Key

relative atomic mass **atomic symbol** name atomic (proton) number

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										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	[98] **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	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111	Elements with atomic numbers 112 – 116 have been reported but not fully authenticated						

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.

AQA C2 Bonding and Structure
Combined Foundation Page 1 of 2

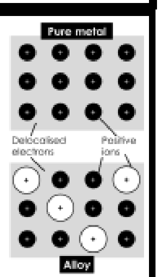
Bonding occurs because chemicals are only stable when the particles have full outer shells of electrons

Keywords

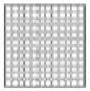
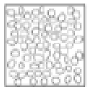
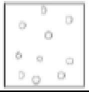
atom	the smallest particle of a chemical element that can exist
element	a chemical made up of only one type of atom
ion	a particle which has a positive or negative charge
electrostatic force	the attraction between positively and negatively charged particles
(chemical) bond	the force of attraction that holds particles together
state (of matter)	whether a substance is a solid, liquid or gas
molecule	a small group of atoms held together by covalent bonds
alloy	a material which contains a metal and at least one other element
delocalised	free to move
malleable	can be bent and shaped
molten	liquid
intermolecular	forces between molecules
intramolecular	covalent bonds within molecules

Alloys

Alloys contain a mixture of a metal and at least one other element. They have the same properties as metals, except that they are harder than pure metals. This is because the layers of ions can't slide over each other due to the different sizes.



States of matter

state	model	state symbol
solid		(s)
liquid		(l)
gas		(g)

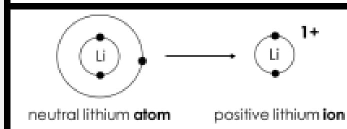
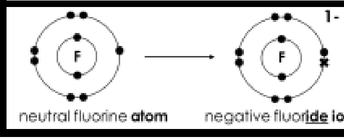
Changes of state

melting point	At this temperature: • solids melt • liquids freeze	**Stronger bond:** • more energy needed to overcome bond • higher melting / boiling point
boiling point	At this temperature: • liquids boil • gases condense	**Weaker bond:** • less energy needed to overcome bond • lower melting / boiling point

Electrical conductivity

For a material to conduct electricity it needs to have:
- charged particles (electrons or ions)
- which can move

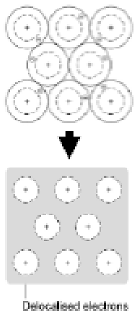
Forming ions

Metals lose electrons forming positive ions	Non-metals gain electrons forming negative ions
	

Metallic bonding – seen in metals and alloys

electrons: Electrons in the outer shells of metals are **delocalised** forming positive metal ions

structure: **Metallic structure** held together by **strong electrostatic forces between the lattice of positive ions and the delocalised electrons**

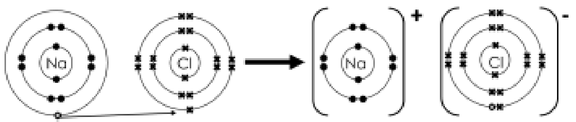


properties: **High melting / boiling points** (a lot of energy needed to overcome strong metallic bonds).
Conduct electricity (delocalised electrons carry charge through the metal).
Conduct thermal energy (delocalised electrons move through the structure transferring energy).
Malleable (layers of ions slide over each other)

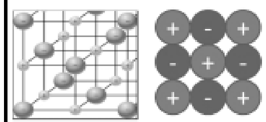
Ionic bonding – between a metal and a non-metal

electrons: Electrons are transferred from the metal to the non-metal forming ions

Dot and cross diagram



structure: **Giant ionic lattice** held together by **strong electrostatic forces between positive and negative ions**



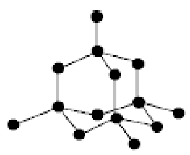
properties: **High melting / boiling points** (a lot of energy is needed to overcome strong ionic bonds).
When solid they do not conduct electricity (ions are held in fixed positions within a lattice and cannot move).
When dissolved or molten they do conduct electricity (when the lattice breaks apart, the ions are free to move and carry charge).

AQA C2 Bonding and Structure

Combined Foundation Page 2 of 2

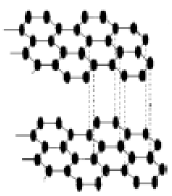
Structure and bonding of carbon

diamond



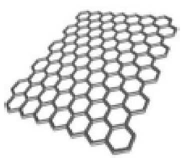
Each carbon atom forms four covalent bonds with other carbon atoms in a giant covalent structure. Because covalent bonds are strong diamond is very hard and has a very high melting point. It does not conduct electricity as the electrons are held between the atoms.

graphite



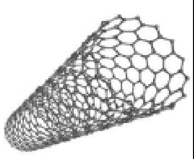
Each carbon atom forms three covalent bonds with three other carbon atoms, forming layers of hexagonal rings. There are weak forces between the layers so they can easily slide over each other.

graphene



Graphene is a single layer of graphite. It has a high melting and boiling point and can conduct electricity, making it useful in electronics and composites.

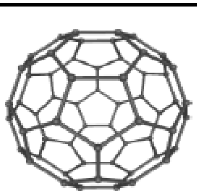
carbon nanotubes



Carbon nanotubes are cylindrical fullerenes with very high length to diameter ratios. They are used for electronics, nanotechnology and materials.

Three electrons from the outer shell of each carbon atom form covalent bonds, then the fourth electron is delocalised. Therefore these structures can conduct electricity.

fullerenes



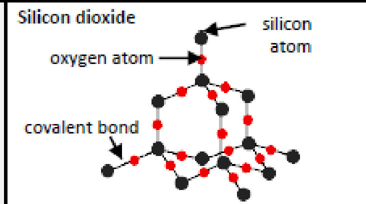
Fullerenes are large molecules of carbon atoms with hollow shapes. They contain rings of 5, 6, or 7 carbon atoms. The first to be discovered was Buckminsterfullerene (C_{60}).

Giant covalent structures – bonds between non-metal atoms

electrons

All of the atoms are linked to other atoms by strong covalent bonds forming a **giant covalent structure. Examples are diamond, graphite and silicon dioxide**

structure



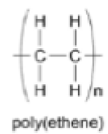
properties

High melting / boiling points (a lot of energy is needed to overcome strong covalent bonds).
Do not conduct electricity (electrons are localised in bonds so cannot move or carry charge).

polymers

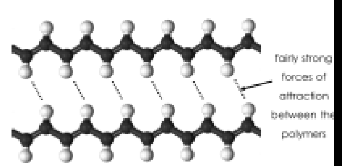
structure

These are very large molecules containing atoms linked to other atoms by strong covalent bonds.



properties

Normally solids at room temperature (the forces between the molecules are fairly strong).

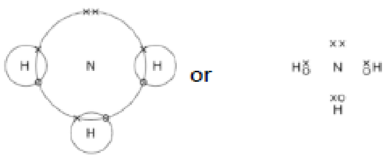


Covalent molecular structures – bonding between non-metals

electrons

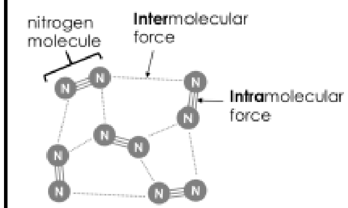
Atoms share pairs of electrons forming strong covalent bonds between the atoms.

Dot-cross diagram (eg. ammonia – NH_3):



structure

Small molecules which have strong intramolecular covalent bonds (bonds within molecules) but weak intermolecular forces of attraction (forces between molecules)

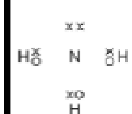


properties

Usually gases or liquids (low melting and boiling points)
Low melting and boiling points (weak intermolecular forces don't need much energy to overcome).
Melting and boiling points increase as molecules get bigger (intermolecular forces are stronger when molecules have a higher mass).
Do not conduct electricity (molecules are neutral so there are no charged particles).

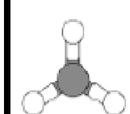
Models of chemicals

Dot-cross diagrams



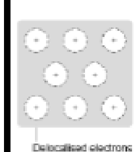
+ve: shows the pairs of electrons
-ve: doesn't show how the particles are arranged in 3D

Ball and stick



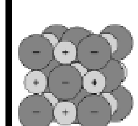
+ve: shows the covalent bonds
-ve: doesn't show the pairs of electrons

2D diagrams



+ve: shows the ions arranged in a lattice
-ve: doesn't show how the particles are arranged in 3D

3D diagrams



+ve: shows how the particles are arranged in 3D
-ve: doesn't show the bonds between the particles

AQA P1a Energy stores and transfers + P1b Heat Transfers Combined Foundation

The following required practicals are covered in this topic:
RP1 - Determining specific heat capacity of a material

Quantities are things that can be measured or calculated.

Quantity	Symbol used in equations	Unit
Work done	W	joules (J)
Force	F	newtons (N)
Distance	s	metres (m)
Gravitational potential energy (GPE)	E_p	joules (J)
Mass	m	kilograms (kg)
Gravitational field strength	g	newtons per kilogram (N/kg)
Height	h	metres (m)
Kinetic energy	E_k	joules (J)
Speed	v	metres per second (m/s)
Power	P	watts (W)
Energy transferred	E	joules (J)
Time	t	seconds (s)
Elastic potential energy	E_e	joules (J)
Spring Constant	k	newtons per metre (N/m)
Extension	e	metres (m)
Change in thermal energy	ΔE	joules (J)
Specific heat capacity	c	joules per degree Celsius (J/kg ^{o}C)
Temperature change	Δθ	degrees Celsius (^{o}C)

Equations are used to calculate an unknown quantity from known quantities (given in a question).

Here are the ones you need to <u>memorise:</u>

Word equation	Symbol equation
work done = force x distance	$W = F\ s$
gravitational potential energy = mass × gravitational field strength × height	$E_p = m\ g\ h$
kinetic energy = 0.5 × mass × speed^2	$E_k = \frac{1}{2} m\ v^2$
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$	
power = $\frac{\text{energy transferred}}{\text{time}}$	$P = \frac{E}{t}$
power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$

These equations are provided for you but you need to be able to select and apply them:

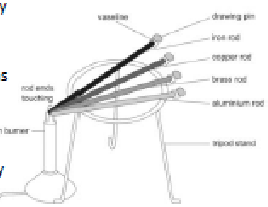
Word equation	Symbol equation
elastic potential energy = 0.5 x spring constant x (extension)^2	$E_e = \frac{1}{2}\ k\ e^2$
change in thermal energy = mass x specific heat capacity x temperature change	$\Delta E = m\ c\ \Delta\theta$

Conduction is a method of thermal energy transfer through the passing on of particle vibrations.

The higher the **thermal conductivity** of a material the higher the rate of energy transfer by **conduction** across the material.

How quickly houses cool down is known as the **rate of cooling.** Houses have a slower rate of cooling if they have thicker walls. The rate of cooling can also be reduced by decreasing the thermal conductivity of the walls by installing **cavity wall insulation.**

The thermal conductivity of materials can be investigated by timing how long it takes for pins to drop off the ends of heated rods. The less time taken, the higher the thermal conductivity of the material.



Key word	Definition	Examples / additional information
System	An object or a group of objects	A kettle of water, a room of air.
Energy store	If a system has a store of energy, it has the ability to do work. Energy stores can increase or decrease when transfers occur. Measured in joules (J).	Kinetic (moving), thermal, gravitational potential, elastic potential, magnetic, electrostatic, nuclear, chemical.
Energy transfer	When energy is moved from one energy store to another. Measured in joules (J).	**Mechanical** (a force moving an object), **work done by current** (due to a voltage/potential difference), **heating** (due to temperature difference), **radiation** (e.g. visible light, infra red).
Work	The amount of energy transferred when an object is moved over a distance by an external force.	Pushing a book along a table, lifting a weight directly upwards.
Energy efficiency	The ratio of **useful** output energy transfer to total input energy transfer, written either as a decimal or a percentage.	A petrol engine car can have an efficiency of 0.30 (30%). This means 30% of the chemical energy in the petrol is transferred to kinetic energy of the car.
Power	The rate at which energy is transferred OR the rate at which work is done, measured in watts (W).	A typical car has a power of 60,000 W – it transfers 600,000 J of energy every second.
Dissipated energy	Energy that has been transferred to a store that is not useful. Sometimes referred to as "wasted" energy. Can be reduced with lubrication or thermal insulation.	5% of transferred energy to a conveyor belt is dissipated to the surroundings (the air) in the form of thermal energy.
Law of conservation of energy	Energy cannot be transferred usefully, stored or dissipated, but cannot be created or destroyed.	The total amount of energy in the universe has always been the same.
Specific heat capacity	The amount of energy required to increase the temperature of 1 kg of a substance by 1 ^{o}C.	Water has a specific heat capacity of 4,200 J/kg ^{o}C. It takes 4,200 J to increase the temperature of 1 kg of water by 1^{o}C.

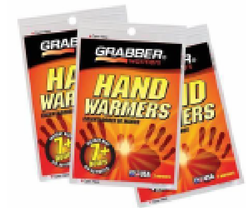
AQA C5 ENERGY CHANGES
COMBINED FOUNDATION
Required practical – Temperature Changes

Key Word	**Definition**
Endothermic	A reaction where energy is taken in from the surroundings so the temperature of the surroundings decreases.
Exothermic	A reaction where energy is transferred to the surroundings so the temperature of the surroundings increases.
Activation Energy	The minimum amount of energy that colliding particles must have for a reaction to take place.
Reaction Profile Diagram	A reaction profile diagram shows the overall energy changes in a reaction.
Reactant	A chemical you start with before a reaction begins.
Product	A chemical made after a reaction takes place.

Example of Reactions

Endothermic Reactions:
Thermal decomposition and sports injury packs.

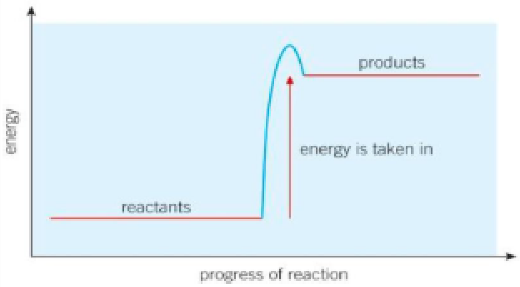
Exothermic Reactions:
Combustion, hand warmers and neutralisation.



REACTION PROFILE DIAGRAMS

In reaction profile diagram, the energy change in a reaction, is the difference between the reactants and products.

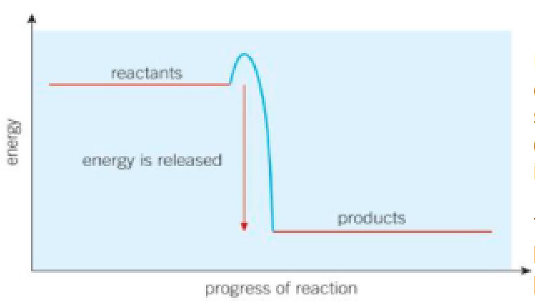
Endothermic Reaction



In an endothermic reaction, energy is taken in from the surroundings. The temperature of the surroundings therefore decreases.

The energy of the products is higher than the energy of the reactants.

Exothermic Reaction



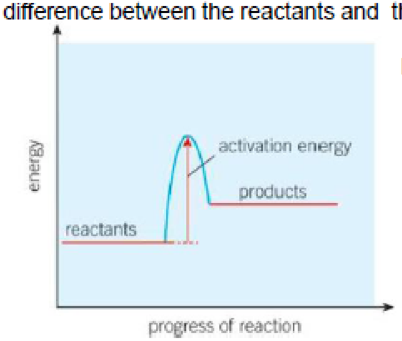
In an exothermic reaction, energy is released to the surroundings. The temperature of the surroundings therefore increases.

The energy of the reactants is higher than the energy of the products.

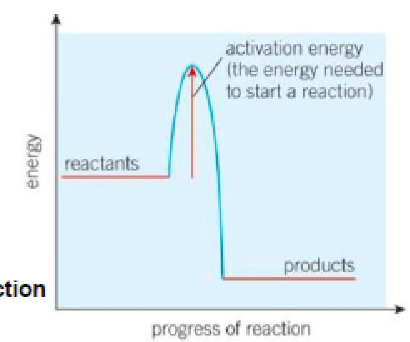
ACTIVATION ENERGY

In order for a reaction to take place, collisions must occur between particles. The activation energy is the minimum amount of energy needed, for particles to successfully collide and react.

The activation energy can also be labelled on reaction profile diagrams. This is the difference between the reactants and the top of a profile diagram.



Endothermic Reaction



Exothermic Reaction