Opening extract from

Oxford Study Science Dictionary

Written by

Chris Prescott

Published by

Oxford Children's Books

Introduction

This study dictionary has been written for students in the 11–16 age group, especially those studying Key Stage 3 and Key Stage 4 Science. It should be a useful reference book for all sciences to GCSE level, including the separate sciences of Biology, Chemistry and Physics.

The dictionary has been divided into 130 scientific themes, each contained on a double-page spread. These have been arranged alphabetically. The themes have been further divided into over 2500 words and phrases, each of which is defined within a sentence or a diagram. Remember that definitions only help you towards making use of a scientific word or phrase. No definition is ever completely correct; it is only a guide. You will need to see the links made between words and begin to use the words yourself in a range of contexts before you can really say you have understood their meanings. The definition should be read through several times and any scientific words you do not understand should be looked up in the Wordfinder at the beginning of the book.

During the writing of this dictionary I have received extensive advice from the staff of Oxford University Press and their readers. Dr Jeremy Marshall gave specialist help as an editor and lexicographer. I wish to express my sincere thanks.

Chris Prescott

April 1999

The Dictionary

acids, bases, and alkalis

acids are **chemical compounds** which produce hydrated **hydrogen ions** $H^+(aq)$ when in aqueous solution. *All acids, when in aqueous solution, have certain general properties. They:*


CORROSIVE

- turn moist **litmus** paper from blue to red in colour
- have a **pH** value of less than 7
- are **electrolytes** because in solution they contain ions
- react with metals like zinc and iron to form a **salt** and **hydrogen gas**
- react with metal carbonates to form a **salt**, water, and carbon dioxide gas
- neutralise **bases** and **alkalis** to form a **salt** and water.

mineral acids are **acids** which are often strong and corrosive **inorganic** compounds. *Most do not occur naturally but are made for laboratory and industrial use. They include sulphuric acid* H_2SO_4, *nitric acid* HNO_3, *hydrochloric acid* HCl, *and carbonic acid* H_2CO_3.

organic acids are naturally occurring **acids** found in vegetables, fruit and other foodstuffs. *They are usually weaker acids but still have a sharp or sour taste. They include ethanoic acid (found in vinegar), citric acid (in lemons), lactic acid (in milk), and oxalic acid (in rhubarb).*

acidic oxides are **oxides** of **non-metallic elements** which react with water to form acids. *Many non-metal oxides like sulphur dioxide and oxides of nitrogen are gases. If they are found in the* ***atmosphere****, they will dissolve in rainwater to form* ***acid rain****.*

Acidic oxide	**Acid formed in water**
carbon dioxide	carbonic acid
sulphur dioxide	sulphurous acid
phosphorus (V) oxide	phosphorous acid
nitrogen dioxide	nitric/nitrous acids

bases are **chemical compounds** that react with **acids** to form a **salt** and water. *Simple bases are oxides and hydroxides of metals. Complex bases include many organic compounds containing the amine group* ($-NH_2$), *such as those found in* ***DNA****.*

basic oxides are **oxides** of a **metallic elements** that will react with acids to form a **salt** and water only. *A few basic oxides dissolve in water to form* ***alkalis****.*

Basic oxide	**Alkali formed in water**
potassium oxide	potassium hydroxide
sodium oxide	sodium hydroxide
calcium oxide	calcium hydroxide

alkalis are water-soluble bases which produce hydrated hydroxide ions $OH^-(aq)$ when in aqueous solution. *Potassium hydroxide solution* $KOH(aq)$, *sodium hydroxide solution* $NaOH(aq)$, *and calcium hydroxide solution* $Ca(OH)_2(aq)$ *are alkalis, and so is ammonia solution* $NH_3(aq)$. *All alkalis are soapy to touch and share several properties. They:*

- turn moist red **litmus** paper from red to blue
- have a **pH** value greater than 7
- are **electrolytes** because in solution they contain ions
- produce **ammonia gas** when warmed with ammonium salts
- neutralise **acids** to form a **salt** and water.


CORROSIVE

amphoteric describes a **chemical compound** that can act as an acid in one reaction but as a base in another (e.g. ZnO, Al_2O_3).

strength of acids The strength of an acid depends on its degree of ionisation in aqueous solution. *Strong acids like sulphuric acid are fully ionised in water. Weak acids like carbonic acid are only partially ionised in water: most of the ions formed recombine and remain as molecules. This is shown by the* ***reversible sign*** *in the chemical equation.*

$$H_2SO_4(l) \xrightarrow{\text{water}} 2H^+(aq) + SO_4^{2-}(aq)$$

$$H_2CO_3(l) \overset{\text{water}}{\rightleftharpoons} 2H^+(aq) + CO_3^{2-}(aq)$$

pH The pH scale is a logarithmic number scale (0 to 14) for showing the strength of an acid or alkali. *pH is an abbreviation for 'potential of hydrogen'. As the scale is logarithmic, a change of pH from 4 to 2 means that the substance is 100 times more acidic. Any pH value below 7 represents an acidic solution, and the lower the value the stronger the* ***acid****. Any pH value above 7 represents an alkaline solution, and the higher the value the stronger the* ***alkali****.*

neutral describes a solution which has a **pH** of exactly 7 and is neither acidic nor alkaline. *Neutral solutions have the same concentration of hydrogen and hydroxide ions. Pure water, salt water, and various organic liquids are neutral solutions.*

pH value	Colour of universal indicator	Strength
0, 1, 2, 3	red	strong acid
4	pink	weak acid
5	orange	weak acid
6	yellow	weak acid
7	green	neutral
8	turquoise	weak alkali
9	blue	weak alkali
10	dark blue	weak alkali
11, 12, 13, 14	violet	strong alkali

neutralisation is the chemical reaction between a **base** and an **acid** to form a **salt** and water.

$$\text{acid} + \text{base} \rightarrow \text{salt} + \text{water}$$

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

indicator An acid–base indicator changes colour, reversibly, according to whether a solution is acidic or alkaline. *Many plant extracts, such as red cabbage juice, act as indicators.*

litmus is an **indicator** made from a lichen (a tiny plant) which turns red in acid and blue in alkaline solutions.

universal indicator is a mixture of several indicators and turns a range of colours corresponding to different **pH** values.

Indicator	Colour in Acid	Colour in Alkali
litmus	red	blue
methyl orange	red	yellow
screened methyl orange	red	green
phenolphthalein	colourless	pink

buffer solution A buffer solution resists changes in pH when an acid or an alkali is added or when the solution is diluted. *Buffer solutions are normally weak acids and the salts of such acids (or weak alkalis and their salts). Living organisms are very sensitive to pH changes, so blood and tissue fluids contain important natural buffers.*

atmosphere The atmosphere is the **air** that surrounds the Earth and is held to it by gravity.

air is a mixture of gases, the most important of which are **nitrogen**, **oxygen**, and **carbon dioxide**. *The gases are extracted by liquefying the air. This is done by repeatedly compressing it, and then rapidly expanding it, which lowers its temperature. The components are then separated by* ***fractional distillation****. Air is the main source of* ***oxygen****,* ***nitrogen****, and* ***noble gases****.*

Component	Percentage by volume	Boiling point in °C
nitrogen	78.08	-196
oxygen	20.95	-183
argon	0.93	-186
carbon dioxide	0.03	-78
neon	0.0018	-246
helium	0.0005	-269
krypton	0.0001	-157
xenon	0.00001	-108

COMPOSITION OF AIR

oxygen is the most important gas in the air. *Oxygen has many uses and is essential for* ***combustion*** *and* ***respiration****.*

- Life support systems in hospitals use oxygen gas. Patients with breathing difficulties are also given oxygen gas.
- Oxyacetylene flames burn at very high temperatures (3300°C). Such flames are useful for welding and cutting metals.
- **Steel** manufacturing uses oxygen. The gas is 'blasted' into molten iron to remove any impurities. It does this by oxidising the main impurities, sulphur and carbon, into their oxides which escape as gases.
- Liquid oxygen (LOX) is used with rocket fuels. Outside the Earth's atmosphere, no fuel can burn unless an oxygen supply is available. Any fuel will burn more fiercely in pure oxygen than in air.
- High-altitude workers (climbers, pilots) and underwater workers (divers) need oxygen. The higher up in the atmosphere you go, the lower the air pressure becomes. The air becomes thinner and so contains less oxygen in a given volume (e.g. a lungful of air).

nitrogen is the main gas in the air, and takes part in the natural **nitrogen cycle**.

- Nitrogen's main industrial use is in the manufacture of ammonia gas by the **Haber process**. Ammonia is very important in the manufacture of **fertilisers** such as ammonium nitrate.
- Nitrogen is a very unreactive gas and is used as an inert atmosphere to prevent explosions, and in food packaging, where it prevents the oxidation of natural oils and reduces bacterial decay.
- Liquid nitrogen is used as a refrigerant. Its low temperature of –196°C is ideal for rapidly freezing foods such as vegetables and meat.

carbon dioxide is present in very small amounts in the **atmosphere** (0.03%), but it is very important because it is used for **photosynthesis** in plants. *Much carbon dioxide is dissolved in the seas and the lakes, or combined to form* ***carbonates*** *in the rocks.*

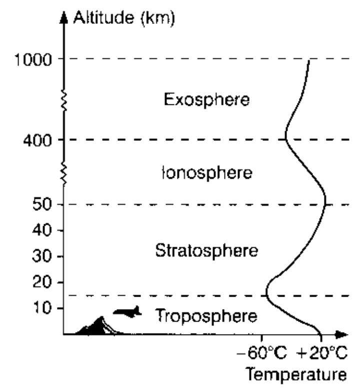
noble gases (or **inert gases** or **rare gases** or **group VIII** or **group 0 gases**) occupy around 1% of the **atmosphere,** of which most is argon. *All are colourless, monatomic gases which are extremely inert because their atoms have full outermost* ***electron shells****.*

- **argon** is used to fill ordinary and long-life light bulbs. It prevents the filament inside the bulb from burning out. Argon is also used to provide an **inert atmosphere** in arc-welding metals.
- **neon** is used in advertising signs because it glows red when electricity is discharged through it. It is also used in **Geiger–Müller tubes**.
- **helium** is very light and is used to inflate airships and weather balloons. It is also used in the helium–neon laser and to dilute the oxygen in aqualungs for divers.
- **krypton** and **xenon** are used in lamps in lighthouses, stroboscopic lamps, and photographic flash units.

troposphere The troposphere is the lowest layer of the **atmosphere**, in which most weather occurs. *Its average thickness is around 15 km (ranging from 7 km at the poles to 28 km at the equator). The temperature gradually decreases as we go higher in the troposphere.*

stratosphere The stratosphere is the second lowest layer of the **atmosphere**, up to around 50 km. *Temperature increases slightly in this layer, as it is heated from below by infrared radiation from the Earth's surface.*

ozone is formed in the upper atmosphere (**stratosphere**) when **ultraviolet radiation** from the sun breaks down **oxygen** molecules O_2 to form oxygen atoms which recombine as ozone O_3. *Ozone is also formed in the lower atmosphere by industrial activity, where it contributes to pollution.*



STRUCTURE OF ATMOSPHERE

ionosphere The ionosphere is the third lowest layer of the **atmosphere**, in which gases are ionised by absorption of the sun's radiation. *This layer is important for radio communication, as radio waves of certain wavelengths are reflected by its lower parts and so can travel great distances around the world.*

exosphere The exosphere is the highest region of the **atmosphere**, which begins at an altitude of about 400 km and thins out almost completely at about 1000 km.

primary atmosphere is the term for the thick cloud of gases which surrounded the Earth and other planets in our solar system when they were first formed about 4500 million years ago. *It consisted mainly of hydrogen and helium, which escaped into space.*

secondary atmosphere is the term for the mixture of gases which formed when the Earth cooled, and volcanic activity released water vapour, **methane**, **carbon dioxide**, and **ammonia** into the **atmosphere**. *The water vapour condensed to form the seas. There was no oxygen until the first living organisms appeared that were capable of **photosynthesis**, which releases oxygen. This then oxidised the ammonia and methane to form carbon dioxide, nitrogen, and more water vapour.*

atom An atom is the smallest particle of an element which can take part in a chemical reaction and remain unchanged. *These particles are extremely small. If a golf ball were magnified to the size of the Earth, then an atom would be the size of a marble! They have a radius of around 10^{-10} m and a mass of about 10^{-22} g. During chemical reactions, atoms are rearranged, but not created or destroyed* (***conservation of mass***).

nucleus (plural: **nuclei**) A nucleus is the very small central core of an atom, containing most of the atomic mass. *It is made up of* ***protons*** *and* ***neutrons*** *(except in hydrogen) and the nucleus has a positive charge. Surrounding the nucleus are 'orbiting' electrons. Any radioactive properties of an atom are associated with the nucleus. If an atom was the size of a football pitch then the nucleus (sitting on the centre spot) would be the size of a pea!*

Particle	Approximate radius
Atom	10^{-10} m
Nucleus	10^{-14} m
Electron	10^{-15} m

subatomic particles are particles which are smaller than, or form part of, an **atom**. *There are three subatomic particles which make up most atoms:* ***protons, neutrons****, and* ***electrons****.*

proton A proton is a positively charged **subatomic particle** which is found in the nucleus of an atom. *It has a mass equal to that of a neutron but is 1840 times heavier than an electron. Its charge is equal, but opposite, to that of an electron.*

neutron A neutron is a neutrally charged **subatomic particle** which is found in the nucleus of atoms (except hydrogen). *It has a mass roughly the same as that of a proton.*

electron An electron is a negatively charged **subatomic particle** which is found orbiting the nucleus of atoms. *Its charge is equal, but opposite, to that of a proton. However its mass is only $\frac{1}{1840}$th that of a proton or neutron. The chemical properties of the atom are determined by these orbiting electrons, in particular the outermost ones.*

nucleon A nucleon is a general term to describe particles found in the **nucleus** of atoms. *Nucleons are either* ***protons*** *or* ***neutrons****.*

proton number (or **atomic number**, symbol: **Z**) is the number of **protons** an element has in the **nucleus** of its atom. *Every element is defined by its proton number. If you change the proton number, you change the element. The number of protons in an atom is always equal to the number of electrons, as the atom must have an overall neutral charge.*

mass number (or **nucleon number**, symbol: ***A***) is the total number of **protons** and **neutrons** found in the nucleus of an atom. *The mass number of a particular element can vary as the number of neutrons can change.*

isotopes are atoms of the same **element** (same number of protons and electrons) with different numbers of **neutrons**, and so different mass numbers. *Nearly all elements found in nature are mixtures of several isotopes. Isotopes of a particular element have similar chemical properties but slightly different physical properties (density, rate of diffusion, etc.).*