

2.1 - Atoms and reactions

2.1.1 - Atomic structure and isotopes

<p>The symbols for atomic no. and mass no. are...</p>	<div data-bbox="852 457 1166 655" data-label="Chemical-Block"> <p>A diagram showing a chemical symbol 'X' inside a light blue box. Above the 'X' is the letter 'A' and below it is the letter 'Z'. Three lines point from text labels to these symbols: 'number of protons and neutrons' points to 'A', 'chemical symbol' points to 'X', and 'number of protons' points to 'Z'.</p> </div> <p>Z and A respectively.</p>
<p>What is the A_r of a proton, neutron, and electron?</p>	<p>1, 1, and 1/1836 respectively.</p>
<p>Define isotopes</p>	<p>Atoms of same element with the same number of protons but different numbers of neutrons.</p>
<p>What do chemical properties depend on?</p>	<p>Electronic structure.</p> <p><i>Thus isotopes have the same chemical properties.</i></p>
<p>How do isotopes of the same element vary?</p>	<p>In physical properties (e.g., density).</p>
<p>Define both cation and anion</p>	<ul style="list-style-type: none"> • Cation - positively charged ion. • Anion - negatively charged ion. <p><i>Remember as cats make you positive.</i></p>
<p>Define relative isotopic mass</p>	<p>The mass of an isotope compared to 1/12 of the mass of one carbon-12 atom.</p>
<p>Define relative atomic mass</p>	<p>The weighted mean mass of one atom compared to 1/12 of the mass of one carbon-12 atom.</p>
<p>What is the formula for the A_r of a sample?</p>	$\frac{\sum(\text{isotopic mass} \cdot \text{relative abundance})}{\text{total relative abundance}}$
<p>What does a mass spectrometer measure?</p>	<p>Mass to charge ratio (m/z).</p>

2.1.2 & 2.1.3 - Compounds, formulae, equations, and amount of substance

Formula of a zinc ion	Zn^{2+}
Formula of an ammonium ion	NH_4^+
Formula of a silver ion	Ag^+
Formula of a nitrate ion	NO_3^-
Formula of a nitride ion	N^{3-}
Formula of a carbonate ion	CO_3^{2-}
Formula of a sulfate ion	SO_4^{2-}
Formula of a phosphate ion	PO_4^{3-}
What does a binary compound contain?	ONLY two different elements.
What is the mnemonic for remembering the diatomic elements?	<ul style="list-style-type: none"> • Have No Fear Of Ice Cold Beer. • H_2, N_2, O_2, I_2, Cl_2, Br_2.
What are the steps for writing ionic equations?	<ol style="list-style-type: none"> 1. Balance the equation. 2. Break each (aq) substance into ions. 3. Cancel any ions on both sides (these being the spectator ions). <p>Chemical Equation:</p> $\text{NaCl}_{(\text{aq})} + \text{AgNO}_{3(\text{aq})} \rightarrow \text{NaNO}_{3(\text{aq})} + \text{AgCl}_{(\text{s})}$ <p>Total Ionic Equation:</p> $\cancel{\text{Na}^+_{(\text{aq})}} + \text{Cl}^-_{(\text{aq})} + \text{Ag}^+_{(\text{aq})} + \cancel{\text{NO}_3^-_{(\text{aq})}} \rightarrow \cancel{\text{Na}^+_{(\text{aq})}} + \cancel{\text{NO}_3^-_{(\text{aq})}} + \text{AgCl}_{(\text{s})}$ <p>Net ionic Equation:</p> $\text{Ag}^+_{(\text{aq})} + \text{Cl}^-_{(\text{aq})} \rightarrow \text{AgCl}_{(\text{s})}$
What are spectator ions?	Ions that aren't changing state or oxidation number.
Define one mole	The amount of substance which contains the same amount of particles as there are atoms in 12 grams of carbon-12.

Define molar mass	The mass in grams of 1 mol of a substance given in g mol^{-1} .
What is the equation linking mol (n), mass (m), and molar mass (M_r)?	$n = \frac{m}{M_r}$
What is the equation linking mol (n), volume of gas (dm^3), and molar gas volume (24 dm^3)?	$n = \frac{\text{volume of gas}}{\text{molar gas volume}}$ <i>This is used for anything under standard conditions.</i>
Define molecular formula	The ACTUAL number of atoms of EACH ELEMENT in an element/compound.
Define empirical formula	The SIMPLEST ratio of atoms of EACH ELEMENT in an element/compound.
In what contexts is 'relative molecular mass' and 'relative formula mass' used?	<ul style="list-style-type: none"> • Relative molecular mass - used for easily defined structures in which you know the exact no. of atoms (e.g., O_2). • Relative formula mass - used for giant structures in which you don't know the exact no. of atoms (e.g., lattices such as NaCl).
What is a hydrated/hydrous salt?	A salt molecule loosely attached to water (called waters of crystallization). <i>Thus anhydrous means the opposite.</i>
What is a solute?	What is being dissolved into the solvent.
What is a solvent?	The liquid in which a solute is dissolved in to form a solution.
What is 1 L equal to (in volume)?	1dm^3 .
What is the ideal gas equation and what is each unit measured in?	$pV = nRT$ Where p is pressure (Pa), V is volume (m^3), n is moles (mol), R is the gas constant, T is temperature (K).
What is the conversion factor between Kelvin and Celsius?	Add 273 to C to get K.

What is a limiting reagent?	A reactant that runs out first and thus limits how much product can be formed.
Give 2 reasons for the percentage yield being less than 100%	<ul style="list-style-type: none"> • Reaction may have not had enough time to go to completion. • A side reaction has taken place (e.g., in the glassware). • Product was lost under purification.
What is a salt?	The product of a neutralisation reaction where the H⁺ IONS from the acid is replaced by metal or ammonium IONS .

2.1.4 & 2.1.5 - Acids and redox

What are standard solutions?	A solution for which its concentration is known accurately.
What 3 things should you ensure when making standard solutions?	<ol style="list-style-type: none"> 1. Ensure you have clean dry equipment. 2. Make washings to remove any salt <u>BEFORE MAKING</u> up the solution to the specified amount. 3. Invert the volumetric flask to ensure everything is dissolved.
How does ammonia react with acid?	<ul style="list-style-type: none"> • ammonia + acid → ammonium salt • $NH_3(aq) + HNO_3(aq) \rightarrow NH_4NO_3(aq)$
Give 3 strong acids and 1 weak acid	<ul style="list-style-type: none"> • Strong acids include: HCl, H₂SO₄, and HNO₃. • Weak acids include carboxylic acids such as CH₃COOH.
Give 1 weak base	NH ₃
What are diprotic and triprotic acids (with examples) and what does this mean for neutralisation?	<ul style="list-style-type: none"> • Diprotic acids and triprotic acids donate two and three protons respectively. • Examples include: H₂SO₄ and H₃PO₄. • They need 2x or 3x the number of moles of base to be neutralised.
Give 4 bases/types of bases	Metal oxides, metal hydroxides, metal carbonates, and ammonia.
What are bases and alkalis?	<ul style="list-style-type: none"> • Bases are H⁺ ion acceptors. • Alkalis are soluble bases that release HO⁻ ions into solution.
Reaction between an acid and metal oxide	acid + metal oxide → a salt + water

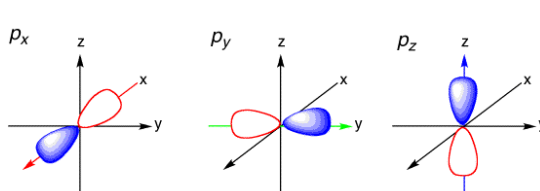
Reaction between an acid and metal carbonate	acid + metal carbonate → a salt + water + carbon dioxide
Reaction between an acid and metal (+ type of reaction)	acid + metal → salt + hydrogen <u>redox</u> (not neutralisation as water isn't formed)
Reaction between an acid and metal hydroxide	acid + metal hydroxide → a salt + water
What is atom economy and how is it calculated?	A measure of how efficient a reaction is. $\text{atom economy} = \frac{\text{Mr of design products}}{\text{Mr of reactants}}$
What are the 2 types of reactions under atom economy?	<ul style="list-style-type: none"> ● Addition - the reactants form a single DESIRED product (100%). ● Substitution - the atoms from a reactant are substituted by others leading to more than one product. <p><i>Addition reactions are usually where a reactant is added to an unsaturated molecule to make saturated molecule.</i></p>
Give 3 reasons for why a high atom economy is good	<ul style="list-style-type: none"> ● Environmental friendly (due to less waste). ● Economical (due to not separating materials). ● Sustainable (as it prolongs finite materials).
Give 2 ways of improving atom economy	<ol style="list-style-type: none"> 1. Use an alternate reaction pathway with a higher atom economy. 2. Find a use for the waste products.
What is oxidation number?	The no. of electrons removed from an atom.
What are the 4 main rules for oxidation numbers?	<ol style="list-style-type: none"> 1. Elements always have an oxidation no. of 0. 2. Sum of oxidation no.'s in a compound = 0. 3. Sum of oxidation no.'s of an ion = its charge. 4. The most electronegative element in a compound is always negative (so work with this first).
What are the 3 exceptions to oxidation rules?	<ol style="list-style-type: none"> 1. Hydrogen is always +1 except when in a hydride where it's -1. 2. Oxygen is always -2 except with fluorine (more electronegative) and as peroxides where it's -1.

	3. Chlorine is always -1 except when bonded with oxygen and fluorine (more electronegative) where it's different.
What is a hydride?	A binary compound of hydrogen and a metal.
What is a peroxide?	A compound containing two oxygen atoms bonded together (O-O).
What is an -ide?	A binary compound in which the nonmetal is given an -ide suffix (e.g., sodium oxide).
What are oxidising and reducing agents?	<ul style="list-style-type: none"> • Oxidising agents gain electrons leading to oxidation elsewhere. • Reducing agents lose electrons leading to reduction elsewhere.
What is a reduction reaction? What is a oxidation reaction?	<ul style="list-style-type: none"> • Reduction reactions are the loss of oxygen atoms or gaining of electrons. • Opposite for oxidation.
What do -ate compounds contain?	<p>Oxygen and at least one other element.</p> <p><i>Examples include: chlorate, nitrate, and carbonate.</i></p>
What is the end point in a titration?	The point where the indicator changes colour.

2.2 - Electrons, bonding and structure

2.2.1 - Electron structure

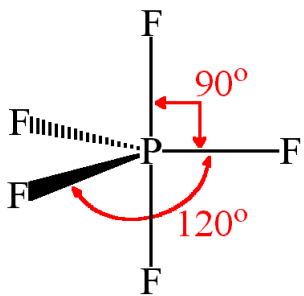
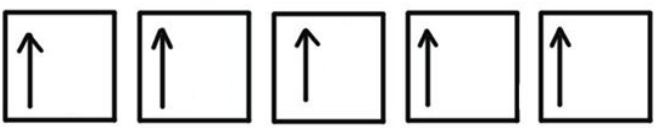
What do most noble gases have an outermost electron structure of?	ns^2np^6 .
Which shells have which subshells?	<ul style="list-style-type: none"> • 1 has s. • 2 has s p. • 3 has s p d. • 4 has s p d f.

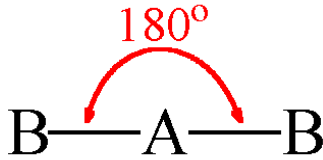
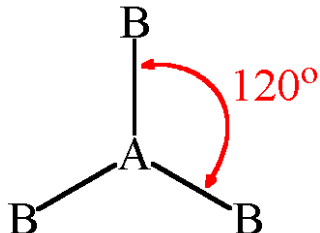
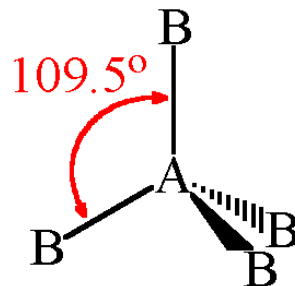
What are orbitals?	Regions around the nucleus that can hold 2 electrons with opposite spins.
What are degenerate orbitals?	Orbitals that have the same energy levels. Eg, p-subshell consists of 3 degenerate p-orbitals.
How many orbitals does each subshell have?	<ul style="list-style-type: none"> • s has 1 orbital. • p has 3 orbitals. • d has 5 orbitals. • f has 7 orbitals.
How do atoms fill up with electrons?	In subshells, in order of increasing energy.
What is the shape of an s-orbital/s-subshell?	Sphere. <i>The greater the shell number, the greater the radius.</i>
What are the shapes of the p-orbitals?	Dumbbells. 
What are the 2 rules for all orbitals of the same energy?	<ol style="list-style-type: none"> 1. Electrons won't pair in the same subshell if they don't have to. 2. Electrons in the same orbitals must have opposite spin. <ul style="list-style-type: none"> • This is to avoid repulsion.
Which key orbital fills first and empties first, when, and why?	<ul style="list-style-type: none"> • The s-orbital, past and including the 4th shell. • It has less energy than the d-orbital but when the d-orbital gains electrons, it drops below s-orbital.

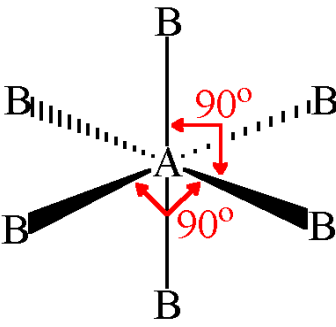
What are the blocks of the periodic table?	<p>The diagram illustrates the four blocks of the periodic table based on the type of atomic orbitals being filled:</p> <ul style="list-style-type: none"> s-block: Groups 1A and 2A. Orbitals shown: 1s, 2s, 3s, 4s, 5s, 6s, 7s. d-block: Groups 3B to 10B. Orbitals shown: 3d, 4d, 5d, 6d. p-block: Groups 13A to 18A. Orbitals shown: 2p, 3p, 4p, 5p, 6p. f-block: Lanthanide and actinide series. Orbitals shown: 4f, 5f.
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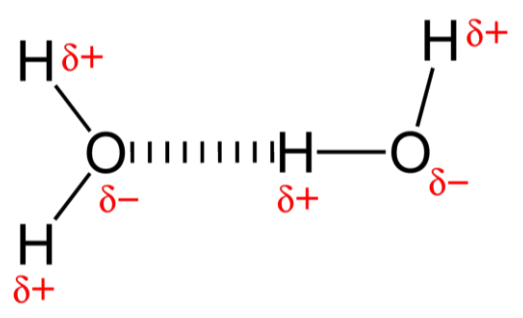
2.2.2 - Bonding and structure

What is a σ -bond?	The overlap of orbitals directly between atoms.
Define ionic bond	The electrostatic force of attraction between oppositely charged ions formed by electron transfer.
Describe and explain the conductivity of ionic compounds under different states	<ul style="list-style-type: none"> Doesn't conduct when solid (1) because the ions are fixed in a lattice (1) so cannot carry a charge. Conducts when molten or dissolved because the ions can move and thus act as charge carriers (2).
Why are ionic compounds soluble?	As water molecules are polar solvents (1) so will surround each ion (1).
Why are some ionic compounds less soluble than others?	Greater charge difference (e.g., Mg^{2+} and O^{2-}) meaning stronger attraction which is less easily overcome.
Define covalent bond	The strong electrostatic attraction between a shared pair of electrons and the nuclei of the bonded atoms.
Give an example of a covalent molecule whose central atom has fewer than 8 electrons in its outermost shell	<p>BF_3.</p>

What must an atom have access to for expansion of the octet to occur?	<p>Its d subshell meaning the atom must have 3 or more shells.</p> <p><i>You can only hold 8 electrons in an sp hybrid so require the d subshell to hold more.</i></p>
Give an example of a molecule which expands the octet	<p>PF₅.</p>  <p><i>Trigonal bipyramidal.</i></p>
How is PF ₅ formed (electron-wise)?	<p>By freeing up 5 orbitals by moving electrons into unoccupied d subshell orbitals.</p>  <p><i>This is an spd hybrid that can hold more than 8 unlike the sp hybrid.</i></p>
What is a coordinate/dative bond?	A shared pair of electrons where both electrons are from the same atom.
What is used to show a coordinate bond?	An arrow from the atom providing the coordinate bond. E.g., in an ammonium ion.
Give the 3 bond angles largest to smallest	<ol style="list-style-type: none"> 1. The bond angle between lone pairs. 2. The bond angle between a lone pair and a bonding pair. 3. The bond angle between bonding pairs.
What are the 3 wedges for shape of molecules?	<ol style="list-style-type: none"> 1. Solid line is a bond on the plane of the page. 2. Solid wedge is a bond that comes out of the plane of the page. 3. Dotted line is a bond going into the plane of the page.
What do lone pairs repel by and why?	An extra 2.5° as they're closer to the nucleus and thus take up more space.
Describe the linear shape of molecule with an example	<ul style="list-style-type: none"> • 2 bonding pairs. • 180 degrees.

	<ul style="list-style-type: none"> An example is CO₂. 
Describe the trigonal planar shape of molecule with an example	<ul style="list-style-type: none"> Planar meaning flat on the page 3 bonding pairs and 0 lone pairs. 120 degrees. An example is BF₃. 
Describe the tetrahedral shape of molecule with an example	<ul style="list-style-type: none"> 4 bonding pairs. 109.5 degrees. An example is NH₄. 
Describe the pyramidal shape of molecule	<ul style="list-style-type: none"> 3 bonding pairs and 1 lone pair. 107 degrees (because tetrahedral minus 2.5 degrees).
Describe the nonlinear shape of molecule	<ul style="list-style-type: none"> 2 bonding pairs and 2 lone pairs. 104.5 degrees between bonding pairs (because tetrahedral minus 2 x 2.5 degrees). <p><i>The angle between the two lone pairs is the greatest.</i></p>
Describe the octahedral shape of molecule with an example	<ul style="list-style-type: none"> 6 bonding pairs. 90 degrees. An example is SF₆

	
How should you tackle a 'explain the shape of molecule' question in 4 steps?	<ol style="list-style-type: none"> 1. State the no. of BONDING PAIRS and lone pairs 'surrounding the central atom'. 2. State that 'electrons repel and try to get as far apart as possible' (1). 3. If there are lone pairs, state lone pairs repel more than BONDING PAIRS (1). Otherwise state electron pairs get repelled equally (1). 4. State the shape of molecule with the bond angle. <p><i>Treat double bonds as single bonds here.</i></p>
Why are chemists able to predict the shapes of molecules?	As electron pairs REPEL (1) and the shape is determined by the no. of bonding pairs and the no. of lone pairs (1).
Define electronegativity	The ability of an atom to attract electrons (1) in a covalent bond (1) towards itself.
When can you tell a bond is polar?	Generally, if the two atoms are of different elements, it's polar (except for carbon-hydrogen).
How can a molecule be nonpolar yet contain polar bonds?	As it's symmetrical (1) so dipoles cancel each other out (1).
How can you work out if a molecule is symmetrical?	<p>Generally, if it has no lone pairs and the same bond pairs then it's symmetrical.</p> <p><i>You may have to rotate it in different planes to confirm this.</i></p>
What are permanent dipole-dipole interactions?	Electrostatic forces of attraction between polar molecules

	$\begin{array}{ccccccc} \delta+ & & \delta- & & & & \delta+ & & \delta- \\ \text{H} & - & \text{Cl} & - & - & - & - & \text{H} & - & \text{Cl} \end{array}$
Which will have a higher b.p., HF or HCl, and why?	HF \because stronger permanent dipole-dipole interactions (due to the difference in electronegativity being greater) which requires more energy to overcome.
What are 'London Forces' also called?	Induced-dipole-dipole interactions. <i>Calling them 'Van der Waals' is too ambiguous.</i>
Does every structure have London Forces? If so which ones don't?	No. Lattices like SiO ₂ .
Describe induced dipole-dipole interactions	Unequal distribution of electrons (1) \Rightarrow temporary/instantaneous dipole (1) \Rightarrow induces a dipole in a nearby molecule (1) leading to attraction.
Why do the strength of induced dipole-dipole interactions increase down groups?	The no. of electrons increases \Rightarrow stronger dipoles (due to stronger charges) \Rightarrow stronger attraction. <i>This is why oxygen has a higher b.p. than hydrogen.</i>
What is a hydrogen bond?	<p>The electrostatic attraction between a hydrogen atom bonded to an electronegative atom and a lone pair on an electronegative atom of a different molecule.</p>  <p><i>The bond is represented by a dashed line and the line must be parallel to the covalent bond from the hydrogen.</i></p>
Which electronegative elements will hydrogen bonding happen with and why?	Oxygen, nitrogen, and fluorine \because they're the most electronegative and most dense in electrons. <i>Chlorine's electron density is too low due to its extra shell.</i>

Give 3 reasons why water has a higher m.p. and b.p. to structurally similar compounds	<ol style="list-style-type: none"> 1. Hydrogen bonding provide it with stronger intermolecular forces. 2. Forms up to four hydrogen bonds. 3. Oxygen is the second most electronegative meaning stronger hydrogen bonds.
Describe and explain the 2 anomalous properties of ice	<ol style="list-style-type: none"> 1. Ice is less dense than water as the molecules are held apart by hydrogen bonds in an open lattice. 2. Ice has a higher m.p. than expected as hydrogen bonds provides it with strong intermolecular forces.
What causes high surface tension in water and why?	Hydrogen bonding leading to a strong and flexible lattice structure.
What can polar molecules and nonpolar molecules dissolve into?	<p>Polar solvents and nonpolar solvents respectively.</p> <p><i>This means nonpolar molecules (e.g., oil) are insoluble in water.</i></p>
Why doesn't water and oil mix?	Water is polar and oil is nonpolar and the strongest bonds oil can make is with other oil molecules and this is the same for water. This need for stability leads to separation.
What are the strongest to the weakest intermolecular forces?	<ol style="list-style-type: none"> 1. Hydrogen bonds 2. Permanent dipole-dipole interactions. 3. Induced dipole-dipole interactions. <p><i>Yet, London forces can become stronger than the other 2 if there are a lot of electrons.</i></p>
Why is a p-block element considered a p-block element?	<p>As its highest energy electron occupies a p-orbital.</p> <p><i>This is because the water molecules are slightly attracted to the polar areas of a CO₂ molecule.</i></p>
Why won't all CO ₂ be released from a reaction involving a solution?	As CO ₂ is slightly soluble.
How does the structure of elements change across period 3?	<ol style="list-style-type: none"> 1. Na, Mg, Al - giant metallic lattices. 2. S - giant covalent lattice. 3. P₄, S₈, Cl₂, Ar - simple molecular.