UNIT 2

PARTICLES, BONDING AND STRUCTURES

Answers

Lesson 1 – What happens when atoms join together?

Test your knowledge 1.1: Classifying materials

Answers: (a) element; (b) compound (NH_3); (c) mixture; (d) mixture; (e) compound (H_2O); (f) compound (CO_2); (g) mixture; (h) mixture; (i) element (an allotrope of carbon); (j) compound (SiO_2); (k) element; (l) compound (CH_4)

Test your knowledge 1.2 – Demonstrating the laws of chemical combination

(a) 7.5/2.5 = 3; 30/10 = 3 so consistent (ie composition is always the same)
(b) 13.6/6.8 = 2 (a small whole number ratio, so consistent)

Lesson 2 – What is ionic bonding?

Summary Activity 2.1: Which atoms attract electrons most strongly?

- As you cross a Period proton number increases but shielding stays the same, so electrons in the outer shell are more strongly attracted to the nucleus
- As you descend a Group the number of shells increases so shielding increases, so electrons in the outer shell are less strongly attracted to the nucleus

Test your knowledge 2.2: Forming simple ions

(a) lithium ion Li^+, potassium ion K^+, magnesium ion Mg^{2+}, calcium ion Ca^{2+}, aluminium ion Al^{3+}
(b) oxide ion O^{2-}, nitride ion N^{3-}, sulphide ion S^{2-}, bromide ion Br^-, phosphide ion P^{3-}

Test your knowledge 2.3: Forming simple ionic compounds

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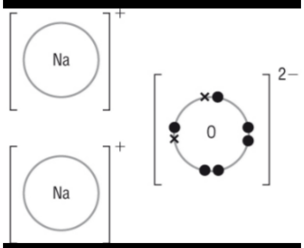

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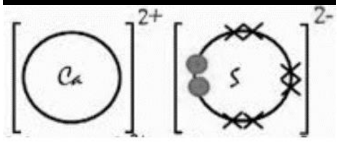

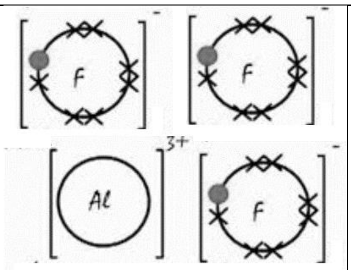

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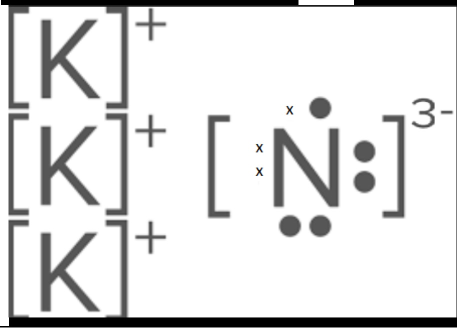

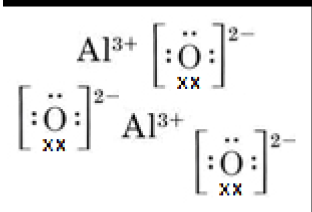

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Lesson 3 - What is covalent bonding?

Test your knowledge 3.1: Forming simple molecules

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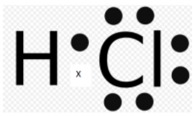
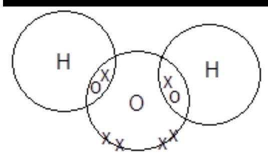
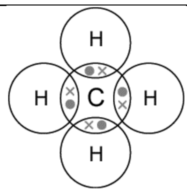




[redacted]; (d)



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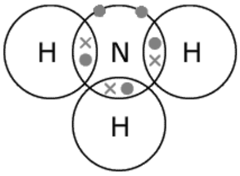
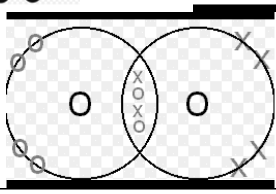
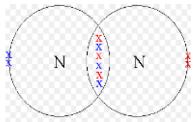
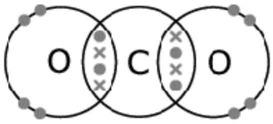


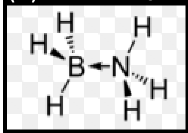




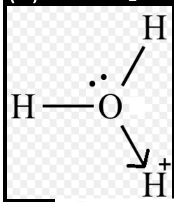


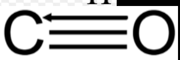
Test your knowledge 3.2: Understanding dative covalent bonding

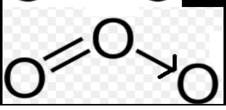
(a) N in NH_3 on forms dative covalent bond with B in BH_3; N provides both electrons



(b) O in H_2O forms dative covalent bond with H^+; O provides both electrons

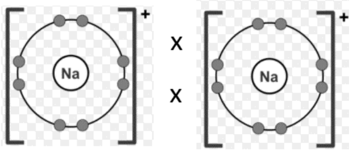


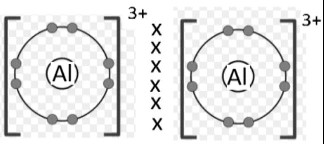
(c) 

(d) 

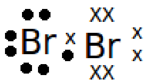
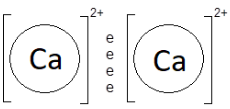
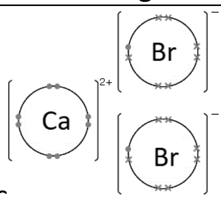
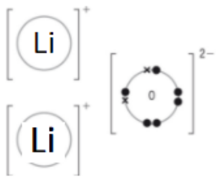
Lesson 4 - What is a metallic bond?

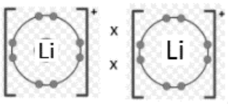
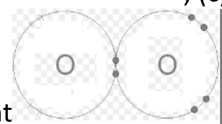
Test your knowledge 4.1: Forming metallic bonds





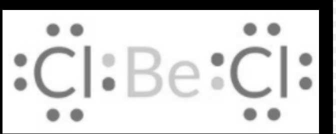
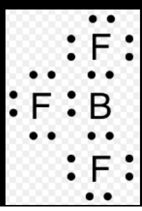
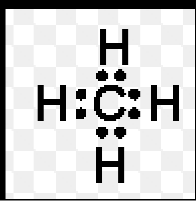
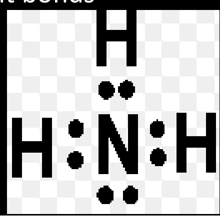
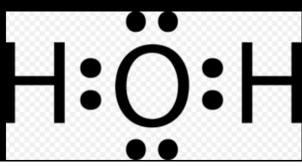
Test your knowledge 4.2: Understanding ionic, covalent and metallic bonding

(a) covalent  ; (b) metallic  ; (c) ionic  ; (d) ionic  ;

(e) metallic  ; (f) covalent 

Lesson 5 – What shapes do different molecules have?

Summary Activity 5.1: Lewis dot structures for different molecules

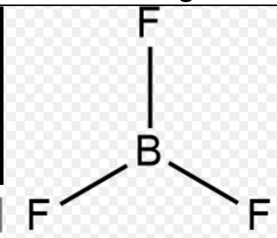
- Covalent bond: pair of electrons shared between two atoms
- Molecule: small group of atoms held together by covalent bonds
-     

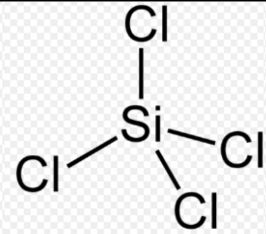
Activity 5.2: Investigate the shapes balloons form when tied together

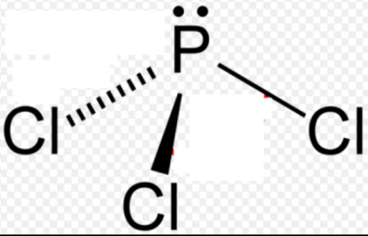
Equipment needed: 4 balloons
Two inflated balloons should naturally sit 180° apart when tied; three inflated balloons 120° apart and four inflated balloons 109.5° apart, in the shape of a tetrahedron when tied

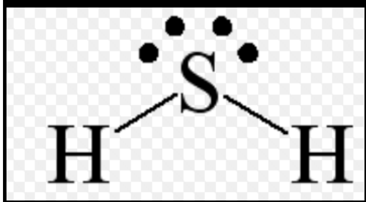
Test your knowledge 5.3: Understanding Molecular Shapes

Linear (180°)

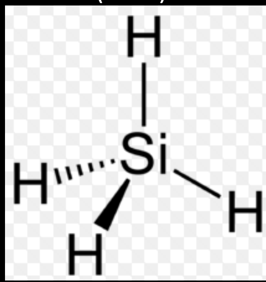

Trigonal Planar (120°)

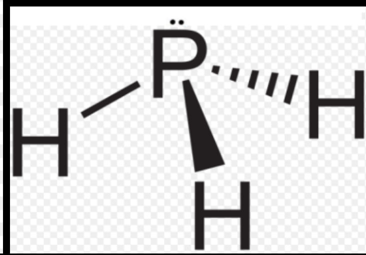

Tetrahedral (109.5°)


Pyramidal (107°)


Non-linear (104.5°)

H-H
linear


Tetrahedral (109.5°)


Pyramidal (107°)

O=O
linear

O=C=O
Linear (180°)

Extension 5.4: Understanding molecular shapes

Free choice question so no answers available

Lesson 6 – What are Intermolecular Forces?

Test your knowledge 6.1: Distinguishing between temporary and permanent dipoles

(a) $BeCl_2$ no because dipoles on bonds cancel
(b) BF_3 no because dipoles on bonds cancel
(c) $SiCl_4$ no because dipoles on bonds cancel
(d) PCl_3 yes because dipoles on bonds don't cancel
(e) H_2S yes because dipoles on bonds don't cancel
(f) H_2 no because the bond is not polar
(g) SiH_4 no because the dipoles on bonds cancel
(h) PH_3 yes because the dipoles on bonds don't cancel
(i) O_2 no because the bond is not polar
(j) CO_2 no because dipoles on bonds cancel
(k) HCl yes because there is only one bond and it is polar

Extension 6.2: Distinguishing between temporary and permanent dipoles

Free choice question so no answers available

Test your knowledge 6.3: Understanding factors affecting the strength of Van der Waal's forces

(a) Ar, because there are more electrons in each atom, and so stronger Van der Waal's forces
(b) C_2H_6, because there are more electrons in each molecule, so stronger Van der Waal's forces
(c) Br_2, because there are more electrons in each molecule, so stronger Van der Waal's forces
(d) $CH_3CH_2CH_2CH_3$, because the surface area of the molecule is larger, so stronger Van der Waal's forces
(e) SO_2, because there are more electrons in each molecule, so stronger Van der Waal's forces, and because it has a permanent dipole

Lesson 7 – What is hydrogen bonding?

Test your knowledge 7.1: Recognising hydrogen bonding

(a) (i) BeH_2 no - no electropositive H; (ii) BH_3 no - no electropositive H; (iii) CH_4 no - no sufficiently electropositive H; (iv) PH_3 no - no sufficiently electropositive H; (v) H_2O yes - electropositive H because bonded to O; (vi) H_2 no - no electropositive H; (vii) HCl no - no sufficiently electropositive H; (viii) NH_3 yes - electropositive H because bonded to N; (ix) HF; yes - electropositive H because bonded to F; (x) CO_2 no – no H; (xi) H_2S no - no sufficiently electropositive H
(b) Water molecules can form strong hydrogen bonds with other water molecules; but CO_2 cannot; CO_2 will have stronger Van der Waal's forces between molecules but the effect of hydrogen bonding is more significant

Test your knowledge 7.2: Using the Kelvin temperature scale

(a) (i) 298 K; (ii) 308 K; (iii) 573 K; (iv) 223 K, (v) 73 K
(b) (i) -223 °C; (ii) 20 °C; (iii) -73 °C; (iv) 35 °C; (v) 327 °C

Lesson 8 – What are solids and what are the properties of solids?

Demonstration 8.1: Warm ice, sulphur and iodine

Equipment needed: clay pipe triangle, three crucibles, tripod, Bunsen burner and gas, tongs, a block of ice, a spatula of sulphur powder, a spatula of iodine crystals

If possible, warm the sulphur and the iodine in a fume cupboard; if not, use an open space and keep the students a safe distance from the crucible

Place a clay pipe triangle on a tripod over a Bunsen burner connected to gas; take the ice block and place it into a crucible; then place the crucible into the clay pipe triangle; light the Bunsen burner and heat the crucible gently (medium flame) until it starts to melt; then remove the crucible, replace it with a crucible containing one spatula of sulphur, and repeat the warming process; then remove the crucible, replace it with a crucible containing one spatula of iodine, and repeat the warming process

Demonstration 8.2: Determine the melting point of naphthalene

Equipment needed: thermometer with range up to 100 °C, capillary tube sealed at one end, a small quantity (less than 1 g) of finely powdered naphthalene, a spatula, a clamp, stand and boss, a 250 cm^3 beaker half-filled with water, a tripod, gauze, Bunsen burner and access to gas

Fill the capillary tube with 1 cm of naphthalene and strap it to a thermometer using an elastic band; place a gauze onto a tripod over a Bunsen burner connected to a gas supply; half-fill the 250 cm^3 beaker with water; use the boss to attach the clamp to the stand; place the thermometer into the beaker at a depth so that the napthalene is submerged in the water but the top of the capillary tube is not; fix the thermometer in place with the clamp; light the Bunsen burner and heat the water on a medium flame until the naphthalene starts to melt

The melting point of naphthalene is 80 °C

Lesson 9 – What are liquids and what are their properties?

Demonstration 9.1: Heat water

Equipment needed: gauze, tripod, Bunsen burner and gas, tongs, a 250 cm^3 beaker, access to water

Pleace the gauze on the tripod; place the Bunsen burner under the tripod; half-fill the beaker with water; place the beaker on the gauze; light the Bunsen burner; heat the water on a medium flame

- as the water is heated, small bubbles start to form due to evaporation; the number of bubbles increases as the water gets hotter; then the bubbles start to get very large
- the water is boiling and the bubbles become large
- some of the water evaporates before it boils

Demonstration 9.2: Determine the boiling point of water

Equipment needed: thermometer with range up to 150 °C, quickfit 250 cm^3 round-bottomed flask, quickfit three-way head, quickfit bung with hole for thermometer, quickfit condenser, 100 cm^3 beaker, tripod, gauze, Bunsen burner, access to gas, 2 clamp stands, each with boss and clamp, 2 pipes to connect water to tap and sink

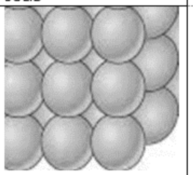
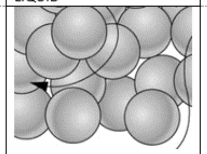
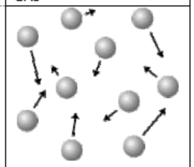
Set up close to a sink; place a gauze on a tripod; place a Bunsen burner connected to gas underneath the tripod; pour 100 cm^3 of water into the flask; place the flask on top of the gauze and clamp into position using a stand, boss and clamp; insert the three way head into the top of the flask, place the thermometer through the quickfit bung with hole, insert the bung into the top of the head; adjust the height of thermometer so it is well above the level of the water; attach condenser to head; clamp condenser into position using another stand, boss and clamp; place beaker underneath lower end of condenser to catch water; use water tube to connect tap to lower water valve on condenser; use another water tube to connect upper water valve on condenser to sink; turn tap on and ensure that condenser is full of water and that there is a steady flow of water into the sink; then light Bunsen burner and heat on medium flame until temperature has reached a steady level

- The boiling point of water is 100 °C

UNIT 2 – PARTICLES, BONDING AND STRUCTURES

Lesson 10 - What are gases and what are their properties?

Test your knowledge 10.1: Understanding the structure and properties of solid, liquids and gases

	SOLID	Change of state	LIQUID	Change of state	GAS
Arrangement of particles (diagram)		→ melting		→ boiling	
Arrangement of particles (description)	Particles are packed close together in a regular arrangement and cannot move; particles vibrate abut fixed positions		Particles are packed close together but not in a regular arrangement; there are some spaces so particles can move		Particles are far apart and moving freely
Properties (volume and shape)	Fixed volume Fixed shape	← freezing	Fixed volume No fixed shape	← condensing	No fixed volume No fixed shape
Bonds between particles (intact or broken)	All bonds are intact		Most bonds are intact; some are broken		All bonds are broken
Degree of disorder	High order Low randomness		Less order/more randomness than solids but more order/less randomness than gases		Low order High randomness

Test your knowledge 10.2: Understanding mixtures and solutions

(a) Take melting point by placing a small sample in a capillary tube and strapping to a thermometer; immerse in a suitable liquid and heat until it melts; note temperature at which it starts and finishes melting; compare melting point with that of aspirin; if sample melts sharply and at same temperature it is pure; if it melts gradually over a range of lower temperatures it is not pure

(b) Mg^{2+} ions, Cl^- ions and water molecules; the Mg^{2+} and Cl^- are distributed evenly throughout the water molecules; the solute is magnesium chloride (or Mg^{2+} and Cl^-) and the solvent is water

Lesson 11 – What evidence is there to support the kinetic model of matter?

Demonstration 11.1: Observe Brownian motion in pollen grains or powdered sulphur

Equipment needed: microscope, slide, slide cover, smoke cell, pollen grains, dropping pipettes, access to water

Take a micro-spatula measure of pollen grains and place them on a slide; add a drop of water and then add the slide cover; remove any pollen/water which gets squeezed out when the slide cover is added.

Repeat using sulphur powder instead of pollen grains.

Light a small piece of wood or paper and collect some of the smoke using a dropping pipette; inject the smoke from the dropping pipette into the smoke cell and place a slide cover over it to keep the smoke in.

Place all three under a microscope in turn. Students should be able to see Brownian motion

- pollen grains, smoke particles and sulphur grains can be seen moving randomly and changing direction suddenly (Brownian motion)

Activity 11.2: Observe Brownian motion in the classroom

If there is direct sunlight coming into the room, students should be able to observe Brownian motion in the dust particles

- dust particles moving randomly, changing direction constantly

Demonstration 11.3: Observe bromine or nitrogen dioxide diffuse through air

Note: This demonstration should be carried out in a fume cupboard.
Equipment needed: two gas jars with lids, access to liquid bromine or copper (II) nitrate
If using bromine: take one dropping pipette full of bromine and drop in into a gas jar inside a fume cupboard; when most of the gas jar is full of bromine, place a lid on the gas jar. Carefully place the gas jar horizontally and position another gar jar close by. Remove the lid and quickly connect the gas jars, ensuring that the bromine cannot escape.
If using NO_2: Place 1 g of copper nitrate in a boiling tube. Heat the copper nitrate until it starts to decompose, giving off a brown gas. When the boiling tube is full of the brown gas, remove it from the heat. Then connect the boiling tube to another empty boiling tube upside down so that the air in the two tubes can mix.

- The orange/brown colour will gradually fill the other jar or tube, although it does take some time

Activity 11.4: Observe diffusion using smell

Note: this demonstration should be carried out either close to the end of a lesson or in another empty classroom so the room can be evacuated immediately afterwards. Take care that the smell does not overpower the students closest to the bottle. Replace the lid as quickly as possible.

- Students closest to the ammonia bottle will smell it quickly; students further away will take longer
- The ammonia molecules evaporate and diffuse through the room; they move slowly because they keep bumping into air particles

Test your knowledge 11.5: Using Graham's Law of Diffusion

(a) He most quickly, Kr most slowly
(b) √(40/4) = 3.2 times faster
(c) √(84/20) = 2.0 times faster

Lesson 12 – What are the gas laws?

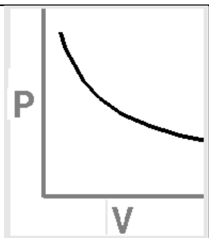
Test your knowledge 12.1: Using the gas laws

(a) 180,000 Pa; (b) 50 dm^3; (c) 300,000 Pa; (d) 125,000 Pa; (e) 180 dm^3; (f) 500,000 Pa

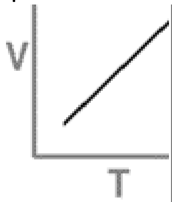
Test your knowledge 12.2: Using the combined gas law

(a) 229,000 Pa; (b) 100,000 Pa; (c) 45.8 dm^3; (d) 125,000 Pa; (e) 396 K; (f) 11.1 dm^3, (g) Gay-Lussac, Boyle, Charles, Combined

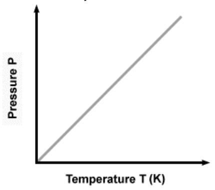
Extension 12.3: Applying the gas laws



(a) volume decreases as pressure increases;
when you reduce the volume of a balloon the pressure increases until it it more than the balloon can bear



(b) volume increases as temperature increases,
at low temperatures the volume of the tyre is smaller, so it looks deflated



(c) pressure increases as temperature increases,
as the air temperature in the tyre increases, so does the pressure in the tyre, on very hot days the pressure will be very high and maybe too much for the tyre to bear

Test your knowledge 12.4: Using Dalton's Law of Partial Pressures

(a) H_2O: 2.3/100 x 102 = 2.35 kPa; Ar: 1.0/100 x 102 = 1.02 kPa; N_2 = 77.4/100 x 102 = 78.95 kPa ; O_2 = 19.3/100 x 102 = 19.7 kPa

Lesson 13 – What are giant ionic structures?

Test Your Knowledge 13.1: Understanding the physical properties of giant ionic structures

Property	Explanation
high melting point	Strong ionic bonds Need a large amount of energy to break
non-conductor of electricity in solid state	Ions Are not free to move
conductor of electricity in molten or aqueous state	Ions Are free to move
brittle	Layers cannot slide over each other As it would cause repulsion between the ions

Test Your Knowledge 13.2: Deducing the unit formula of giant ionic structures

(a) Li_2O; (b) $BaCl_2$; (c) Li_3N; (d) NH_4Cl; (e) KNO_3; (f) $Al(NO_3)_3$; (g) $Mg(OH)_2$; (h) $MgSO_4$; (i) NH_4NO_3; (j) $(NH_4)_2SO_4$

Extension 13.3: Comparing the melting points of giant ionic structures

(a) NaCl because Na^+ is smaller than K^+ so stronger attraction to Cl^-
(b) $MgCl_2$ because Mg^{2+} is smaller and more highly charged than Na^+ so stronger attraction to Cl^-
(c) MgO because O^{2-} is more highly charged than Cl^- so stronger attraction to Mg^{2+}
(d) NaF because F^- is smaller than Cl^- so stronger attraction to Na^+

Lesson 14 – What are giant metallic structures?

Test Your Knowledge 14.1: Understanding the physical properties of giant metallic structures

Property	Explanation
High melting point	Strong metallic bonds Require lots of energy to break
Conductor of electricity	Delocalised electrons Are free to move
Malleable	Ions can be moved around Without breaking the metallic bonds

Extension 14.2: Comparing the physical properties of giant metallic structures

(a) Be, because the Be^{2+} ions are smaller and more highly charged than Li^+, so attract the delocalised electrons more strongly
(b) Be because B the Be^{2+} ions are smaller than Mg^{2+}, so attract the delocalised electrons more strongly
(c) Be will be harder/less malleable and ductile

Test Your Knowledge 14.3: Exploring different simple molecular structures

	Type of substance	
State at room temperature	Element	Compound
SOLID	I_2	$C_{12}H_{22}O_{11}$
LIQUID	Br_2	H_2O
GAS	Cl_2 O_2 N_2	CO_2 NH_3 CH_4

Lesson 15 – What are the physical properties of simple molecular substances?

Summary Activity 15.1: Intermolecular forces

- Temporary dipoles, caused by random movement of electrons in molecules, induce temporary dipoles in adjacent molecules; the resulting attraction between the molecules is a Van der Waal's force
- Hydrogen bonding is the attraction between an electropositive hydrogen atom on one molecule and an electronegative atom (O, N or F) on another molecule; it arises when H is attached to a very electronegative atom, which makes it very positive and very small
- Br_2 has more electrons in molecule so stronger Van der Waal's forces between molecules
- Water has hydrogen bonding between molecules but carbon dioxide does not

Test Your Knowledge 15.2: Explaining the boiling points of simple molecular structures:

(a) More electrons in one molecule of I_2 than in one molecule of Br_2, so stronger Van der Waal's forces between molecules of I_2, which are strong enough to hold I_2 molecules together as a solid at room temperature
(b) More electrons in one molecule of O_2 than in one molecule of N_2, so stronger Van der Waal's forces between molecules of O_2
(c) More electrons in one molecule of HBr than in one molecule of HCl, so stronger Van der Waal's forces between molecules of O_2
(d) Hydrogen bonding between HF molecules but not between HCl molecules, so overall intermolecular forces stronger between HF molecules, despite stronger Van der Waal's forces between HCl molecules

Test Your Knowledge 15.3: Explaining the physical properties of simple molecular structures:

Property	Explanation
Low melting point	Only the weak intermolecular forces need to be broken Not a lot of energy is needed to break them
Non-conductor of electricity	There are no ions and no free electrons So no mobile charged particles

Thinkabout 15.4: The special properties of water

Strong hydrogen bonding causes strong surface tension in water, allowing some insects to walk on water
Strong hydrogen bonding causes ice to form an open lattice structure, causing it to be less dense than water

Lesson 16 – What are giant covalent structures?

Test Your Knowledge 16.1: Explaining the physical properties of giant covalent structures:

Property	Reason
High melting point	Strong covalent bonds between the atoms Require lots of energy to break
Non-conductor of electricity (except graphite)	No free electrons and no ions Graphite has delocalised electrons
Hard if the lattice is 3D, soft if the lattice is 2D	3D lattices do not have layers which can slid over each other but 2D lattice do

Test Your Knowledge 16.2: Understanding different types of chemical formula

a) Simplest whole number ratio of ions (in an ionic compound) or atoms (in a giant covalent compound); it is used for ionic compounds and giant covalent compounds; eg KCl, Na_2CO_3, SiO_2
b) Number of atoms of each type in one molecule of the substance; it is used for elements and compounds with simple molecular structures; eg Cl_2, CO_2, O_2, H_2O
c) Elements with giant covalent, giant metallic or simple atomic structures (ie all elements except those with simple molecular structures)

Lesson 17 – Why do some substances dissolve in water but not others?

Thinkabout 17.1: Which substances dissolve in water and which do not?

- sodium chloride (salt), sucrose (sugar), vinegar all dissolve in water
- most oils, calcium carbonate (chalk) and most rocks do not dissolve in water
- many paints use ethanol or methanol or a mixture of the two (methylated spirits) as a solvent

Test your knowledge 17.2: Predicting Solubility in water and in non-polar solvents

BH_3, CH_4, H_2, CO_2 non-polar so more soluble in hexane
HCl highly polar so more soluble in water
NH_3, HF can form hydrogen bonds with water so more soluble in water
NaCl ionic so more soluble in water

Lesson 18 – How can we relate the physical properties of a substance to its structure?

Demonstration 18.1: **Compare the physical properties of different materials**

Equipment needed: tongs, Bunsen burner, access to gas, three test tubes, three spatulas, three small beakers (100 cm^3), two crocodile clips, two electrical wires, one small light bulb in socket connectible to wires, 12V power supply, strip of copper, 2 graphite electrodes, 1 graphite rod, a gram of sugar, a gram of sand, a gram of salt, access to water

- Hold the copper and graphite strips separately with tongs and place it in a medium Bunsen flame for one minute; nothing will happen
- Pour a small amount (1 cm depth) of sugar, sand and salt separately into test tubes, hold the test tubes with tongs and place each in a medium Bunsen flame; the sugar will quickly melt but the sand and salt will not
- Connect crocodile clips to each end of the copper strip and graphite rods, use a wire to connect one end of the strip to one side of the bulb, and use two more wires to connect the other end of the strip and the other side of the bulb to a 12V power supply (set the power lower than this); in both cases the bulb will light and shine brightly
- Place the graphite electrodes 5 cm apart in a beaker half filled with water with the circuit otherwise complete and the power supply set at 12V; the bulb will not light;
- Add a small spatula measure of sand to the water and stir gently; the sand will not dissolve and the bulb will not light
- Repeat, but adding sugar; the sugar will dissolve in the water but the bulb will not light
- Repeat, but adding salt; the salt will dissolve in the water and the bulb will light

Property	**A** **copper**	**B** **water**	**C** **salt**	**D** **sugar**	**E** **sand**	**F** **graphite**
Melting Point	high	low	high	low	high	high
Electrical Conductivity	yes	no	In aqueous solution only	no	no	Yes
Structure	Giant metallic	Simple molecular	Giant ionic	Simple molecular	Giant covalent	Giant covalent

Test your knowledge 18.2: Summarising the relationship between physical properties and structure

Structure	Property	Reason
Giant ionic lattice	Melting point: high	strong ionic bonds (attraction between oppositely charged ions) require lots of energy to break
	Electrical Conductivity: low in solid state, but high in molten or aqueous states	Ions cannot move in the solid state, but can move in molten or aqueous states
	Mechanical properties: hard and brittle	Layers of ions cannot slip over each other due to repulsion between ions with the same charge
Giant metallic lattice	Melting point: high	strong metallic bonds (attraction between cation and delocalised electrons) require lots of energy to break
	Electrical Conductivity: high	Delocalised electrons can move
	Mechanical properties: malleable	Layers of cations can slip over each other without affecting metallic bonds
Simple molecular	Melting point: low	Weak intermolecular forces (between molecules) do not require much energy to break
	Electrical Conductivity: low	No ions or free electrons
	Mechanical properties: soft and weak	Weak intermolecular forces can be easily broken
Giant covalent lattice (3D)	Melting point: high	Strong covalent bonds (attraction between shared electrons and nuclei) require lots of energy to break
	Electrical Conductivity: low	No ions or free electrons
	Mechanical properties: hard and brittle	Layers of atoms cannot slip over each other without breaking strong covalent bonds

Test your knowledge 18.3: Using structures to explain physical properties

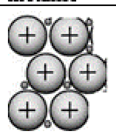
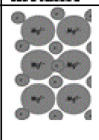
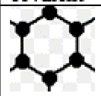
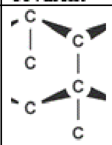
(a) giant ionic - NaCl; giant metallic - Mg; simple molecular - Cl_2; giant covalent - SiO_2; (b) strong ionic bonds require lots of energy to break; (c) ions can move when molten but not when solid; (d) Na^+ and Cl^- ions attracted to polar water molecules; (e) delocalised electrons can move; (f) layers of cations can slip over each other without breaking the metallic bonds; (g) strong metallic bonds require lots of energy to break; (h) intermolecular forces between Cl_2 molecules don't require much energy to break; (j) strong covalent bonds require lots of energy to break; (k) graphite has delocalised electrons, diamond does not; (l) layers of atoms in diamond cannot slip over each other without breaking covalent bonds; layers of atoms in graphite can slip over each other - only intermolecular forces need to be overcome; (m) it is very hard; (n) it is very soft and the layers can slip off

Lesson 19 – How does structure and bonding in the elements change across the Periodic Table?

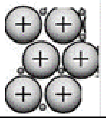
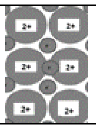
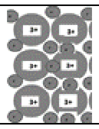
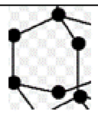
Summary Activity 19.1: Periodic properties of atoms

- Atomic size decreases across a Period; nuclear charge increases, shielding stays the same, no nuclear attraction increases and outer shell electrons are pulled in more strongly
- Atomic size increases down a Group; number of shells increases so shielding increases; nuclear attraction decreases (despite increase in nuclear charge) and outer shell electrons are pulled in less strongly
- Electronegativity increases across a Period; nuclear attraction increases so attraction to bonding electrons increases
- Electronegativity decreases down a Grouo; nuclear attraction decreases so attraction to bonding electrons decreases

Test your knowledge 19.2: Explaining the bonding and structure of the Period 2 elements

Element	Li	Be	B	C (diamond)	N	O	F	Ne
Bonding	metallic	metallic	covalent	covalent	covalent	covalent	covalent	-
Structure	giant metallic	giant metallic	giant covalent	giant covalent	simple molecular	simple molecular	simple molecular	simple atomic
Diagram					N≡N N≡N N≡N	O=O O=O O=O	F—F F—F F—F	Ne Ne Ne Ne Ne Ne

Test your knowledge 19.3: Explaining the bonding and structure of the Period 1 and 3 elements

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Bonding	metallic	metallic	metallic	covalent	Covalent	covalent	covalent	-
Structure	giant metallic	giant metallic	giant metallic	giant covalent	simple molecular	simple molecular	simple molecular	simple atomic
Diagram					P_4 P_4 P_4 P_4	S_8 S_8 S_8 S_8	Cl-Cl Cl-Cl Cl-Cl	Ar Ar Ar Ar Ar Ar Ar

Element	H	He
Bonding	covalent	-
Structure	simple molecular	simple atomic
Diagram	H-H H-H H-H	He He He He He He

Lesson 20 – How does structure and bonding in compounds change across the Periodic Table?

Test your knowledge 20.1: Describe the structure and bonding in oxides and chlorides

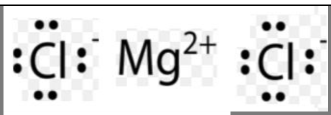
Giant ionic lattice	Giant covalent lattice	Simple molecular
LiCl, Li_2O, BeO, Na_2O, NaCl, $MgCl_2$, MgO, Al_2O_3	SiO_2	NO, P_4O_6, SO_2, HCl, H_2O, $BeCl_2$, B_2O_3, BCl_3, CO_2, CCl_4, NCl_3, Cl_2O, OF_2, ClF, $AlCl_3$, $SiCl_4$, PCl_3, SCl_2

Test your knowledge 20.2: Summarising structure and bonding in the Periodic Table

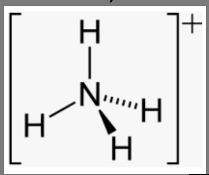
a) Electronegativity increases so less tendency to form metallic bonds
b) Metals - lithium, beryllium, sodium, magnesium, aluminium; Non-metals: any of the other 13!
c) LiCl, NaCl and $MgCl_2$
d) Any oxide in the simple molecular column of LA 2.16
e) Sodium chloride is giant ionic but aluminium chloride is simple molecular
f) Aluminium oxide is giant ionic but silicon dioxide is giant covalent

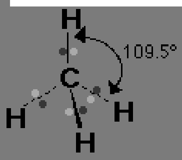
Lesson 21 – What have I learned about Particles, Bonding and Structure?

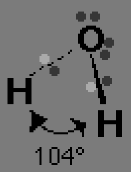
21.1 END-OF-TOPIC QUIZ
UNIT 2 – PARTICLES, BONDING AND STRUCTURES

1. 

2. 

3. Difference in electronegativity between Mg and Cl is large; difference in electronegativity between N and H is much smaller
4. N on NH_3 has a lone pair; it can form a dative covalent bond with H^+ by providing both of the shared electrons; the resulting species is NH_4^+


5. 

, tetrahedral
6. 

, non-linear (104.5°)
7. Random movement of electrons causes temporary dipole, which induces a dipole in the adjacent molecule; the resulting dipoles attract
8. SO_2 is non-linear so the dipoles on the two bonds do not cancel out; CO_2 is linear so the dipoles on the two bonds do cancel out
9. Particles vibrate about fixed positions in a solid; on heating, the particles get more energy so vibrate more and faster; eventually the particles have enough energy to break some of the bonds between the particles and so the particles are able to move around
10. Brownian motion is the random movement in different directions of visible particles such as smoke, pollen or sulphur; it shows that the particles are constantly being hit by smaller particles and pushed in different directions
11. $P_1V_1/T_1 = P_2V_2/T_2$ so $V_2 = P_1V_1T_2/P_2T_1 = 29.2\ dm^3$
12. 3D lattice of Mg^{2+} cations, held together by a sea of delocalised electrons; the delocalised electrons are free to move
13. 3D lattice of C atoms, each attached to four others in a tetrahedral arrangement; all atoms are held in place by strong bonds and the atoms cannot move without breaking the bonds, so the structure is hard to break and cannot be bent
14. 3D lattice of Na^+ and Cl^- ions; each Na^+ surrounded by 6 Cl^- and vice versa; water is a polar molecule; the Na^+ ions are attracted to the negative pole and the Cl^- ions are attracted to the positive pole
15. Water can form hydrogen bonds, H_2S can only form Van der Waal's forces, hydrogen bonds are generally stronger