ROYAL SOCIETY OF CHEMISTRY

UNIVERSITY OF BIRMINGHAM

Topic 2 – Chemical Bonds

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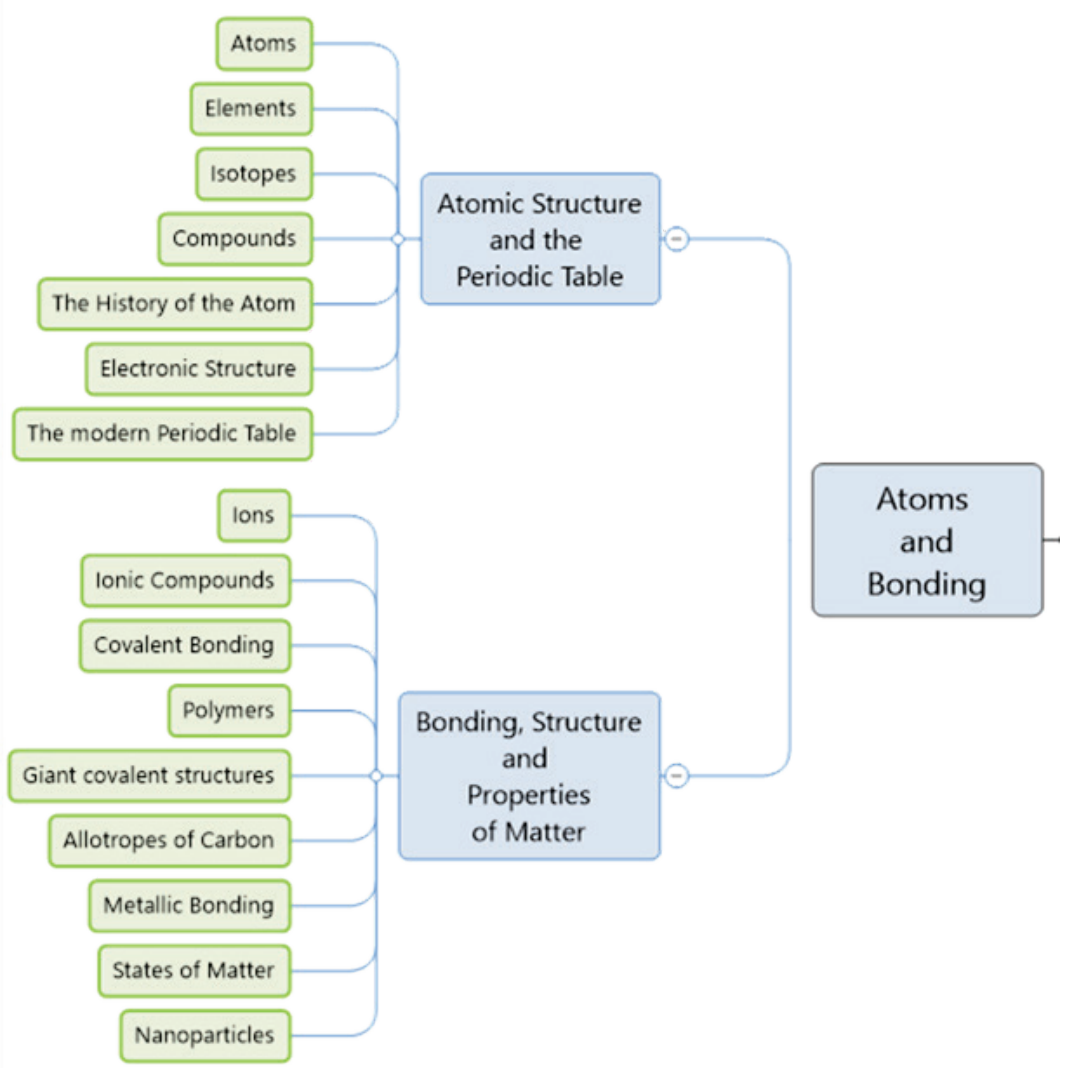
Topic 2 – Chemical Bonds

Sub Topics



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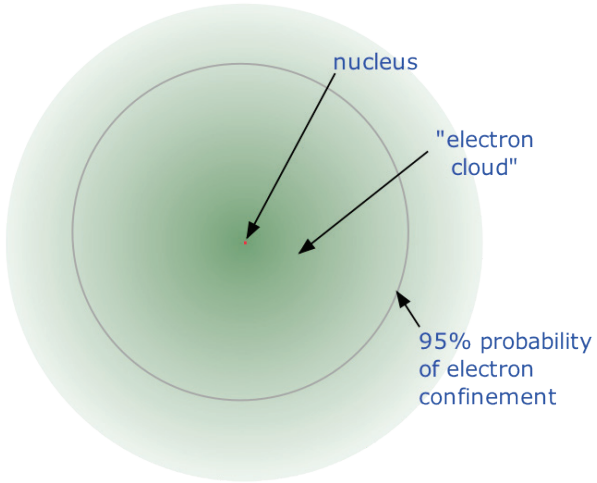
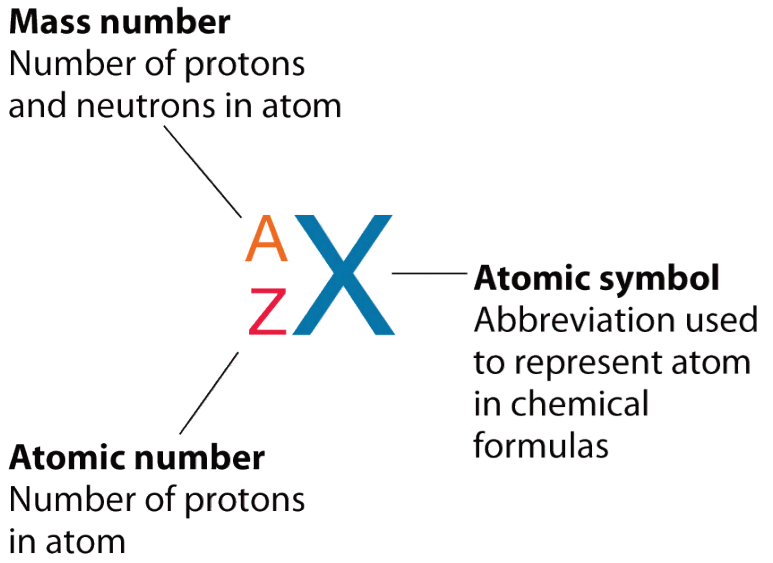
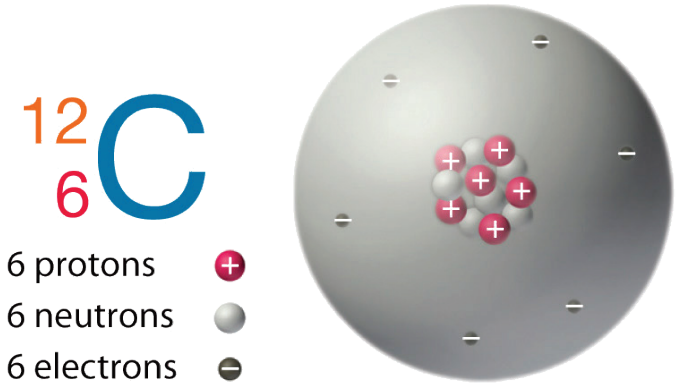
The Nuclear atom

Rutherford's famous 1911 a-ray scattering experiment.
Established:





Almost all of the atomic mass is contained within a tiny (∴extremely dense) nucleus carrying a positive electric charge whose value identifies each element and is known as the atomic number of the element.



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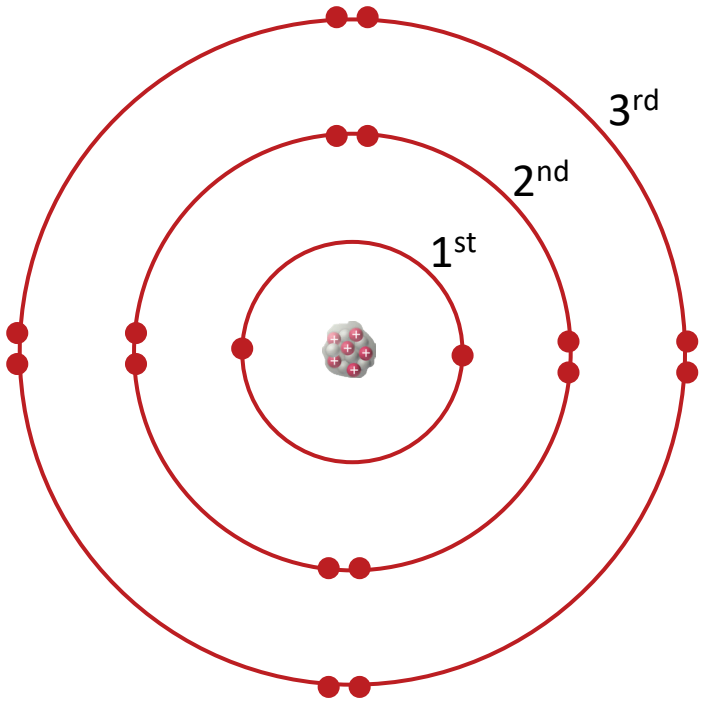
Bohr's Electronic Structure



Electronic configuration: 2,8,8

Electron Shell Rules:

1. Electrons always occupy shells (energy levels)
2. The lowest energy levels are filled first – ones closest to nucleus
3. Each shell has a maximum capacity

1st Shell: 2 | 2nd Shell: 8 | 3rd Shell: 8

- Atoms more stable with FULL electron shells (e.g. Noble Gases in Group 0)
- For most atoms, the outer shell (valence shell) is NOT Full Thus the atom want's to React to fill it

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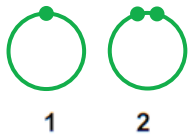
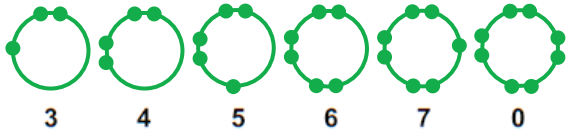
Valence Shells





																	4 He helium 2
7 Li lithium 3	9 Be beryllium 4											11 B boron 5	12 C carbon 6	14 N nitrogen 7	16 O oxygen 8	19 F fluorine 9	20 Ne neon 10
23 Na sodium 11	24 Mg magnesium 12											27 Al aluminium 13	28 Si silicon 14	31 P phosphorus 15	32 S sulfur 16	35.5 Cl chlorine 17	40 Ar argon 18
39 K potassium 19	40 Ca calcium 20	45 Sc scandium 21	48 Ti titanium 22	51 V vanadium 23	52 Cr chromium 24	55 Mn manganese 25	56 Fe iron 26	59 Co cobalt 27	59 Ni nickel 28	63.5 Cu copper 29	65 Zn zinc 30	70 Ga gallium 31	73 Ge germanium 32	75 As arsenic 33	79 Se selenium 34	80 Br bromine 35	84 Kr krypton 36
85 Rb rubidium 37	88 Sr strontium 38	89 Y yttrium 39	91 Zr zirconium 40	93 Nb niobium 41	96 Mo molybdenum 42	[97] Tc technetium 43	101 Ru ruthenium 44	103 Rh rhodium 45	106 Pd palladium 46	108 Ag silver 47	112 Cd cadmium 48	115 In indium 49	119 Sn tin 50	122 Sb antimony 51	128 Te tellurium 52	127 I iodine 53	131 Xe xenon 54
133 Cs caesium 55	137 Ba barium 56	139 La* lanthanum 57	178 Hf hafnium 72	181 Ta tantalum 73	184 W tungsten 74	186 Re rhenium 75	190 Os osmium 76	192 Ir iridium 77	195 Pt platinum 78	197 Au gold 79	201 Hg mercury 80	204 Tl thallium 81	207 Pb lead 82	209 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[267] Rf rutherfordium 104	[270] Db dubnium 105	[269] Sg seaborgium 106	[270] Bh bohrium 107	[270] Hs hassium 108	[278] Mt meitnerium 109	[281] Ds darmstadtium 110	[281] Rg roentgenium 111	[285] Cn copernicium 112	[286] Nh nihonium 113	[289] Fl flerovium 114	[289] Mc moscovium 115	[293] Lv livermorium 116	[293] Ts tennessine 117	[294] Og oganesson 118

Key: relative atomic mass / atomic symbol / name / atomic (proton) number

1 H hydrogen 1

Non-Metals

Metals

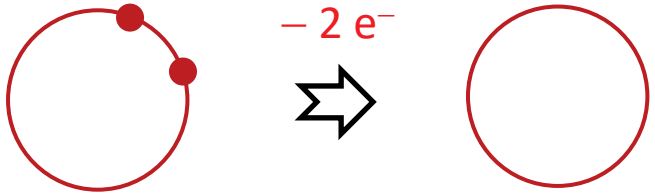
Topic 2 – Chemical Bonds

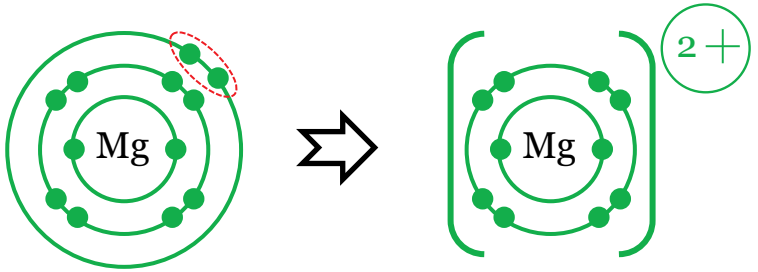
Ions

Ions form when Electrons are Transferred

1. Ions are charged particles – can be single atoms (e.g. Na^+) or groups of atoms (NO_3^-)
2. When atoms gain or lose electrons – they try to fill the outer shell
   (Atoms with full outer shells are very stable)
3. Metals lose electrons from outer shell to form positive ions (e.g. Ca^{2+})

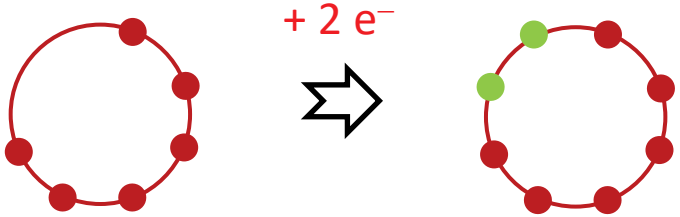
Easier for this metal to lose 2 e^- than gain 6 e^- !





4. Non-metals gain electrons into the outer shell to form negative ions (e.g. O^{2-})

Easier for this non-metal to gain 2 e^- than lose 6 e^- !



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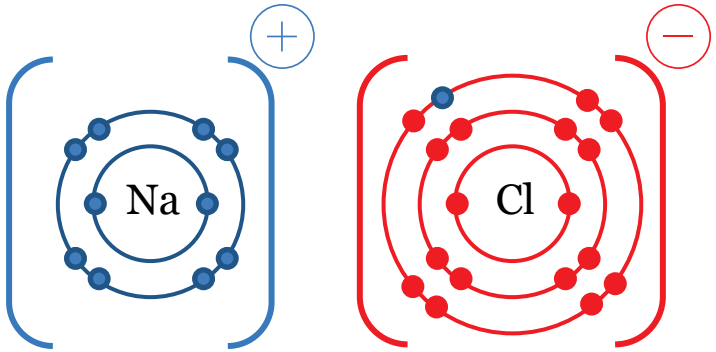
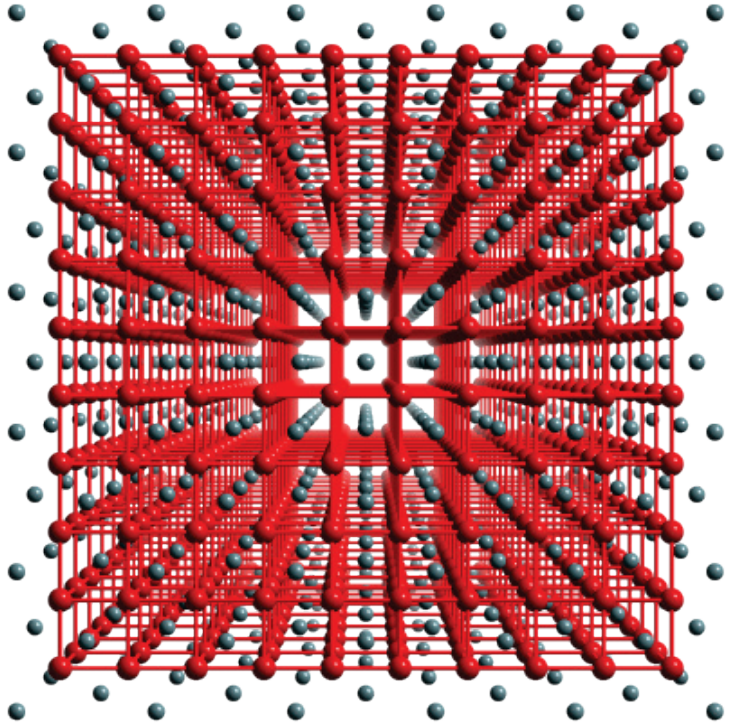
Ionic Bonding

Oppositely charged ions are strongly attracted to each other by electrostatic forces



This attraction is called an ionic bond.

Ionic compounds have regular lattice structures



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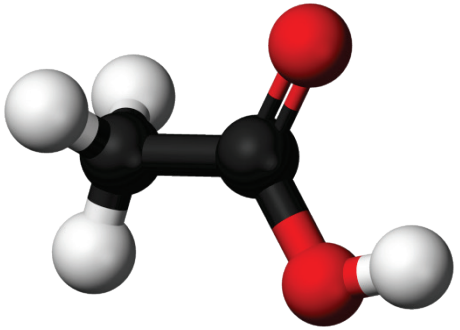
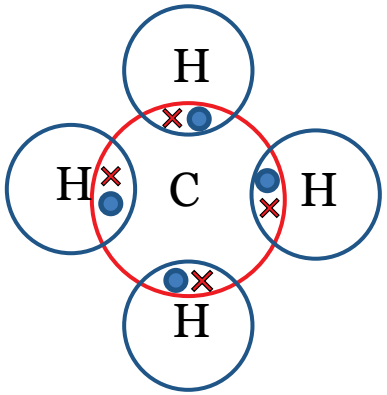
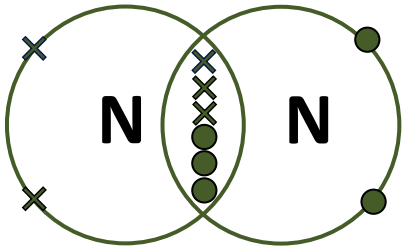
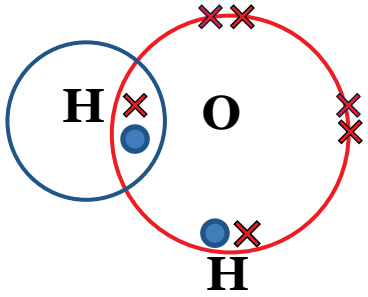
Covalent Bonding

Covalent Bonds share electrons:









Non-metal atoms bond together by sharing pairs of electrons to form covalent bonds

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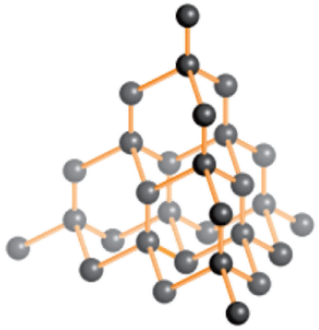
Allotropes of Carbon

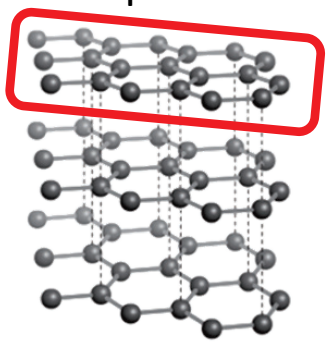
How atoms are bound together in a compound has a profound effect on its chemical and physical properties



Diamond

Graphite

Graphene



Why do these materials composed of C have such different properties?

The answer lies within the bonding of the C atoms…

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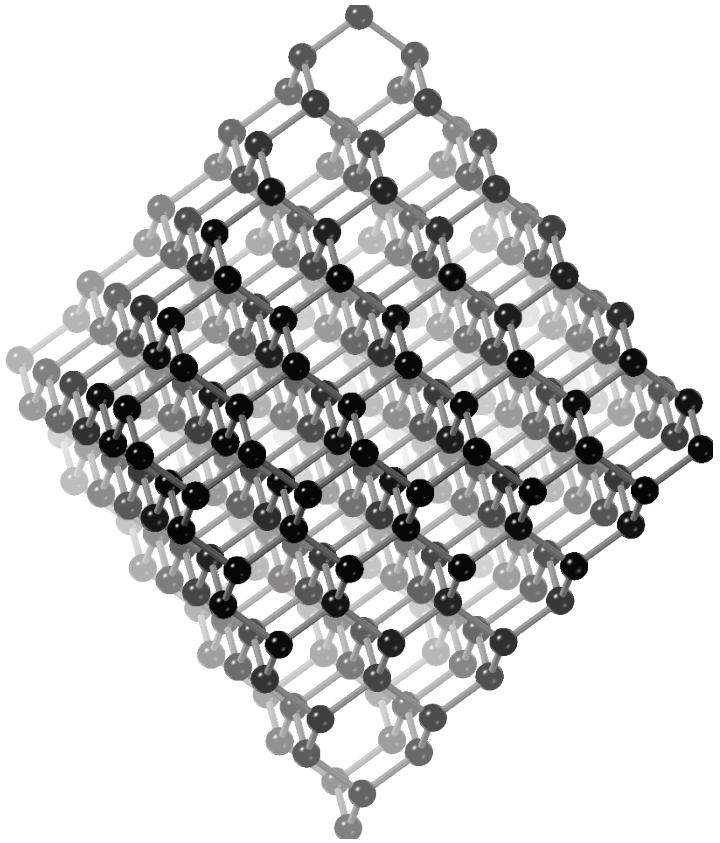
Allotropes of Carbon

Macromolecules – atoms bonded by strong covalent bonds.

Diamond



- Giant covalent structure formed from Carbon atoms – each forming four covalent bonds making the structure exceptionally hard.
- These strong covalent bonds require a lot of energy to break, therefore high M.P.
- Does not conduct electricity because there are no free electrons or ions.

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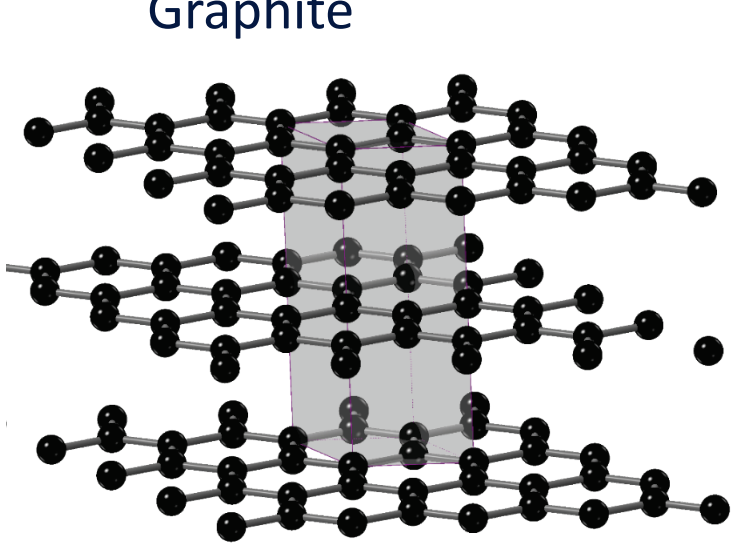
Allotropes of Carbon

Graphite Contains Sheets of Hexagons

Graphite



Only 3 of Carbons 4 outer e^-s are used in bonding – each C has 1 delocalised e^- that is free to move – Graphite conducts electricity and thermal energy!

- Each C atom only forms 3 covalent bonds creating sheets of C atoms arranged in hexagons.
- No covalent bonds between layers – held together by weak Van der Waals forces – free to move over each other – used as lubricating material.
- Covalent bonds in layers require lot of energy to break – high M.P.

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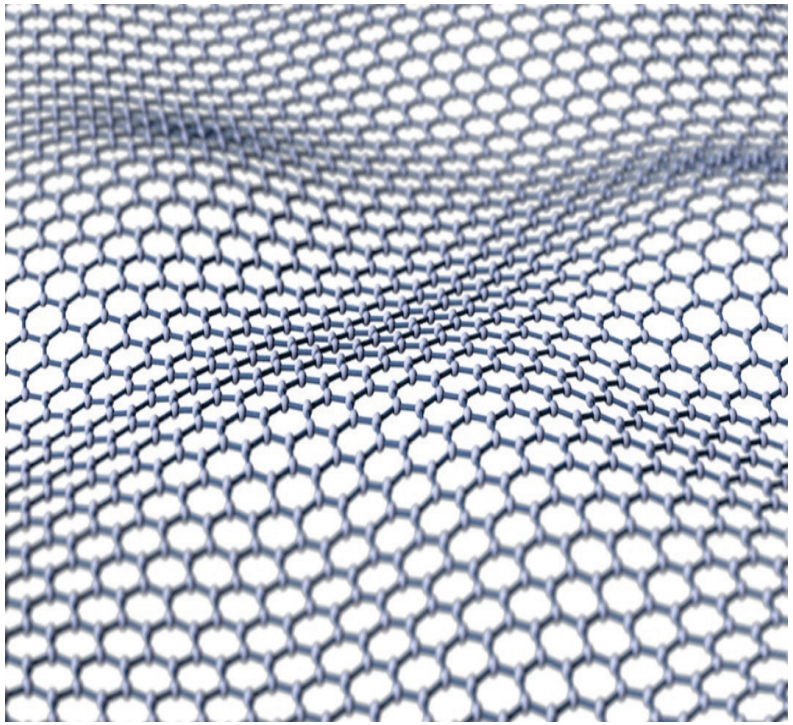
Allotropes of Carbon

Graphene is a single layer of Graphite

- Graphene – sheet of C atoms joined in hexagons.
- Sheet is one atom thick – 2D structure
- Network of covalent bonds make it exceptionally strong. Being light – often added to composite materials to improve strength.
- Like graphite – delocalised e^-s – can conduct electricity through whole structure. Potential use in electronics.



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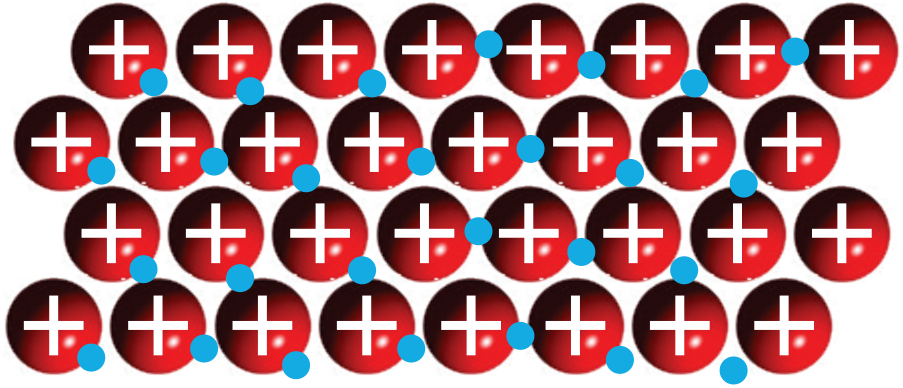
Metallic Bonding



- Metals consist of a giant structure
- Outer shell electrons are delocalised
- Strong electrostatic forces between positive metal ions and shared electrons
- Delocalised electrons produce the properties of metals