Demonstrate understanding of aspects of acids and bases

Structure of the atom

Atom consists of 3 types of subatomic particles

- Protons (+) located in nucleus
- Neutrons (0) located in nucleus
- Electrons (-) located around nucleus in energy levels or shells

Atoms are neutral overall so no. of protons = no. of electrons. Number of protons can be found from atomic number (given on the Periodic Table)

Sometimes atoms are written in a shorthand way: ${}^{A}_{Z}X$

- A is mass number (P + N)
- Z is atomic number (P)
- X is symbol e.g. ${}^{23}_{11}Na$: sodium has 11 protons, 12 neutrons and 11 electrons

Isotopes

These are atoms of the same element – they have the same atomic number. But they have a different mass number. They have the same number of protons and electrons (and so the same chemical properties) but the isotopes have a different number of neutrons in their nucleus.

e.g. ${}^{35}_{17}Cl$ and ${}^{37}_{17}Cl$; ${}^{35}_{17}Cl$ has 17 protons & 17 electrons and 18 neutrons while ${}^{37}_{17}Cl$ has 17 protons & 17 electrons and 20 neutrons

Electrons

They are arranged in energy levels around the nucleus: Each level can hold a maximum number: Ist level: 2 2nd level 8; 3rd level 8. Electrons fill up from innermost (lowest) energy level. Eg Na has 11 electrons. It has an electron arrangement or "configuration" is 2.8.1. The outermost energy level is called the valence shell.

Ions

Ions are charged particles formed when atoms lose or gain electrons, to achieve a FULL valence shell – which is a stable arrangement. Metals lose electron(s) to form + ions (cations): Non metals gain electron(s) to form negative ions (anions)

- atom Na (2.8.1) ion Na_+ (2.8)
- atom Al (2.8.3) ion Al^{3+} (2.8)
- atom Cl (2.8.7) ion Cl^- (2.8.8)

Group	Number of valence electrons	Ion charge
1	1	1+ or +
2	2	2+
16	6	2-
17	7	1- or -

The charge on an ion is related to its position in the Periodic Table. E.g. Mg is in group 2 so ion is Mg^{2+}. S is in group 16 so ion is S^{2-}.

Non-metal ions change their name from atom

E.g. chlorine atom / chloride ion; oxygen atom / oxide ion; sulfur atom / sulfide ion

Ionic bonding

An ionic bond is a type of chemical bond formed through an electrostatic attraction between two oppositely charged ions.

Table of Ions

+1	+2	+3	-2	-1
NH_4^+	Ca^{2+}	Al^{3+}	O^{2-}	**OH^-**
Na^+	Mg^{2+}	Fe^{3+}	S^{2-}	Cl^-
K^+	Cu^{2+}		**CO_3^{2-}**	**NO_3^-**
Ag^+	Pb^{2+}		**SO_4^{2-}**	**HCO_3^-**
H^+	Fe^{2+}			F-
	Ba^{2+}			
	Zn^{2+}			

ammonium ion

hydroxide ion

nitrate ion

hydrogen carbonate or bicarbonate ion

carbonate ion

sulfate ion

You will be given one of these in the exam but you do need to know the names of the ions. The six in **bold** need brackets if used more that once. Make sure you know the difference between sulfide S^{2-} and sulfate SO_4^{2-}.

Writing ionic formulae: You will have a table of ions. From the ions we can work out formulae. Note: all compounds must have no overall charge.

To write formulae, number of + charges must equal the number of - charges

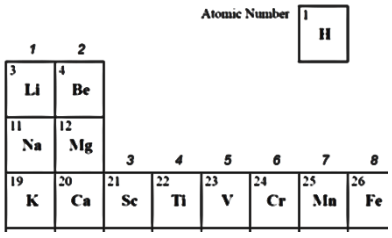
zinc oxide Zn^{2+} and O^{2-} = ZnO zinc chloride Zn^{2+} & Cl^- = $ZnCl_2$ aluminium oxide Al^{3+} & O^{2-} = Al_2O_3

Some ions(called polyatomic ions) are made up of two or more different atoms "grouped" together: OH^-, NO_3^-, HCO_3^-, CO_3^{2-}, SO_4^{2-} . The formula is worked out in exactly the same way, by considering the charges on the ions. However when a "group" is used more than once, you must put it in brackets. Eg $Ca(OH)_2$, $Cu(NO_3)_2$ but NOT Na(OH) or $Cu(SO_4)$.

Periodic table:

You will be given one of these in the exam but you do need to know the names of the common elements. The number above each column is the group number. Li, Na are in group 1, Be, Mg are in group 2 etc.

The atomic number is the number of protons in an atom. Eg Li has 3 protons (and since atoms are neutral Li has 3 electrons). You can't work out number of neutrons from this Periodic Table.



Metals: Order of reactivity (most) Na, Ca, Mg, Al, Zn, Fe, Pb, Cu (least)

Sodium Na – a light grey soft metal, stored in oil to keep away from O_2 and H_2O

Aluminium Al – appears less reactive than it is due to formation of tough insoluble layer of aluminium oxide that forms when aluminium reacts with oxygen.

Iron Fe – a very useful metal – the only metal to RUST (Reaction of others with air and/or water is called corrosion)

Lead Pb – particularly soft and dense metal (dense = heavy for size)

Copper Cu – described as a pinky-orange metal

Reactions of metals with acids: If the acid is hydrochloric, HCl, the salt is a chloride; if it is sulfuric acid, H_2SO_4, the salt is a sulfate. (The reaction of metals with nitric acid is complicated so don't worry about these).

metal + acid → salt + hydrogen $Mg + 2HCl \rightarrow MgCl_2 + H_2$ $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Reaction with	Na	Ca	Mg	Al*	Zn	Fe	Pb	Cu
Dilute acid e.g. HCl or H_2SO_4	React dangerously – very, very vigorous reaction		React with acid with decreasing reactivity					No reaction

*Al does not always show its true reactivity; the acid must first react and remove an aluminium oxide coating on the metal before the acid can reach the metal and the two substances start to react.

Acids and Bases

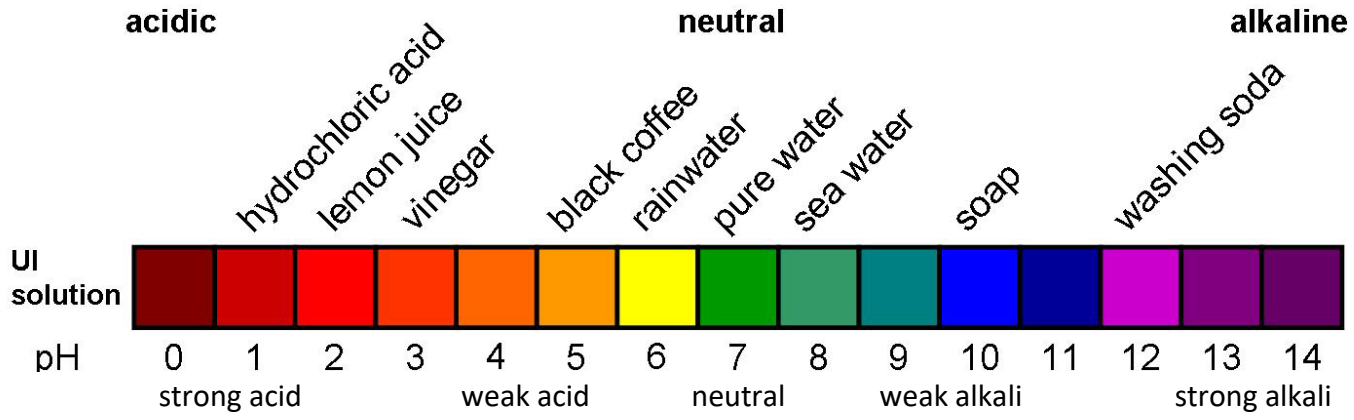
Measuring acidity.

Litmus paper or litmus solution can only be used to show whether a solution is acidic, neutral or alkaline.

acidic	Neutral	alkaline
red litmus stays red	red litmus stays red	red litmus turns blue
blue litmus turns red	blue litmus stays blue	blue litmus stays blue

Universal Indicator solution or paper can tell us how acidic or alkaline a solution is. The colour matches a pH value. Acid pH 1-6 (red – yellow), Neutral pH 7 (green) Alkaline pH 8-14 (greeny-blue – purple)

An acid is a solution containing a lot of hydrogen ions, H^+ ions. All acids dissolve in water to give solutions that contain these H^+ ions.



The acids you need to know are:

hydrochloric acid, HCl sulfuric acid, H_2SO_4 nitric acid, HNO_3

Other acids may be included in examination questions. The names and formulae of any such acids will be given, e.g. ethanoic acid HCH_3COO (or CH_3COOH) which forms salts called ethanoates.

Acid patterns:

- *Acid + metal → salt + hydrogen*
  (Has to be a reactive metal like Mg, Al, Zn, or Fe. Pb reacts very very slowly). Cu doesn't react with dilute acid.
  E.g. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ $Mg + 2HCl \rightarrow MgCl_2 + H_2$
  The magnesium bubbles – a colourless gas is given off, the tube gets hot and the metal "dissolves"
- *Acid + base → salt + water*
  E.g. heat an excess of copper oxide in dilute sulfuric acid, and filter to remove unreacted copper oxide. It reacts to form a blue solution of copper sulfate. $H_2SO_4 + CuO \rightarrow CuSO_4 + H_2O$
- *Acid + carbonate → salt + water + carbon dioxide*
  E.g. Add dilute hydrochloric acid to some marble chips. Marble chips are made of the chemical called calcium carbonate. The marble chips fizz – a colourless gas is given off – and they slowly "dissolve".
  $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

Bases and neutralisation

When you neutralise an acid you take away its acidic properties. Substances that do this are called BASES. Bases are substances that remove H^+ ions.

Bases belong to one of three types of compounds.

- metal hydroxides (and ammonium hydroxide)
- metal oxides
- metal carbonates (and ammonium carbonate) or metal hydrogen carbonates

The visible sign of a reaction between metal carbonates and metal hydrogen carbonates and acids is that they both FIZZ / BUBBLE if they are mixed with acids – the gas made is CO_2. The will neutralise the acid.

Alkalis and bases

Most bases do not dissolve in water. Those that do are called alkalis. Alkalis either contain the hydroxide ion, OH^- (e.g. sodium hydroxide NaOH and potassium hydroxide, KOH) or are substances that react with water *to release* hydroxide ions.
When the acid reacts with an alkali in a neutralisation reaction, the equation is: $H^+ + OH^- \rightarrow H_2O$

Gas Tests

Test for hydrogen: Collect some gas by trapping it with your thumb on top of a test tube. Bring a lit splint to the top of the tube and remove your thumb at the last moment! The hydrogen gas burns with a pop or a squeak. (DON'T just say "do the pop test!")

Test for carbon dioxide: Bubbling the gas through lime water, a solution of calcium hydroxide $Ca(OH)_2$, can be used to identify the carbon dioxide gas. The carbon dioxide released turns the lime water from colourless to milky white colour due to the formation of insoluble calcium carbonate.
$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

NOTE: This Achievement Standard also contains a section on "Rates of reaction and particle theory" which will be covered separately.