS**: There is a strong electrostatic attraction between the "sea" of delocalised electrons and the lattice of positively charged metal ions. A large amount of thermal energy is required to move them apart from each other in melting and even more so in boiling.

• Metals are **MALLEABLE** (can be hammered into sheets): If the lattice of metal ions is flattened by hammering, the mobility of the "sea" of delocalised electrons allows it to move with the changes. In doing so, it is able to maintain the alternation of charge (positive/negative) that is necessary to keep metal ions apart from each other (like charges repel) yet maintain the attractions (electron/ion) that keep the metal tightly bound.



• Metals are **DUCTILE** (can be drawn into wires): If the lattice of metal ions is stretched with the application of force, the mobility of the "sea" of delocalised electrons allows it to move with the changes. In doing so, it is again able to maintain the alternation of charge (positive/negative) that is necessary to keep metal ions apart from each other (like charges repel) yet maintain the attractions (electron/ion) that keep the metal tightly bound.



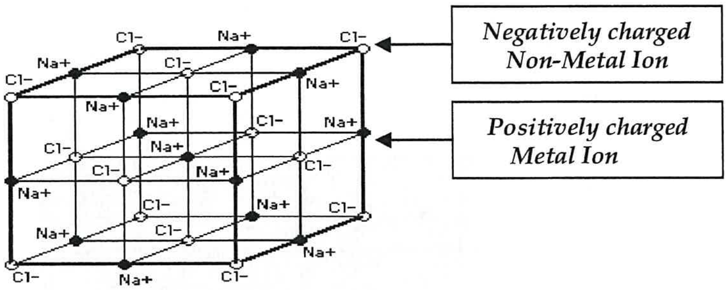
IONIC BONDING

- Ionic bonds arise when a ***metal atom*** reacts with a ***non-metal atom*** with which it comes into contact with sufficient energy. Metals have a tendency to lose electrons in chemical reaction due to their low ionisation energies, while non-metals resist doing so, but may accept them. In this way electrons are transferred from the metal atom to the non-metal atom in a typical **REDOX** reaction. The metal is always **oxidised** (Loses electrons), while the non-metal is always **reduced** (Gains electrons). The metal atom that loses one or more electrons is converted into a positive ion and is more chemically stable, while the non-metal atom is converted to a likewise stable negatively charged ion. Often both ions have become "isoelectronic" with their nearest inert gas and have formed a more stable compound known as an ionic compound.

- The ions, thus formed, arrange themselves into an alternating array due to their opposite charges (Like charges repel: Unlike charges attract). In this lattice the positive metal ions are surrounded by negatively charged non-metal ions and vice versa.

THE GLUE :

- The force that holds ionic compounds together is: The force of ***electrostatic attraction*** between the lattice of ***positively charged metal ions*** and ***negatively charged non-metal ions***.



COMMON SALT
(SODIUM CHLORIDE)

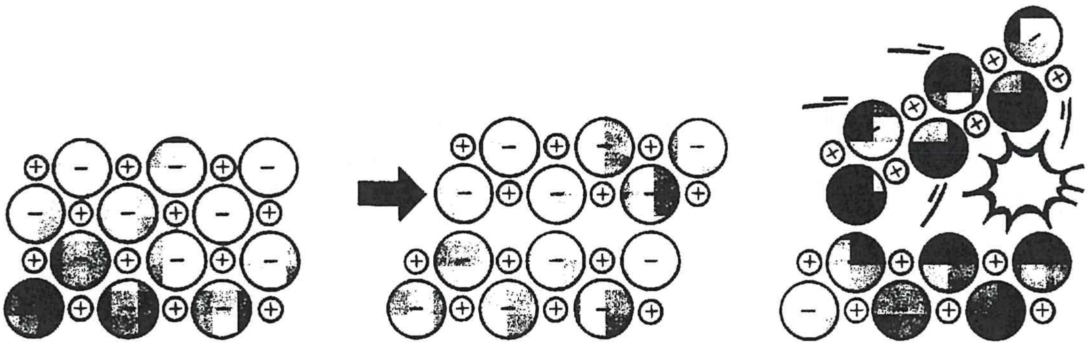
PROPERTIES EXPLAINED :

- Ionic solids have **HIGH MELTING** and **BOILING POINTS**: The strong electrostatic attraction between the oppositely charged ions in the lattice requires a great deal of thermal energy to overcome it.

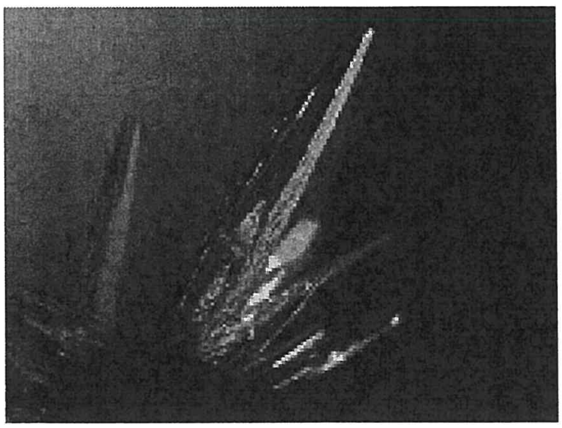
- Ionic solids are **NON-CONDUCTORS** of **ELECTRICITY** whereas the liquid and aqueous phase will conduct: For electrical conductance a material must have ***mobile charged particles*** (M.C.P). In an ionic solid there are certainly charged particles, these being the ions in the lattice, however due to strong electrostatic attraction between the oppositely charged ions they are held rigidly in fixed positions and are unable to move. When the solid is melted the ions gain mobility and are now able to transmit charge, the same is true when the ions dissociate when dissolved in water.

- Ionic solids are **POOR CONDUCTORS** of **HEAT:** For heat to be transferred through a solid there must be particles that are able to conduct it. The vibration of these particles or indeed their movement from one place to another will allow the energy to be transmitted. The ions in an ionic solid are held rigidly in place due to the strength of the electrostatic attraction between them, this limits their movement and indeed vibration.

• Ionic solids are **HARD** but **BRITTLE** (they shatter when struck with a hammer): The strong electrostatic attraction between the oppositely charged ions in the lattice makes it hard to separate them without significant force. When a large force is applied in hammering there is distortion created in the lattice and positively charged ions are brought closer to other positively charged ions, the same is true for the negatively charged ions. As like charges repel, these ions will force each other apart and the crystal lattice will shatter.

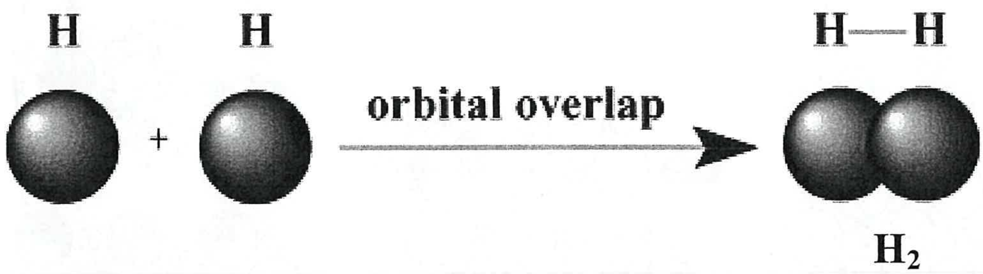


• All ionic solids are **CRYSTALLINE**: The geometry of the regular array of alternating ions that make up the crystal lattice of ionic solids is determined by the size of the ions involved and is a property of each type of solid. All ionic solids have this regular geometry that leads to the formation of well-ordered stacks of ions that we describe as crystals. If crystals are pulverised by hammering we see the formation of the powdered form in which we most commonly use them in the laboratory.



COVALENT BONDING

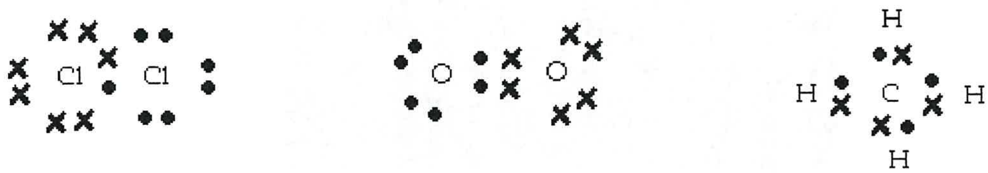
➢ Non-metal atoms are frequently found in groups known as MOLECULES or even in infinite lattices known as NETWORKS. In both cases the type of bond is the same and is known as a COVALENT bond. A covalent bond is formed by a mutual SHARING of electron fields. The valence shells of these elements (***both non-metals***) can overlap so that parts of their electron fields are shared due to the mutual attraction of the nucleus of one atom for the electron field of the other and vice versa.



- Whether the atoms involved in covalent bonding form relatively smaller DISCRETE (separate) molecules or infinite (on the atomic scale) networks depends on the type of atom involved and the number of valence shell electrons that it has. The materials formed in these two ways have markedly different properties.

COVALENT MOLECULAR:

➢ According to our model that explains the extent of electron sharing or the number of valence electrons that two non-metals will share, they will do so until each atom has a share of a stable "octet" of electrons. In achieving this goal the elements gain somewhat in chemical stability, although they are not as stable as in the ionic form in which this goal is achieved by "owning" an octet of electrons. The elements have in a "sense" become isoelectronic with their nearest inert gas. While this model is useful there are molecules that form in ways that are not explainable by this rule and these are termed "non-octet" molecules. Once a non-metal has completed its valence shell in this way the bonding is complete and a molecule has formed. Although there are some very big molecules in nature the majority are small and DISCRETE (separate) units. The molecule itself will never be charged as no electrons have actually been gained or lost.



THE GLUE:

- The force that binds molecules together is the ***strong electrostatic attraction*** between the ***positive charge*** in the ***nucleus*** of one atom in the molecule and the ***negative charge*** in the ***electron field*** of the atom to which it is bonded. This attraction is mutual and is described as being a ***strong covalent bond***.

PROPERTIES EXPLAINED :

- The fact that one molecule is not connected by any chemical covalent bond to neighbouring molecules of its kind, is the reason that the properties of these types of substances contrast markedly with the networks and are as follows:

- Molecular substances have relatively **LOW MELTING** and **BOILING POINTS**: As each molecule is a discrete unit and is not bonded to any other molecule, often very little thermal energy is required to separate them. As the molecules are not charged there is no significant electrostatic attraction between them as there is between particles in metals and ionic substances. What heat is required, is used to overcome any **INTERMOLECULAR FORCE** that exists between the molecules. Intermolecular force is a complicated area, but at this level can be considered to be an attraction based on the mass of the two molecules. As the mass of molecules is generally quite small, so then, is the intermolecular attraction that needs to be overcome.
NB: There are exceptions to this rule. Giant molecules such as those found in plastics (polymers) may have very high intermolecular forces of attraction.

- Molecular substances are **NON-CONDUCTORS** of **ELECTRICITY**: Molecules are formed by electron sharing rather than transfer. The molecules formed in this way are never charged and as such are not capable of transmitting an electric current. For charge transmission ***mobile charged particles*** are required, while molecules may be mobile they are not charged.

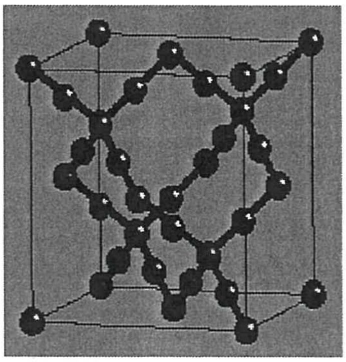
- Molecular solids are generally **SOFT**: As one molecule is not bonded rigidly to others and only held weakly by intermolecular forces it is relatively easy to separate one from another.

- Although molecular materials do not conduct in solid, liquid or gas phase a SELECT few will REACT with water in a process known as IONISATION to produce ions that may transmit a current!

Eg: $HCl_{(g)} + H_2O_{(l)} \rightarrow H_3O^+{}_{(aq)} + Cl^-{}_{(aq)}$

COVALENT NETWORK:

➢ Covalent Network formation is generally associated with the non-metal elements of Group IV of the periodic table (Carbon, Silicon). These elements have four valence electrons and can form covalent bonds in a continuous and 3-dimensional way with other like atoms or indeed certain other elements. The networks formed are not discrete or finite, all atoms are integrally linked by strong covalent bonds.



Cristobalite
SiO_2
A diamond network of Si atoms with O inserted within each network linkage

NB: There is a common misconception amongst students at this level that because covalent molecular substances have low melting points that the covalent bonds holding the atoms of the molecule together must be weak. This is far from the case; the very reason for the low temperature is that the molecules **are not** actually **bonded covalently** at all, but are simply being held together by weak intermolecular forces!!!

THE GLUE:

• The force that binds networks together is the ***strong electrostatic attraction*** between the ***positive charge*** in the ***nucleus*** of one atom in the lattice and the ***negative charge*** in the ***electron field*** of the other atoms to which it is bonded. This attraction is mutual and is described as being a ***strong covalent bond***. All atoms are covalently bonded to others in a linked lattice, there are no separate or discrete units.

PROPERTIES EXPLAINED:

• The fact that all atoms in the network lattice are integrally linked by strong covalent bonds is the reason that network properties contrast sharply from those of molecules and are as follows:

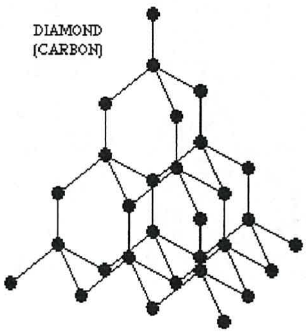
• Covalent Network substances have **VERY HIGH MELTING** and **BOILING POINTS**: As each atom is covalently bonded to others in a continuous array, the only way to melt or boil it is to **break strong covalent bonds**. The strength of these bonds comes from their electrostatic nature, as explained previously, as a result large amounts of thermal energy are required.

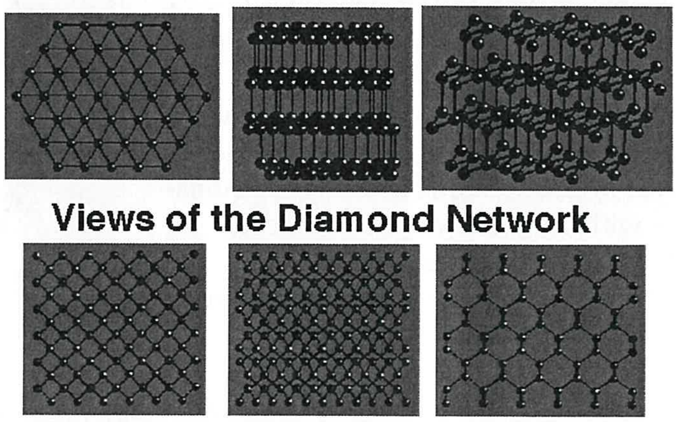
• Covalent Network substances are **NON-CONDUCTORS** of **ELETRICITY**: As each atom's electrons are localised in covalent bonds they are not capable of moving from one part of the lattice to another. The lattice itself has no charged particles as the atoms involved are sharing electrons not transferring them.

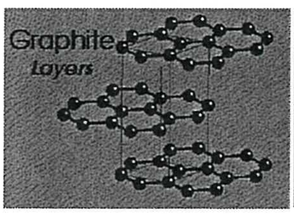
NB: There is one exception to this rule of conductance:
GRAPHITE: In graphite the carbon atoms utilise only 3 of their valence electrons in bond formation, as opposed to all four when forming the network known as Diamond. The fourth electron becomes delocalised between sheets of covalently bonded carbons (similar to metals). Graphite may conduct electricity down the planes formed in its lattice, but not across. The delocalised electron means that each sheet is not covalently bonded to the other and gives them the capacity to slide over one another. It is this sliding that allows graphite to act as a solid lubricant and to be used as the "lead" in "lead pencils"!

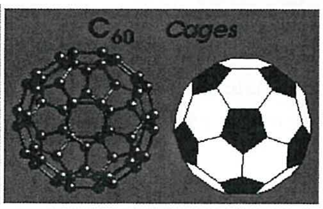
• Covalent network solids are some of the **HARDEST** substances known to man: As all atoms are linked to all others in a network array it is very hard to move one atom away from another by application of physical force.

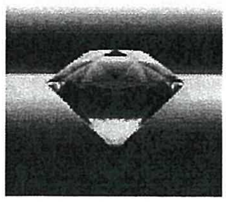
⊠ The most common networks are the four ALLOTROPES of carbon (**Diamond**; **Graphite**; Buckmisterfullerene; Nanotubes) and the many silicates (SiO_2) that exist in nature.

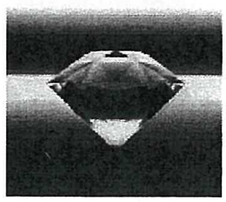












The Physical Properties of Covalent Network Substances Explained.

- **Electrical conductivity** - they are poor electrical conductors because the electrons are held in the lattice, and are not free to move.
- **Melting Points** - are very high because each atom is bound in several directions by strong covalent bonds. A large amount of energy is required to break the bonds.

- **Hardness** - They are hard because the atoms are strongly bound in the lattice, and are not easily displaced.

- **Brittleness** - If sufficient force is applied to the lattice, the bonds will break. Shattering occurs rather than deformation of shape.

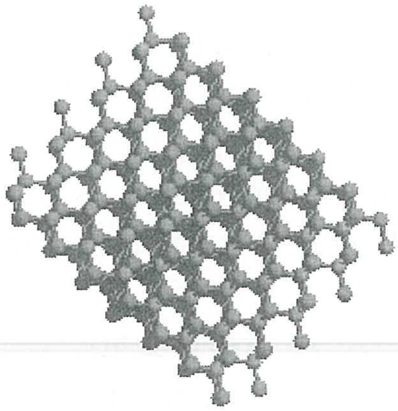
Graphite - (It's SPECIAL)

Graphite is soft. Carbon atoms are covalently bound within each layer, but there are only weak forces between the layers which can therefore slide on one another.

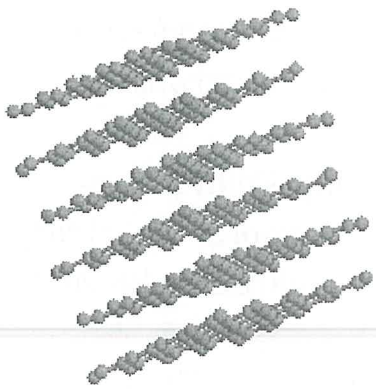
Graphite can conduct electricity in the plane of the layers. Each carbon atom shares three electrons with adjacent carbon atoms in the layer to form covalent bonds. One more electron is delocalised in the layer, rather like the delocalised electrons in metals. These electrons are free to move in the layer.

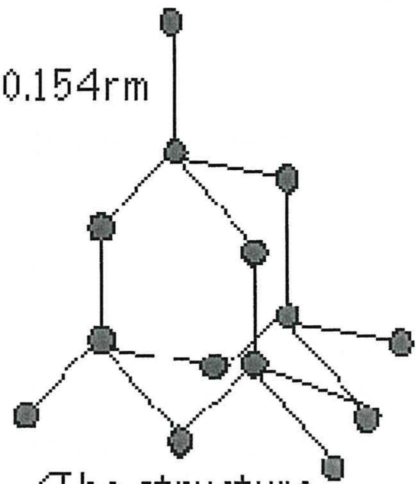
Other views of covalent network substances:

Diamond

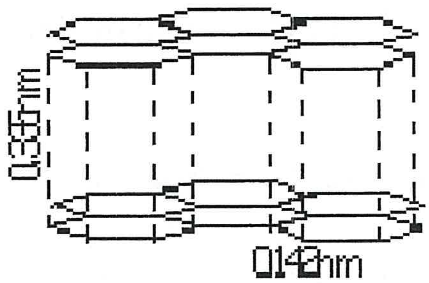


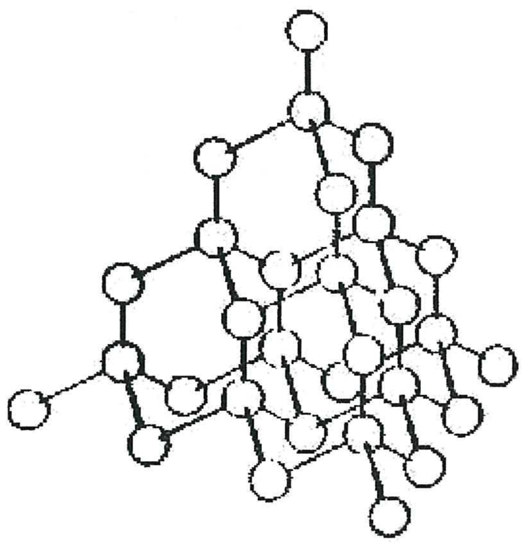
Graphite

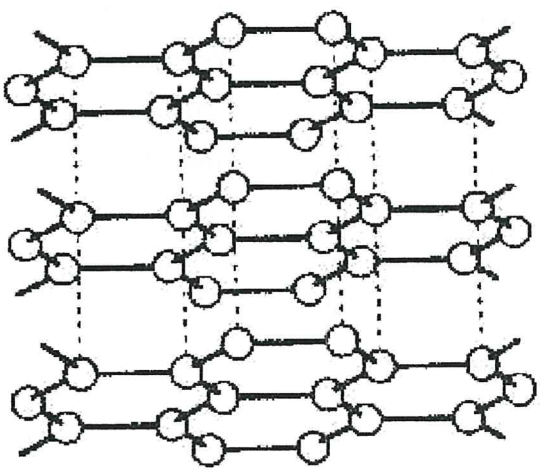




(The structure of diamond.)







CHEMISTRY — USES OF MATERIALS

➢ The particular use a material has will depend entirely on its properties. Materials are selected in a careful way so that the properties of a material suit it to the intended use.

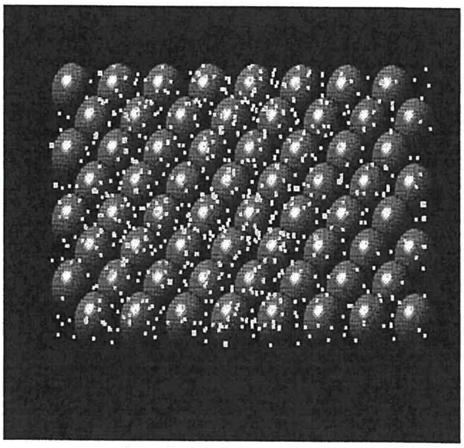
- To understand the properties of a material we must understand the nature of the elements that it contains and the way in which they are bonded (See Yr 11 "Structure of Materials"). It is important to be able to justify the choice of a material through an intimate knowledge of this bonding.
- Each of the major categories of bonded material will be discussed but each has too many uses to cover fully, only a representative sample will be used as examples. It should be noted that it is often the case that mixtures of materials are needed to perform a function.

METALS

Most of the elements in the periodic table are metallic and each has its own unique properties as well as sharing many in common. There are a myriad of everyday uses for metals in the home and society in general. Often metals are melted and alloyed (mixed) to produce specialized materials with intermediate properties.

PROPERTIES SUMMARY :

➢ Metals consist of a ***lattice of positive metal ions*** through which flows a ***sea of delocalized electrons*** that are electrostatically attracted to the ions.



- They are strong yet malleable and ductile.
- Most have high melting and boiling points.
- They are lustrous.
- They are excellent conductors of heat and electricity.

USES RELATED TO PROPERTIES:

- Metals may be used in **jewelry**. The least reactive metals will always present a shiny surface that is free from the effects of oxidation. Due to their **low reactivity**. The lustre of the metal, as light reflects from the mobile sea of delocalized electrons, means that it will be pleasing t the eye. Gold, Platinum and Silver are particularly valued for this reason.
- Metals may be used as a **structural material** in building as they are **hard** yet able to be **cast into shapes** once melted. Different alloys or mixtures of metals can be made with any property required. Structural steel (largely Iron) can be varied in hardness by adding different percentages of carbon. Soft mild steels have < 0.2% carbon while very hard tool grazed steel has between 0.9% - 1.5%. If Molybdenum or Chromium is added the steel is even stronger and may inherit corrosion resistant properties. Stainless steel is used extensively in the home for cutlery and appliances due to its corrosion resistance and relatively lustrous appearance.

- Aluminium is a **low density** metal that is used for **high tension power cables**. The **excellent electrical conductivity** afforded by the mobile sea of electrons and relatively low resistance allows the thick cables to transfer very large currents over long distances. The low density of Aluminium is also well suited to this function as the lines are not excessively heavy. Aluminium is very reactive but forms a protective, non-porous, oxide layer over its surface which means that will also not corrode to any great extent when exposed to the atmosphere. It is for these reasons also that it is a good material for soft drink cans and window and door frames in building.

- Copper is a metal with **low reactivity** and is used extensively in water and gas **plumbing** in homes for this reason. Copper is also an **excellent electrical conductor** and its ductility allows it to be drawn into wires and used throughout homes for **electrical wiring**.

- Zinc is a relatively reactive metal but, like Aluminium, forms **non-porous barriers** to further corrosion. Zinc is used extensively in galvanizing metals to **protect them from corrosion**. It may be used to coat roof materials or nuts and bolts that will be exposed to the elements.

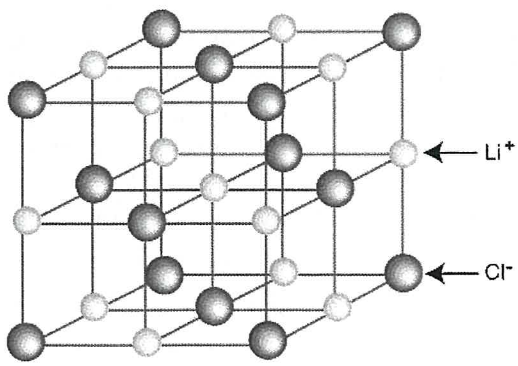
IONIC COMPOUNDS

Ionic compounds are formed by the reaction of metals and non-metals and by definition contain ions. Many of the uses of ions are associated with the solubility of ionic compounds in water which allows the compound to dissociate into separate ions which may have individual functions. Ionic solids are ELECTROLYTES due to their ability to produce aqueous ions in solution and many of their uses arise from this property. There are thousands of different ionic compounds and each has its own unique properties and uses.

PROPERTIES SUMMARY :

➢ Ionic solids consist of a crystal lattice of ***positively charged metal ions*** and ***negatively charged non-metal ions*** held together by a strong ***electrostatic*** force.

  - They have high melting and boiling points.
  - They are non-conductors of electricity in the solid state but will conduct in the aqueous, liquid and rarely seen gaseous state.
  - They are poor conductors of heat.
  - They are hard but brittle.



USES RELATED TO PROPERTIES:

- Many but not all of the uses of ionic salts are to do with their **biological importance** which arises from their ability to form **electrolyte solutions** or to be a source of the elements of life, in a **soluble form** that is available to living creatures.

  - The most commonly used ionic compound is salt ($NaCl$). It has long been used as a preservative where refrigeration is difficult as it will prevent the growth of bacteria and **inhibits food spoilage**.
  - Sodium chloride is used as flavouring in cooking as our tongue has a salt sensitive zone. The reason for this zone is that we need to receive sodium ions in our diet as they play a vital role in **nerve transmission**.
  - Manganese, Nickel, Copper and Zinc ions from whatever source are important for a number of **enzymatic reactions**. Enzymes are biological catalysts that control the rate of chemical processes in living things. The chemical reactions of life are known as our metabolism and without the control that enzymes give we would not survive.
  - Zinc ions are a component of insulin which is a hormone (protein molecule) that **controls blood sugar levels** and insures that our cells receive enough sugar for generating energy in respiration.
  - Iron ions are a key component of haemoglobin , a complex protein found in red blood cells that is responsible for **transporting oxygen** around our bodies from the lungs to the cells for respiration.
  - Magnesium ions are a key component of chlorophyll which is of immense importance in photosynthesis and serves to **trap the sun's energy** so that it may be used to power the reactions that build the sugars produced in this process. Plants are the basis of all food chains on earth and provide the means to convert solar energy into stored chemical energy.
  - **Fertilisers** are important in providing nitrogen and phosphorous for plant growth. Most plants cannot get the nitrogen that they need to **build proteins** directly from the air; Ammonium nitrate and other such salts provide this nitrogen in a **soluble form**.
  - Copper salts provide the copper ions that may be used as a **fungicide** or **algaecide** industrially or in an application as close to home as the swimming pool.
  - Soluble Hypochlorites are ionic compounds that provide a source of chlorine for **bacterial control** in swimming pools.
  - Ionic salts may be used in fireworks as the excitation of ions in the compound can lead to light of particularly pure **colours being evolved** in the chemical reactions that the pyrotechnician designs.
  - Ionic salts are used extensively as **electrolytes** for **batteries** of varying design. Ion migration between the terminals of an electrochemical cell is what allows the battery to operate.
  - Ionic salts also provide a source of material from which to **extract** the original **elements**. All ores that provide us with metals are ionic in nature, many being oxides.
  - Ionic salts such as calcium carbonate in the form of limestone or mortar can be used as building materials.

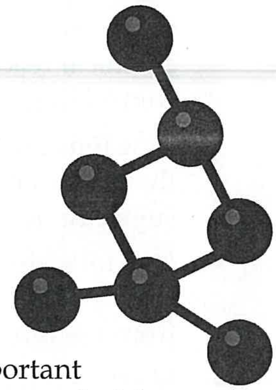
COVALENT MOLECULAR

There is no more important group of materials than the vastly different molecular compounds that are all around us. Our bodies are largely molecular in nature, from the protein that makes our flesh to the water that fills each cell and flows in our veins allowing transport of materials around our bodies. The very air we breathe is a mixture of molecules, everywhere we look we are surrounded by millions of molecules both natural and man made, all with their own unique properties and uses.

PROPERTIES SUMMARY :

- Covalent bonding involves the ***sharing of electrons*** between non-metal elements, each of which retains an attraction for the bonding electrons. Molecules are discrete units formed when non-metals of the same or different elements bond in this way.

  - They have low melting and boiling points.
  - They are non-conductors of electricity.
  - They form soft solids.
  - Some will react with water and form ions.



USES RELATED TO PROPERTIES:

- Many molecules are the basis of life and therefore very important biologically but equally many everyday uses are made of materials fabricated form molecules.

  - The **flesh** of our bodies is made from groupings of nitrogen, carbon, hydrogen and oxygen containing molecules known as amino acids. Chains of these amino acids build to form long chain polymers known as proteins. All **enzymes** and **hormones**, so important in the **regulation of metabolism** are also protein.

  - The air we breathe contains oxygen which is a vital reactant in the **energy producing** reaction known as respiration that occurs in each cell in our bodies. The **low boiling point** of this material is what allows it to exist in our atmosphere as a gas.

  - The sugar that is the fuel of life is molecular. Sugars are manufactured by plants in the process of **photosynthesis** and the **stored chemical energy** in these sugars is vital for us. They are a form of food that we term carbohydrates due to the chemical elements incorporated.

  - Hydrocarbon based fuels or fossil fuels (coal, oil, petroleum) are widely used in society for the **provision of energy**. The **stored chemical potential energy** in the bonds of these molecules allows us to release it in applications for **transport** (car engine), **warmth** (heaters) or even for **electricity** generation (coal or oil fired generator).

- **Plastics** are long chain-like molecules called polymers that are made from smaller hydrocarbon molecules. The molecules that are used to make these chains are many and varied as are the plastics that can be formed from them. The chemical features such as the **double covalent bonds** in the starting units known as monomers are what allow these molecules to link up. The use of plastics is so widespread it is hard to think of our society without them. Some plastics are **soft** and **pliable** while others can be as **hard as steel** and be used in bullet-proof vests or sporting equipment. Plastic can be used to **insulate electrical wires** due to its **lack of electrical conductance**.

- Acid solutions are made from the **reaction** of molecules such as hydrogen chloride **with water**. Acids have many industrial applications from cleaning to maintenance of pH for industrial processes and even in the home swimming pool.

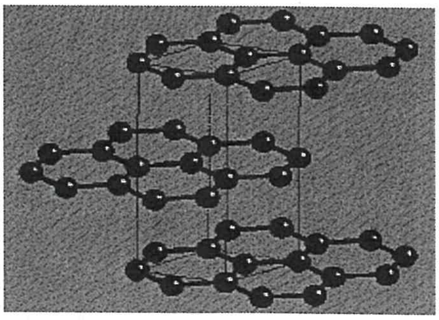
- Hydrogen peroxide H_2O_2 commonly known as "Peroxide" will oxidise the dye stuffs in clothes. The wavelengths of light that are reflected will broaden producing "whiteness". Peroxide is known as "bleach" for this reason.

- Because of the molecular nature of our biology many pharmaceuticals (drugs) are also molecular and cause various changes to our body and its functioning.

COVALENT NETWORK

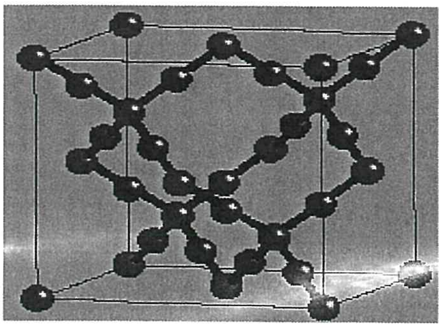
Covalent networks are some of the hardest materials known to man and involve the elements Carbon and Silicon. The sands of the beach and the desert are all silicate networks as is the glass that we make from it. The clays that are fired to make bricks for housing are also silicate mixtures and the marks we make on a piece of paper with a pencil are carbon in one of its network forms.

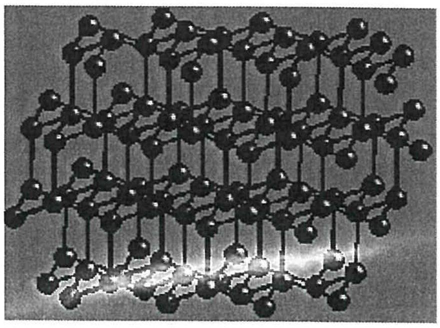
PROPERTIES SUMMARY :



- Covalent bonding involves the *sharing of electrons* between non-metal elements, each of which retains an attraction for the *bonding electrons. The difference with network bonding is that the covalent bonds extend almost infinitely* and no discrete and relatively small molecules are formed.

  - They have extremely high melting and boiling points.
  - They are extremely hard.
  - They are non-conductors of electricity. (Except Graphite)
  - They are poor conductors of heat.





USES RELATED TO PROPERTIES:

- The networks are a select group in that they are predominantly composed of carbon or silicon dioxide. Whether it is the soil in our garden or the sand in the great deserts and oceans the silicates (Silicon/Oxygen networks) are one of the most common materials on earth. Most applications make use of the hardness of these materials.

  - Silicate networks form the basis of sand which under application of great heat can be converted into a **transparent glass** which can be used in buildings for **windows** due to this transparent nature or as an attractive **drinking vessel**. While glass is brittle it is also quite **strong** depending on its thickness.

  - Silicate networks (mixed with certain ionic compounds) form the basis of clays which may be kiln fired to make **porcelain or bricks** which may be used in **construction** of homes and various buildings. The **hardness** of the kiln fired clay comes from the exclusion of water and the attractive forces that arise when water is not present to separate sheets of silicates.

  - The diamond allotrope of carbon is quite **transparent** and **refracts** or bends **light** when cut in particular ways by a jeweler. This gives the characteristic **sparkle** to the diamond that is so valued aesthetically in jewelry.

  - The diamond allotrope of carbon is also the **hardest substance** known to man and this hardness makes it very useful industrially for **drills** that can penetrate even the hardest rock. Diamond drills usually use inferior grade diamonds that are often man made and known as industrial diamonds.

  - The graphite allotrope of carbon is useful as **electrode materials** for industrial processes as it has such a **high melting point** is relatively **chemically inert** and has the unique property of being able to **conduct electricity**. The high melting point means that it can be dipped into molten mixtures without melting.

  - The graphite allotrope of carbon is useful industrially as **a solid lubricant** due to the ability of the **graphite layers to slide** past each other on the **delocalized electrons** between the sheets.

  - The graphite allotrope of carbon is useful for **pencils** as the **layers** of graphite can **slide past each other** and onto a piece of paper and is not toxic as is the case with lead.