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出版前言

1999年出版的《大学英语教学大纲(修订本)》明确提出，“学生在完成基础阶段的学习任务，达到四级或六级后，都必须修读专业英语”。这是大纲修订组在对用人单位进行了广泛调查的基础上，结合英语学习的规律，对大学英语教学提出的新要求。因此，目前国内急需一套内容全面、语言地道的专业英语教材和读物。

《牛津专业英语基础丛书》原版由牛津大学提供，包括物理学、化学、生物学、人体生物学、商务、地理学、心理学、经济学等8种。该丛书原为英国A-level(相当于大学预科)考试的复习用书。书中以图表的形式，归纳整理了学科的主要知识。其中不仅包括常用的专业词汇和句型，还有连贯的短文，十分适合作为大学生专业英语的自学教材。

为了方便读者使用，本社约请了复旦大学、华东理工大学、华东师范大学、上海理工大学、上海财经大学等高校有关专业既有专业特长，又精通英语的教授对该丛书作了详细的注释，并给难读的单词加注了音标。

本丛书既能帮助大学生复习巩固专业知识，又能提高专业英语水平，还可以作为有关专业的人员提高专业阅读和翻译能力的教材或读物。

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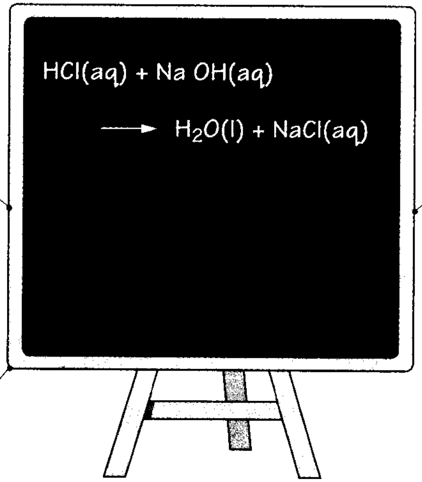
Quantitative chemistry is about chemical equations and what they tell you in terms of the amounts of reactants used up and products made



CHEMICAL CHANGE

Chemical changes have three main features:

- *New substances* are made
- There is an *energy change* between the reacting system and its surroundings
- There is a fixed relationship between the masses of the reactants and products — this is called the *stoichiometry* of the reaction

Stoichiometry is the name given to the property of pure substances to react together in *whole number ratios of particles.*

Chemical changes are nearly always written as equations showing the reactants and products symbolically in the form of some kind of *formula.*

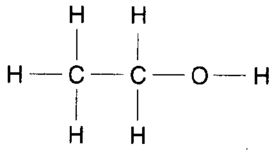
DIFFERENT KINDS OF FORMULA

Empirical formula shows the simplest whole number ratio of atoms in the particles of the substance, e.g. C_2H_6O and CH.

Molecular formula shows the actual number of atoms in a particle of the substance, e.g. C_2H_6O and C_2H_2.

Structural formula shows the arrangement of atoms in the particle

either written as, e.g. CH_3CH_2OH and HCCH
or drawn as




Some people call the drawn formulas displayed formulas, but this is not common.

CHEMICAL EQUATIONS

Reactants are normally written on the left.

Products are normally written on the right.

The arrow → between them means *reacts to give* and sometimes has the conditions written above or below it.
e.g.

$$CuCO_3 \xrightarrow{\text{heat}} CuO + CO_2$$

There are two different kinds of equation and although they are often used interchangeably, they really have different uses depending on which feature of the reaction is being studied:

IONIC EQUATIONS

These are used when we think about how one lot of substances is changed into another.

They are concerned with the bonding, structure, shape, or size of the particles and the mechanism of the reaction.

When writing particle equations state symbols are used, e.g.

$$Cu^{2+}(aq) + 2OH^-(aq) \longrightarrow Cu(OH)_2(s)$$

This equation tells us that a copper aquo ion reacts with two hydroxide ions to make an insoluble product.

FULL EQUATIONS

These are used when the stoichiometry of the reaction is being studied. They are concerned with the relative amounts of the reactants used and products made.

State symbols are usually not essential here, although greater credit is given for their use
e.g.

$$2Mg + O_2 \longrightarrow 2MgO$$

This equation tells us that 2 moles of magnesium react with 1 mole of oxygen molecules to make 1 mole of magnesium oxide.

Calculations from equations

The mole is the unit in which *amounts of substance* are measured in chemistry.

The mole is defined as *that amount of substance that contains the same number of particles as there are atoms in exactly 12 g of the isotope carbon 12.*

The number of particles in a mole is found to be 6.02×10^{23}: this number is called the Avogadro constant and has the symbol L.

KEY RELATIONSHIPS

In the laboratory, substances are most conveniently measured out by weighing for solids and by volume for liquids and gases.

The relationships between amount of substance, number of particles, mass of solid, and volume of gas are very important:

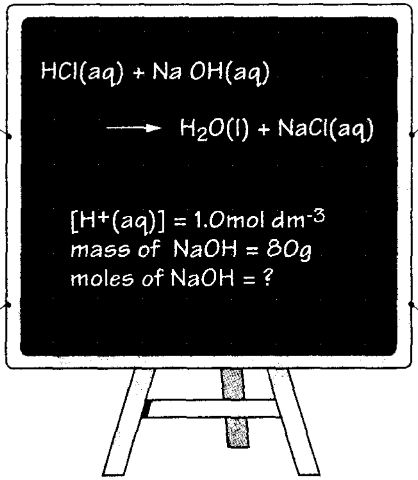
amount	number of particles	mass of solid	volume of gas
1 mole ≡	6.02×10^{23} ≡	A_r or M_r in grams ≡	*22.4 dm^3 at s.t.p.

Many calculations involve converting from one part of this relationship to another; always go back to this key line at the start of your calculation.

* Standard temperature and pressure are 273 K and 1 atmosphere (101 325 Pa). Often room temperature, 298 K is used: at room temperature a mole of any gas has a volume of 24 dm^3.

In electrolysis, the amount of charge involved in the reaction at the electrodes is important:

1 mole of electrons = 96 500 coulombs = 1 Faraday



WHEN DOING CALCULATIONS REMEMBER

1. To define the particles you are talking about

Is your mole of oxygen 6.02×10^{23} oxygen atoms which weigh 16 g or 6.02×10^{23} oxygen molecules which weigh 32 g?

2. Substances are often not pure, but are diluted in solutions

The quantity of substance in a solution is called its *concentration.*

Concentration can be expressed in several different ways:

grams per litre shortened to g/l or g l^{-1}
grams per cubic decimetre shortened to g/dm^3 or g dm^{-3}
moles per litre shortened to mol/l or mol l^{-1}
moles per cubic decimetre shortened to mol/dm^3 or mol dm^{-3}
molar shortened to M where 1 M means 1 mol dm^{-3}

3. Volumes are measured in several different units

1 cubic decimetre ≡ 1 litre ≡ 1 000 cubic centimetres

CALCULATIONS FROM CHEMICAL EQUATIONS

Always try to work through the following steps in this order:

1. write down the equation for the reaction;
2. work out the number of moles of the substance whose amount/mass/volume is given;
3. from the equation, read off the mole ratios (the stoichiometry);
4. using this ratio, work out the number of moles of the unknown substance;
5. using the key relationships above, convert the moles into the units asked for;
6. give your answer to 3 significant figures and remember to put in the units.

Spectroscopy gives us ways of investigating the structure of substances by looking at their spectra

MASS SPECTROMETRY

Description

Particles are bombarded with electrons, which knock other electrons out of the particles making positive ions. The ions are accelerated in an electric field forming an ion beam. The particles in this beam can be sorted according to their masses using an electric field.

Uses

- to measure relative atomic masses
- to find the relative abundance of isotopes in a sample of an element
- to examine the fragments that a molecule might break into so that the identity of the molecule can be found

ULTRAVIOLET, VISIBLE, INFRARED, AND NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

Description

Energy, in the form of electromagnetic radiation, is applied to the sample. Either the energy taken in by the sample or the energy it gives out is studied.

$$\text{SAMPLE} \xrightarrow{\text{apply energy}} \text{EXCITED SAMPLE} \xrightarrow{\text{energy given out}} \text{SAMPLE}$$

apply energy ↓	energy given out ↓
see what wavelengths are absorbed ABSORPTION SPECTRA	see what wavelengths are emitted EMISSION SPECTRA

The energy of different parts of the electromagnetic spectrum is related to the frequency of that part of the spectrum by the equation

$E = h\nu$, where E is the energy, h is a constant, and ν is the frequency.

The frequency is related to the wavelength of the radiation by

$\nu = {}^{c}/_{\lambda}$, where c is the speed of light and λ is the wavelength.

So in summary, the shorter the wavelength, the higher the frequency and the higher the energy.

Different parts of the molecule interact with different wavelengths of radiation. The table below shows how different wavelengths of radiation cause different changes in the particles.

Frequency/MHz: 3, 3×10^2, 3×10^4, 3×10^6, 3×10^8, 3×10^{10}

Wavelength/m: 10^2, 10, 1, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8}, 10^{-9}

Name of radiation	radio waves	microwaves	infra-red	visible	ultra-violet	X-rays
What happens in the particles	nuclei rotate or spin	molecules rotate	molecules vibrate	electrons in atoms and molecules change orbitals		

USES

Ultraviolet and visible

- to work out electronic structures of atoms and molecules
- indicators in acid/base chemistry
- quantitative analysis in both inorganic and organic chemistry

Infrared

- detecting the presence of functional groups in organic compounds

Nuclear magnetic resonance

- detecting the number and position of atoms with odd mass numbers in molecules (usually ^{1}H, but also ^{13}C, ^{15}N, ^{19}F, and ^{31}P)

Mass spectra

THE EXPERIMENTAL SET-UP

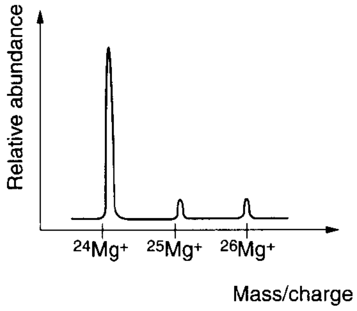
A gaseous sample is hit by an electron beam which knocks electrons off the particles making them into positive ions:

$$M(g) + e^- \rightarrow M^+(g) + 2\,e^-$$

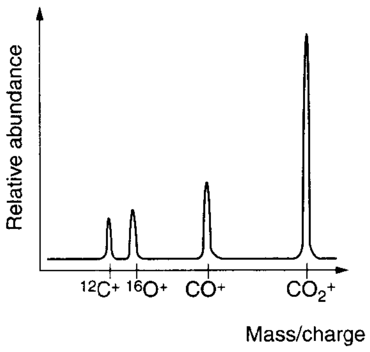
These ions are accelerated in an electric field and aligned into an ion beam. The beam is passed through either an electrostatic field or a magnetic field or both where it is deflected. The deflected particles are then detected and recorded.

THE SPECTRUM

Magnesium spectrum

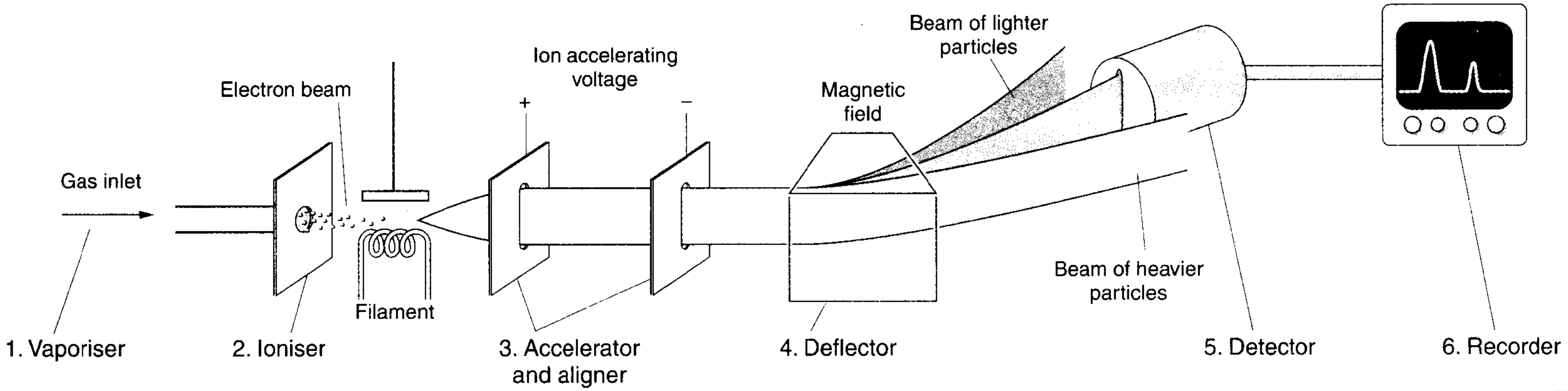


Carbon dioxide spectrum



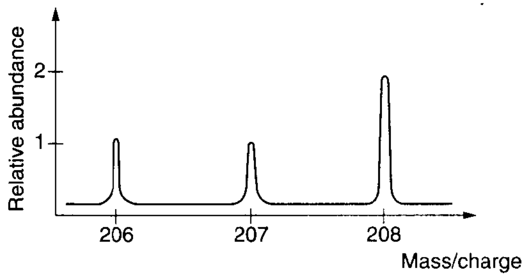
The spectrum for elements shows a different peak for each isotope. The height of the peak indicates the amount of each isotope.

The spectrum for compounds will show peaks representing the whole compound particle (this will have the largest mass) and fragments of it which broke up when they were ionised in the electron beam.



CALCULATIONS FROM MASS SPECTRA

The mass spectrum below is produced from a sample of lead



From it we can see that:

(i) there are three peaks: this tells us that there are three different isotopes present in the sample.

(ii) the peak at 208 is twice as high as the other two peaks at 206 and 207. This tells us that there is twice as much of the isotope of mass number 208 as there is of the other two: so the relative amounts of the three isotopes are:
25% each of 206 and 207 and 50% of 208

(iii) the relative atomic mass of this element is:
$(206 \times {}^{25}/_{100}) + (207 \times {}^{25}/_{100}) + (208 \times {}^{50}/_{100}) = 207.25$

EXPLAINING THE SPECTRUM

The mass spectrometer depends on the fact that a charged particle travelling in an electric field will be deflected and the amount of deflection depends on:
- the mass of the particle
- the speed of the particle
- the strength of the field
- the charge on the particle

In a mass spectrometer the field strength is steadily changed so that particles of increasing mass arrive one after the other at the detector.

Ultraviolet and visible spectra

The experimental set-up

Emission spectra. A gaseous sample is excited with electrical or thermal energy. Ultraviolet or visible radiation is given out; this is focused into a beam and then split by a prism or diffraction grating; the radiation is then viewed through the telescope or detected photographically.

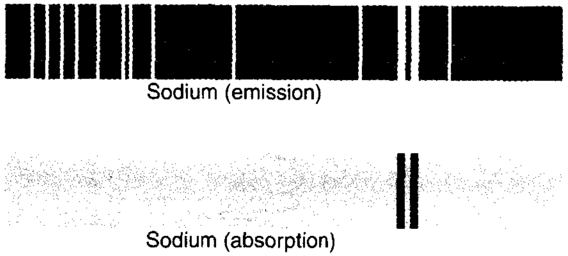
Absorption spectra. White light from a lamp is directed through a gaseous sample of the substance.

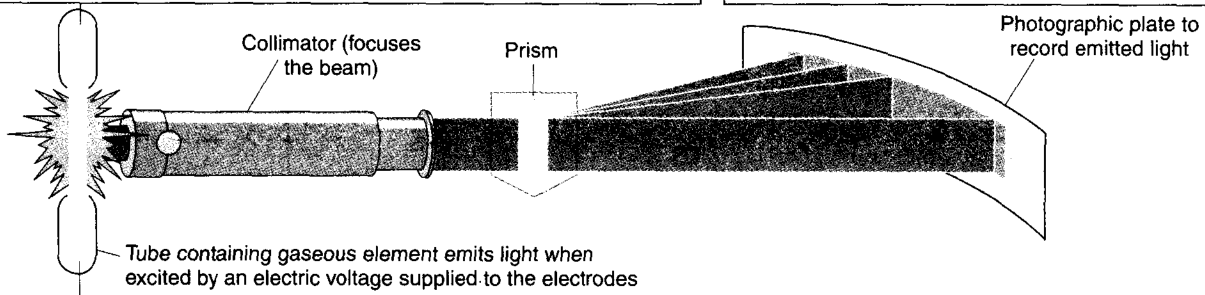
The spectrum

The spectrum produced differs from the normal spectrum of white light in two ways:

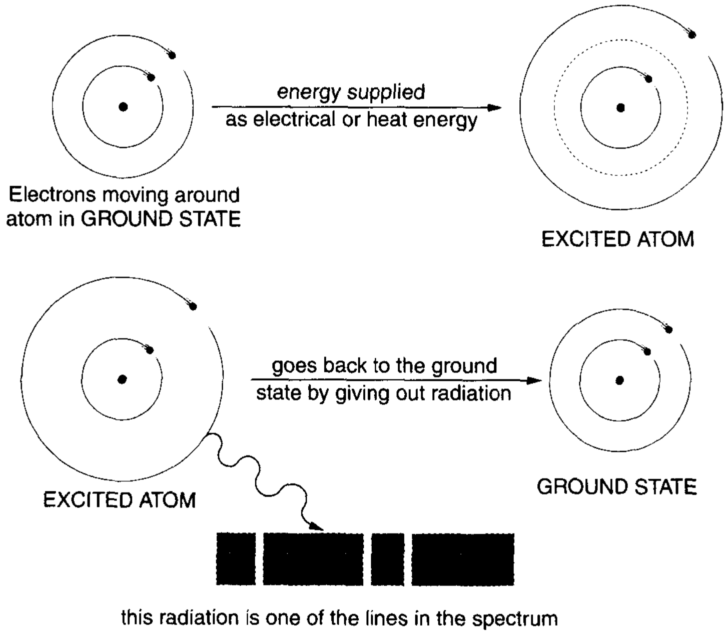
(i) it is made up of separate lines (it is discontinuous).

(ii) the lines are in a converging pattern, getting closer as the frequency or energy of the lines increases.





Explaining the emission spectra



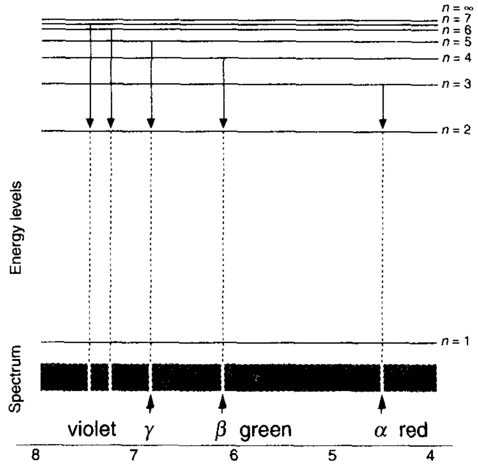
this radiation is one of the lines in the spectrum

Electrons in an atom are each in a particular energy level. When a sample is excited, electrons in the atom take in the extra energy by either moving faster or moving out, away from the nucleus. So they move to a higher energy level. Sometime later, the energy is given out as radiation as the electrons slow down or move back in.

Lines are seen in the spectrum because the energy of electrons is *quantised*. This means that only certain energy levels are allowed in the atom and the electrons can only move between these levels. So each line in an *emission spectrum is the result of electrons* moving from one quantised energy level to a lower one. The difference in energy between the two levels is related to the frequency of the radiation by Planck's constant: $\Delta E = h\nu$

The hydrogen spectrum

In the visible part of the hydrogen spectrum four lines can be seen. Each of these lines represents electrons falling back to the second energy level from one of the levels above. The visible part of the hydrogen spectrum is called the Balmer series.



Flame tests

The emission spectrum of each element is unique to that element and can be used to identify the element. Flame tests, in which a sample of the element or its compound is heated on a wire in a bunsen flame can be used to identify some elements, especially in the s block.

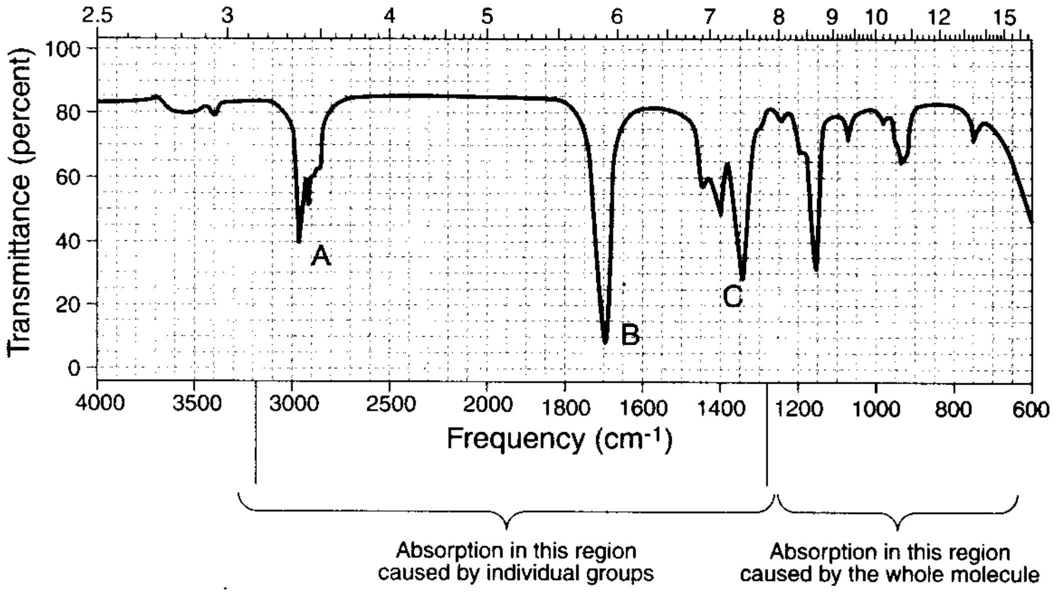
Group 1 element	Flame colour	Group 2 element	Flame colour
sodium	orange	calcium	brick red
potassium	pale purple (lilac)	strontium	crimson
		barium	apple green

Infrared spectra

Explaining the spectrum

In this kind of spectrometry, infrared radiation is absorbed causing the atoms at each end of a bond to vibrate relative to each other. Like a stretched spring between two masses, the energy absorbed by a bond depends on the masses of the atoms and the bond strength. So, as in visible and UV spectra, the vibrational energies are quantised, each kind of bond absorbing its own band of radiation. Only those molecules with charge separation along their bonds absorb in the *infrared* region and only if this results in a change of dipole moment.

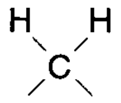
The wavelengths of the energy absorbed, often expressed in **wavenumbers**, appear as dips in the spectrum. Some of these dips indicate the presence of particular functional groups and others are characteristic of the whole molecule.



Infrared spectrum of butanone

A: energy absorbed by C – H bonds stretching

B: energy absorbed by C = O bonds stretching

C: energy absorbed by  $\mathrm{H{-}C{-}H}$ bonds bending

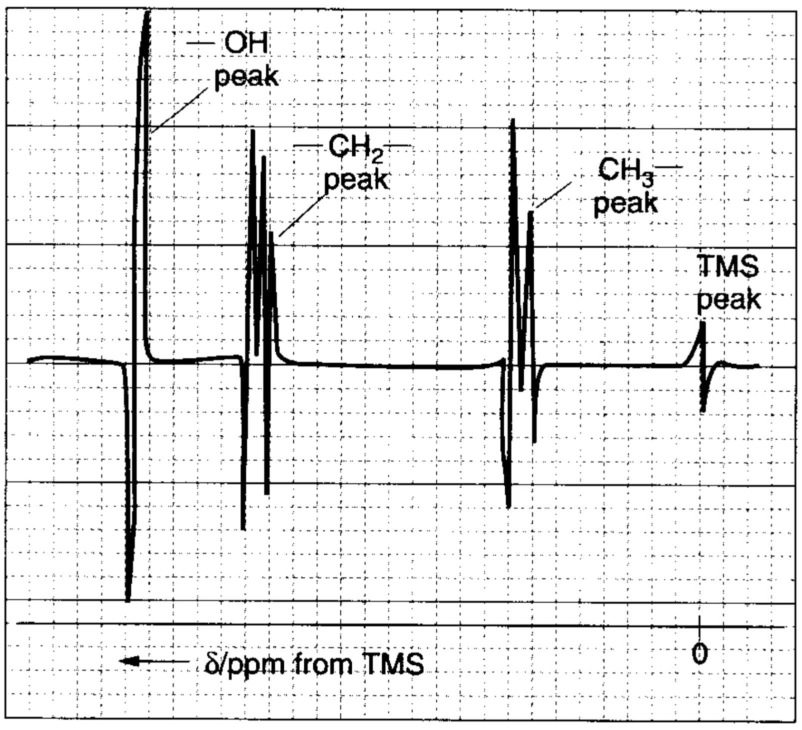
The greenhouse effect

The amount of carbon dioxide (and other gases) is increasing in the atmosphere as the result of burning fossil fuels and other human activities. It is suggested that the increasing amounts of these gases are absorbing more infrared radiation — heat — and so causing the atmosphere to heat up producing the effect known as global warming or the greenhouse effect.

Nuclear magnetic resonance spectra

Explaining the spectrum

Nuclei with an odd number of protons or neutrons have a magnetic moment as though they were spinning in a magnetic field. Normally, there is an equal number of atoms in a sample with each direction of spin and so they cancel each other out. When a strong magnetic field is applied, half the spins align with the field and half against it. This splits the nuclei in terms of energy. Nuclear magnetic resonance, NMR, happens when the nuclei aligned with the field absorb energy and change the direction of their spin. The amount of energy absorbed while they do this depends on the nucleus and its molecular environment and on the magnetic field strength. So NMR can reveal the presence of hydrogen atoms (and other nuclei) in different functional groups. For example, in propanol, there are CH_3—, —CH_2—, and —OH groups and the hydrogens in each of these groups will come into resonance at different frequencies. The frequencies are always measured relative to those for the protons in tetramethylsilane, TMS.



Atomic structure:

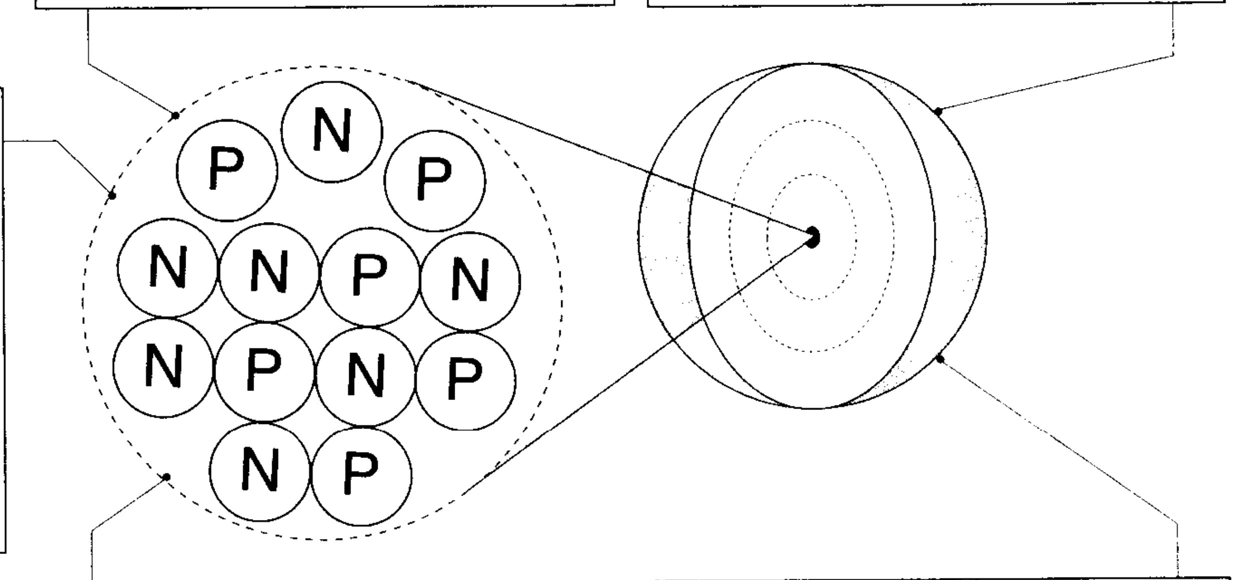
the nuclear atom

Nucleus
This contains protons and neutrons, called collectively **nucleons**.

The **mass number** gives the number of nucleons, that is the number of protons + neutrons.

Isotopes are atoms with the *same atomic number* but *different mass numbers.* All the atoms of an element have the same atomic number and it is this that makes them all atoms of a particular element.

The masses of atoms of particular isotopes, called the **relative isotopic mass**, are expressed on a relative scale on which the mass of an atom of the isotope carbon-12 has 12 units exactly.



The **atomic number** gives the number of protons in the nucleus. It also gives the number of electrons in the neutral atom and the position of the element in the periodic table.

Relative atomic mass
All elements exist in several isotopic forms and it is useful to have an average value for the masses of the atoms of each element. This is called the **relative atomic mass** and is defined as the weighted mean of the masses of the naturally occurring isotopes of the element expressed on the carbon-12 scale. These are found using a mass spectrometer (see page 8)

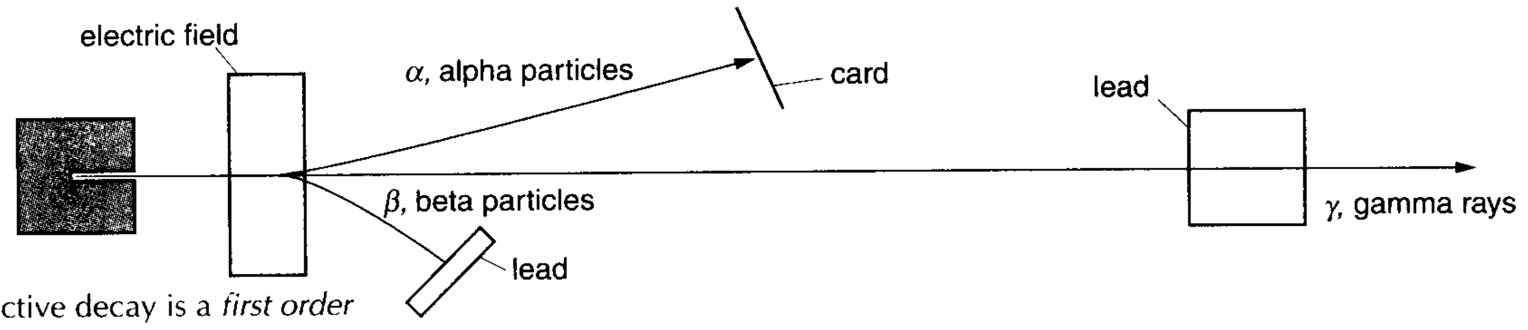
Isotope	Relative isotopic mass	Relative abundance in natural chlorine
^{35}Cl	35	75%
^{37}Cl	37	25%

$$\text{Relative atomic mass} = \frac{(75 \times 35) + (25 \times 37)}{100} = 35.5$$

RADIOACTIVITY

Some isotopes are stable, but others, often with uneven numbers of protons and/or neutrons are unstable. This instability increases with atomic number, resulting from the growing repulsion between increasing numbers of protons. When an unstable isotope **decays** it gives off radiation known as **radioactivity**. This can be in one of three forms as this table shows.

Name of radiation	*Made of*	*Behaviour in electric field*	*Penetrating power*
alpha	helium nuclei	deflected slightly	stopped by paper
beta	electrons	deflected a lot in other direction	stopped by mm of lead
gamma	electromagnetic radiation	similar to X-rays	penetrates cm of lead



All radioactive decay is a *first order rate* process (see page 38)

Uses of isotopes
Isotopes are often used as **tracers**. Very small traces of an isotope can be detected and hence followed through a process.

- biology e.g. ^{32}P to study nutrient uptake in plants
- industry e.g. ^{57}Fe to study wear and lubrication in engines
- geography e.g. ^{57}Fe to study river flow
- medicine e.g. ^{131}I to study thyroid function
- generating power e.g. ^{235}U in fission reactors; ^{3}H in fusion
- archaeology e.g. ^{14}C in carbon dating

The last example is well known. Nitrogen high in the atmosphere is converted into carbon-14 by cosmic rays coming from space.

The amount of this carbon-14 relative to carbon-12 in the atmosphere was constant until the industrial revolution when the burning of fossil fuels began to dilute it. This means that all carbon-containing objects such as wood and paper started with the same relative amount of carbon-14 as there was in the atmosphere. However, carbon-14 decays back into nitrogen with a half-life of 5568 years, so by measuring the amount of carbon-14 in an object it can be dated to within 200 years. Objects like the Dead Sea scrolls and the Turin Shroud have been dated in this way.