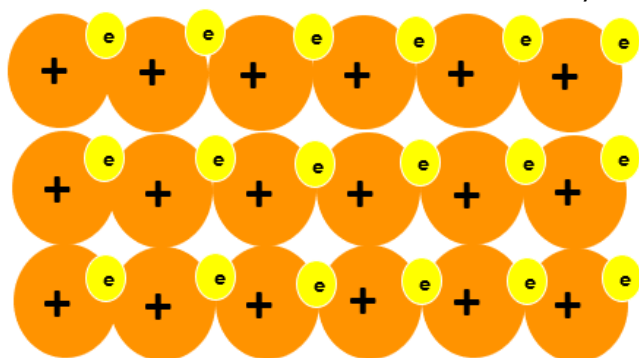
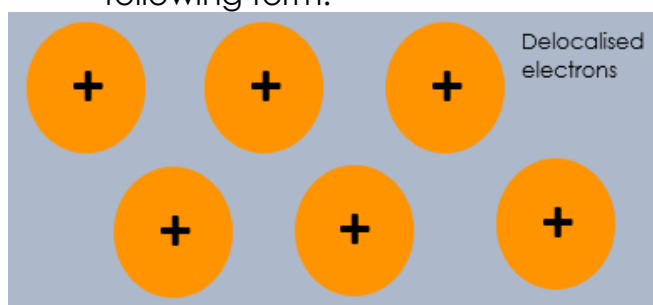


Metals and Alloys

1. Metals consist of giant structures of atoms arranged in a regular pattern.
2. The electrons in the outer shell of metal atoms are delocalised and so are free to move through the whole structure. The sharing of delocalised electrons gives rise to strong metallic bonds.
3. Metallic bonding is the force of attraction between the positive metal ions (shown below as big circles with +) and the 'sea' of delocalised electrons forming a giant metallic structure (shown below as smaller circles with 'e')

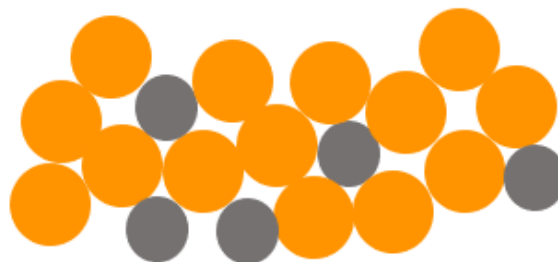


4. The sharing of delocalised electrons in metals can be represented in the following form:



5. Metals have giant structures of atoms with strong metallic bonding.
6. This means that most metals have high melting and boiling points.
7. In pure metals, atoms are arranged in layers, which allows metals to be bent and shaped.

8. Pure metals are too soft for many uses and so are mixed with other metals to make alloys which are harder.
9. An alloy is a mixture of chemical elements of which at least one is a metal. As shown below, the large circles are metal ions, and the small circles are carbon atoms.



10. Alloys are harder and stronger than pure metals.
11. This is because in an alloy, there are atoms of different sizes. This distorts the layers of atoms in a pure metal. This means that a greater force is required for the layers to slide over each other.
12. Alloys have a number of uses such as in construction and braces for teeth.
13. Shape memory alloys are useful for many uses, for example in spectacles.

Alloys (Chemistry Only)

14. Most metals in everyday use are alloys.
15. Bronze is an alloy of copper and tin.
16. Brass is an alloy of copper and zinc.
17. Gold used as jewellery is usually an alloy with silver, copper and zinc.
18. The proportion of gold in the alloy is measured in carats. 24 carat being 100% (pure gold), and 18 carat being 75% gold.
19. Steels are alloys of iron that contain specific amounts of carbon and other metals.



- 20. High carbon steel is strong but brittle.
- 21. Low carbon steel is softer and more easily shaped.
- 22. Steels containing chromium and nickel (stainless steels) are hard and resistant to corrosion.
- 23. Aluminium alloys are low density.

Properties of Ionic Substances

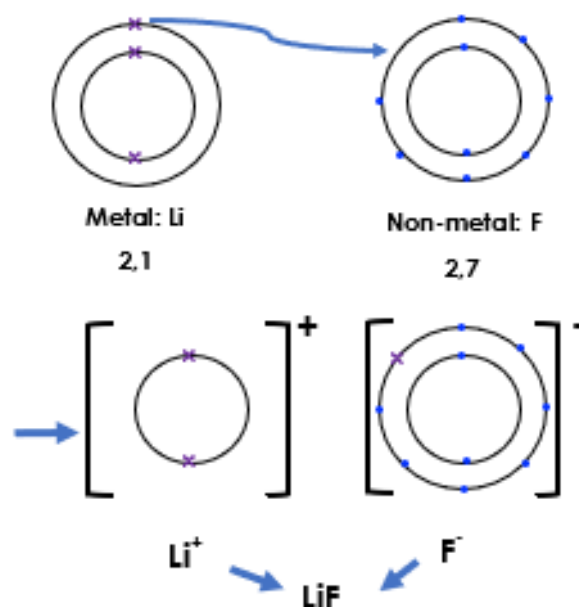
- 24. Ionic substances have high melting and boiling points
- 25. When melted or dissolved in water, ionic compounds conduct electricity
- 26. The properties of ionic substances can be explained by their structure.
- 27. Ionic compounds have regular structures, also called giant ionic lattices
- 28. Giant ionic lattices contain strong electrostatic forces of attraction in all directions between oppositely charged ions
- 29. Giant ionic lattices have high melting and boiling points because of the large amounts of energy needed to break the many strong bonds
- 30. When melted or dissolved in water, ionic compounds conduct electricity because the ions are free to move and so charge can flow.

Ionic bonding

- 31. Ionic bonding occurs in compounds formed from metals combined with non-metals.
- 32. For ionic bonding the particles are oppositely charged ions.
- 33. When a metal atom reacts with a non-metal atom electrons in the

outer shell of the metal atom are transferred.

- 34. Metal atoms lose electrons to become positively charged ions.
- 35. An ion is a charged atom or group of atoms
- 36. Non-metal atoms gain electrons to become negatively charged ions.

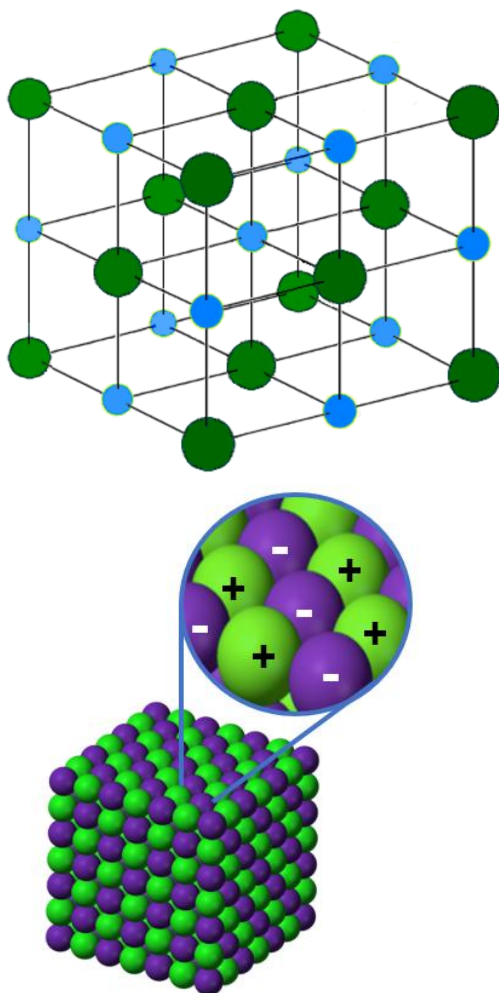


- 37. The ions produced by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 have the electronic structure of a noble gas (Group 0).
- 38. The electron transfer during the formation of an ionic compound can be represented by a dot and cross diagram.
- 39. The charge on the ions produced by metals in Groups 1 and 2 and by non-metals in Groups 6 and 7 relates to the group number of the element in the periodic table.
- 40. An ionic compound is a giant structure of ions. Ionic compounds are held together by strong electrostatic forces of attraction between oppositely charged ions. These forces act in all directions in



the lattice and this is called ionic bonding.

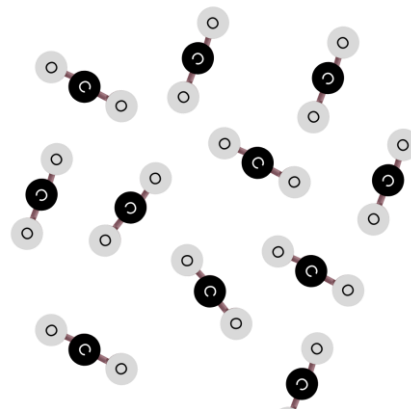
41. The structure of sodium chloride can be represented in the following forms:



Properties of covalent substances

42. Covalently bonded substances may consist of small molecules, for example those in water, hydrogen gas, carbon dioxide.
43. Some covalently bonded substances have very large molecules, such as polymers.
44. Some covalently bonded substances have giant covalent structures, such as diamond and silicon dioxide.
45. Substances that consist of small molecules are usually gases or

liquids that have relatively low melting points and boiling points.

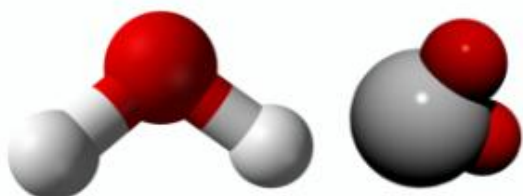
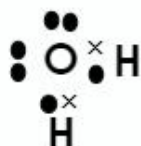
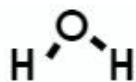


46. Although the covalent bonds holding molecules together are strong, the intermolecular forces acting between molecules are weak.
47. It is these intermolecular forces that are overcome, not the covalent bonds, when the substance melts or boils.
48. The intermolecular forces increase with the size of the molecules, so larger molecules have higher melting and boiling points.
49. These substances do not conduct electricity because the molecules do not have an overall electric charge.
50. Substances that consist of giant covalent structures are solids with very high melting points.
51. All of the atoms in these structures are linked to other atoms by strong covalent bonds.
52. These bonds must be overcome to melt or boil these substances.
53. Diamond and graphite (forms of carbon) and silicon dioxide (silica) are examples of giant covalent structures.

Covalent Bonding

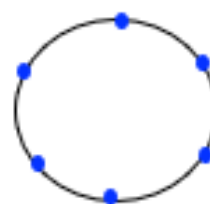


54. The covalent bonds in molecules and giant structures can be represented in a number of different forms.

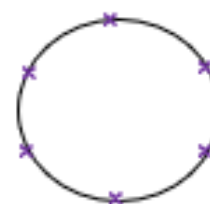


55. A single line on a diagram of a molecule represents a single covalent bond (one pair of shared atoms)
56. Atoms may form multiple covalent bonds
57. A double line on a diagram of a molecule represents a double covalent bond (two pairs of shared electrons)
58. Covalent bonding occurs in most non-metallic elements and in compounds of non-metals.
59. For covalent bonding the particles are atoms which share pairs of electrons.
60. The electrons involved in covalent bonding are in the outer shells of electrons.
61. When atoms share pairs of electrons, they form covalent bonds.
62. These bonds between atoms are strong.
63. Covalent bonds are strong because both nuclei are strongly

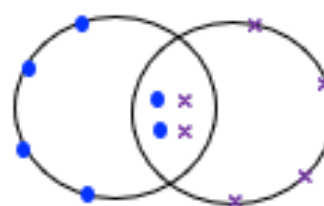
attracted to the shared pair of electrons in the covalent bond



Oxygen atom
2, 6



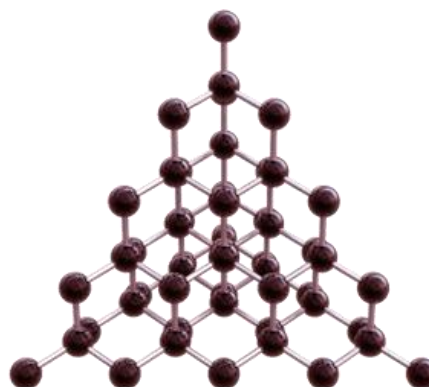
Oxygen atom
2, 6



Oxygen molecule
 O_2

Diamond

64. In diamond, each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure



65. The rigid network of carbon atoms, held together by strong covalent bonds, makes diamond very hard.
66. Diamond has a high melting point, because the network of carbon atoms are held together by strong covalent bonds.
67. Diamond being very hard makes it useful for cutting tools, such as



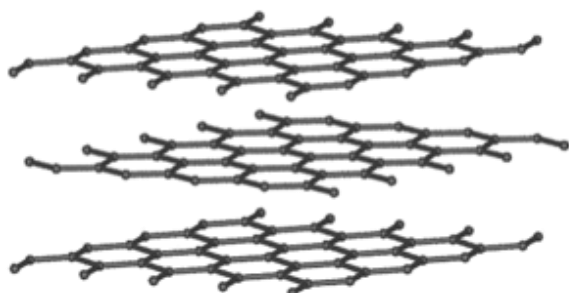
diamond-tipped glass cutters and oil rig drills.

68. Diamond does not contain any delocalised electrons, so it does not conduct electricity.

Graphite

69. Graphite has a giant covalent structure in which:

- each carbon forms three covalent bonds with other carbon atoms
- the carbon atoms form layers of hexagonal rings
- there are no covalent bonds between the layers
- there is one delocalised electron from each atom



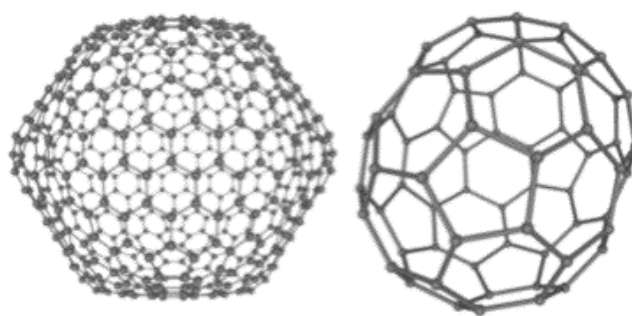
70. Graphite has delocalised electrons, like metals.
71. These delocalised electrons are free to move between the layers in graphite, which is why graphite can conduct electricity.
72. As graphite can conduct electricity, it is useful for electrodes in batteries and in electrolysis.
73. The forces between the layers in graphite are weak
74. This means that the layers can slide over each other.
75. This makes graphite slippery, so it can be used as a lubricant, and in pencils.

Graphene and fullerenes

76. Graphene and fullerenes are made of carbon.
77. Graphene is a single layer of graphite.



78. Graphene has strong covalent bonds between the carbon atoms
79. These strong covalent bonds cause graphene to be very strong with a high melting point.
80. Graphene has delocalised electrons which mean it can conduct electricity.
81. This makes graphene useful for electronics and composites.
82. Fullerenes are molecules of carbon atoms with hollow shapes.



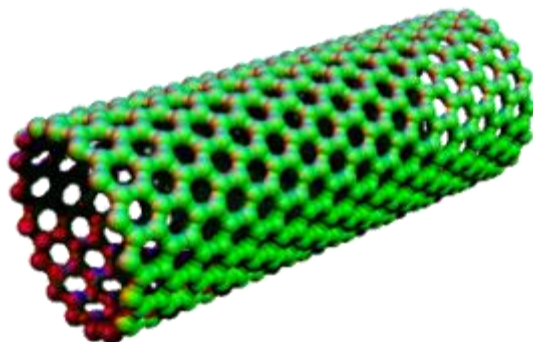
83. The structure of fullerenes is based on hexagonal rings of carbon atoms.
84. Fullerenes may also contain rings with five or seven carbon atoms.
85. The first fullerene to be discovered was Buckminsterfullerene (C₆₀) which has a spherical shape.
86. There are weak intermolecular forces between molecules of buckminsterfullerene.
87. The weak intermolecular forces between molecules of buckminsterfullerene need little



energy to overcome, so it is slippery with a low melting point.

Nanotubes

- 88. One use of fullerenes is carbon nanotubes
- 89. Carbon nanotubes are fullerenes in cylindrical shapes, like a layer of graphene rolled into a cylinder.



- 90. Nanotubes are long but extremely narrow, which gives them a high length to diameter ratio.
- 91. Nanotubes have high tensile strength, so they are strong in tension and resist being stretched.
- 92. Nanotubes have delocalised electrons which mean they can conduct electricity.
- 93. The carbon atoms in nanotubes are bonded by covalent bonds, which makes nanotubes strong.
- 94. Nanotubes are useful for nanotechnology, electronics and materials.

Nanoparticles (Chemistry Only)

- 95. Nanoscience refers to structures that are 1-100 nm in size. This is approximately as big as a few hundred atoms.
- 96. Nanoparticles, are smaller than fine particles (PM_{2.5}), which have diameters between 100 and 2500 nm (1×10^{-7} m and 2.5×10^{-6} m).

- 97. Coarse particles (PM₁₀) have diameters between 1×10^{-5} m and 2.5×10^{-6} m.
- 98. Coarse particles are often referred to as dust.
- 99. Nanoparticles have very large surface area to volume ratios.
- 100. As the side of cube decreases by a factor of 10 the surface area to volume ratio increases by a factor of 10.
- 101. Nanoparticles may have properties different from those for the same materials in bulk because of their high surface area to volume ratio.
- 102. It may also mean that smaller quantities are needed to be effective than for materials with normal particle sizes.
- 103. Nanoparticles have many applications in medicine, in electronics, in cosmetics and sun creams, as deodorants, and as catalysts.
- 104. New applications for nanoparticulate materials are an important area of research.
- 105. There are possible risks associated with the use of nanoparticles
- 106. Some people are concerned that the small size of nanoparticles makes it possible to breathe them in, or for them to pass into cells.

Bonding Review

- 107. For metallic bonding the particles are atoms which share delocalised electrons.
- 108. Metallic bonding occurs in metallic elements and alloys.
- 109. Bonding involves electrostatic forces and the sharing or transfer of electrons.





110. Electrostatic forces are attractive or repulsive forces between particles, caused by their electric charges.

111. There are three types of strong chemical bonds: ionic, covalent and metallic.

112. Diagrams that represent bonding have limitations, including ball and stick diagrams, dot and cross diagrams and 2 and 3 dimensional diagrams.

113. The table below shows the different models for bonding and their limitations:

Model of ionic bonding	Dot and cross model	2D model	3D model (ball and stick model)
Example			
Advantage	Shows how the ionic bonds are formed and the ratio in which atoms react	Clearly shows arrangement of ions in one layer	Clearly shows how the ions are arranged in a lattice
Limitation	Does not show how the ions are arranged in space	Does not show the arrangement of ions in different layers	Is not to scale and does not give information about the forces of attraction between ions

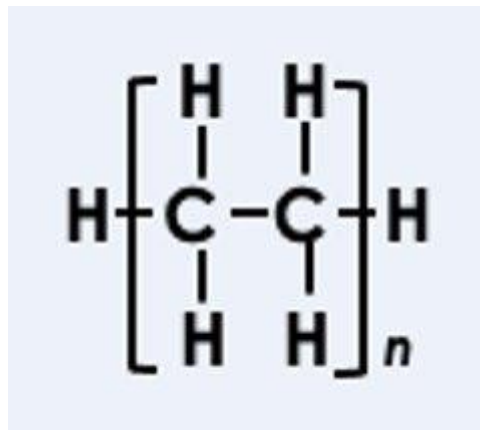
Model of covalent bonding	Dot and cross model	Structure	Ball and stick model	Space-filling model
Example				
Advantage	Shows how the pairs of electrons are shared in covalent substances	Clearly shows arrangement of ions in one layer	Clearly shows how the atoms are arranged in a molecule or giant covalent structure	Clearly shows how the atoms are arranged in a molecule or giant covalent structure
Limitation	Does not show how the atoms are arranged in space	Does not show how the bond is formed	Is not to scale and does not give information about the sharing of electrons	Is not to scale and does not give information about the sharing of electrons

114. The empirical formula of an ionic compound can be worked out from a diagram showing the ionic structure, by looking at the ratio of each type of ion in the compound.



Polymers

115. Polymers have very large molecules. The atoms in the polymer molecules are linked to other atoms by strong covalent bonds.
116. Polymers can be represented in the form where n is a large number



117. The intermolecular forces between polymer molecules are relatively strong and so these substances are solids at room temperature.
118. The properties of polymers depend on what monomers they are made from and the conditions under which they are made. For example, low density (LD) and high density (HD) poly(ethene) are produced from ethene.
119. Thermosoftening polymers melt when they are heated.
120. Most composites are made of two materials, a matrix or binder surrounding and binding together fibres or fragments of the other material, which is called the reinforcement.
121. Thermosetting polymers do not melt when they are heated.

