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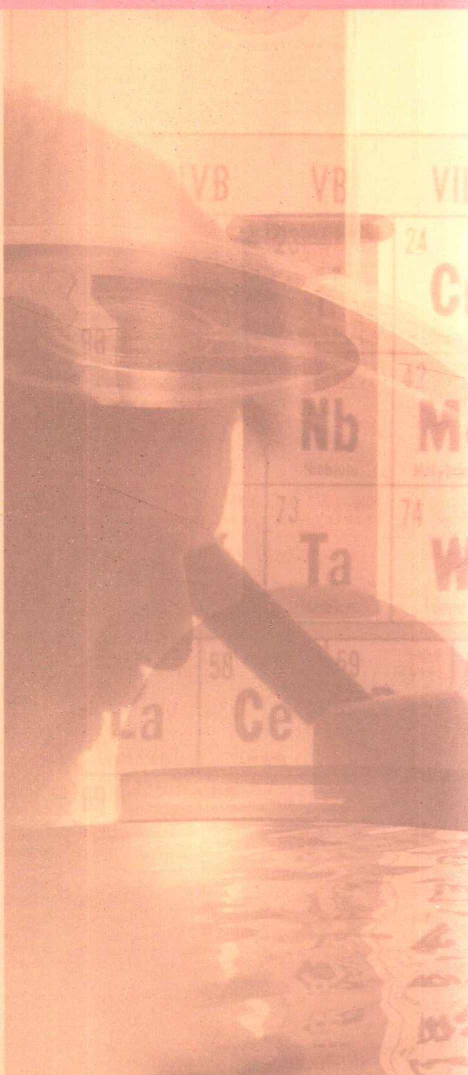
拓展课程
ESP

Advanced Chemistry through Diagrams

牛津化学英语图示教程

Michael Lewis



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荣国斌 饶腊霞 注释

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Advanced
CHEMISTRY
through diagrams

Michael Lewis

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出 版 说 明

教育部最新颁布的《大学英语课程教学要求》将大学英语的教学目标确定为“培养学生的英语综合应用能力，特别是听说能力，使他们在今后学习、工作和社会交往中能用英语有效地进行交际，同时增强其自主学习能力，提高综合文化素养，以适应我国社会发展和国际交流的需要”，并提出：“将综合英语类、语言技能类、语言应用类、语言文化类和专业英语类等必修课程和选修课程有机结合，确保不同层次的学生在英语应用能力方面得到充分的训练和提高。”《大学英语课程教学要求》明确要求大学英语教学中开设选修课，以满足大学生的实际需求。

依据《大学英语课程教学要求》，上海外语教育出版社邀请国内外英语教学专家开发编写了选修教材，通过教材的出版引领、促进了大学英语选修课程设置的发展，丰富了我国大学英语教学。这些教材品种丰富，涵盖面广，包括以下多个系列：大学英语应用提高阶段专业英语系列教材、大学英语综合应用能力选修课系列教材、职场英语选修教程系列、大学目标英语、牛津专业英语基础丛书等。这些年来，全国数百所高校使用了这些教材，部分老师对教材的内容和编写形式提出了宝贵的建议，为我们进一步完善教材提供了实践依据。

虽然很多高校多年来一直尝试开设选修课，专家学者也进行了理论研究，但目前此类课程在大学英语教学中所占比重并不大，仍处于探索阶段。多数教学专家对大学英语选修课程的具体教学目标和教学内容范围未形成统一认识，教育主管部门亦未出台具体的选修课教学要求。为了进一步推动大学英语选修课教学的发展，外教社在多年选修课教材使用情况调研的基础上，结合专家学者的最新研究成果和建议，充分考虑我国目前的大学英语教学现状、师资条件、实际需求等因素，重新策划编写了“大学英语拓展课程系列”，该系列教材包括EAP、ESP和EOP三个子系列。

- EAP（English for Academic Purposes）
  学术英语类，侧重高级水平英语听、说、读、写、译等技能的培养，为大学生出国留学、攻读研究生、进行科研等学术活动打下更扎实的英语基础。此类课程包括：演讲听说、跨文化交际、文学赏析、学术英语写作等。适合需要继续在学术上深造的大学生使用。

- ESP（English for Specific Purposes）
  专业英语类，侧重提升专业英语能力，在培养学生听、说、读、写、译等基本语言技能的基础上，教授与该专业相关的英语词汇和表达，并尽可能传授专业知识，以使大学生轻松通过英语媒介获取本专业知识和信息。此类课程适合相关专业学生学习，针对性强。

- EOP（English for Occupational Purposes）
  职场英语类，侧重提升职场英语能力，为大学生将来在英语环境中工作打下扎实的职场交际基本功。此类课程多数适合所有大学生使用，有部分教程与专业结合，适合相应专业学生使用。

除了重新修订已出版的教材外，我们还通过邀请更多海内外英语教学专家参与编写、和国外出版社合作出版等方式，扩大本系列教材的选题规模，以满足各专业大学生的学习需求。本系列教材具有时代感强、实用性强、课堂可操作性强等特点，相信会给我国大学英语教学带来新风向。

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目　录

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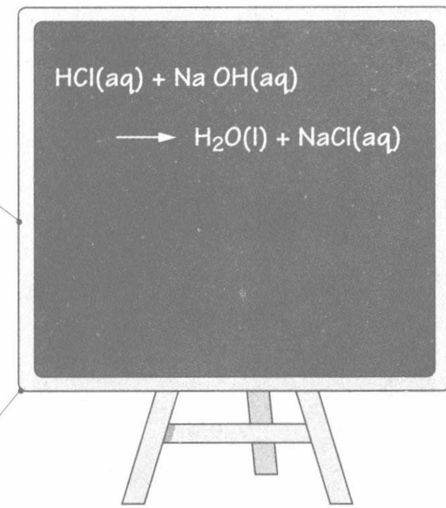
Quantitative chemistry is about chemical equations and what they tell you in terms of the amounts of reactants used up and products made



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.*

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:

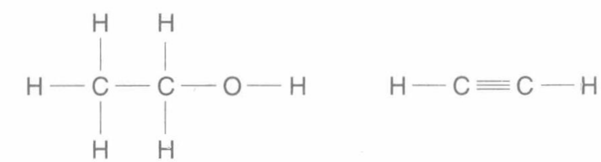
DIFFERENT KINDS OF FORMULA

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.

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.

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

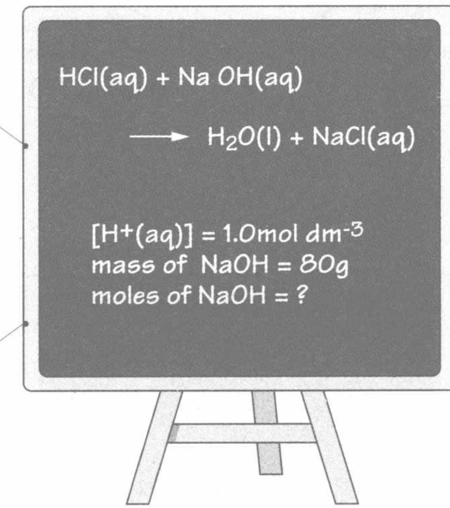
This equation tells us that 2 moles of magnesium react with 1 mole of oxygen molecules to make 1 mole of magnesium oxide.

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.

SAMPLE —apply energy→ EXCITED SAMPLE —energy given out→ SAMPLE

- apply energy ⇩ see what wavelengths are absorbed: ABSORPTION SPECTRA
- energy given out ⇩ 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

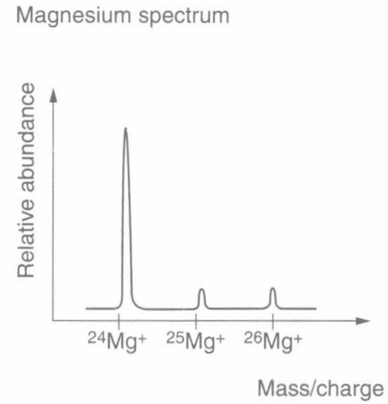
THE EXPERIMENTAL SET-UP

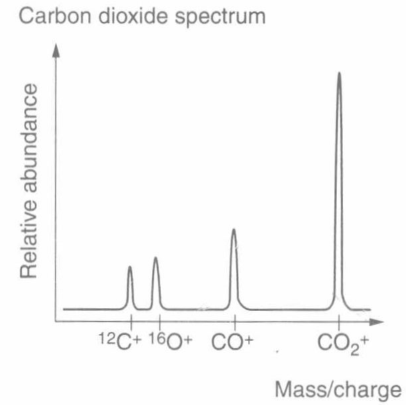
A gaseous sample is hit by an electron beam which knocks electrons off the particles making them into positive ions:

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

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.

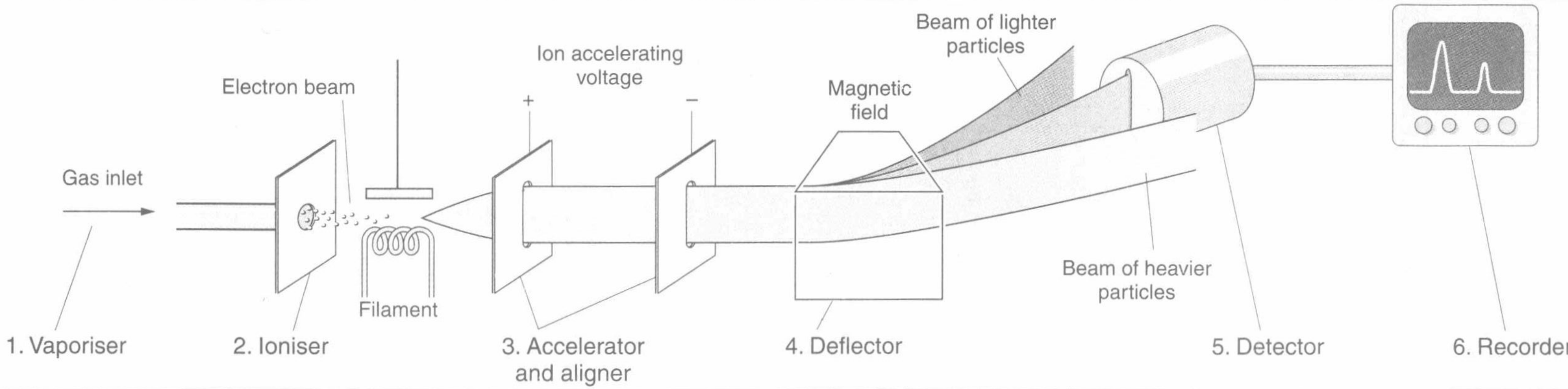
THE SPECTRUM





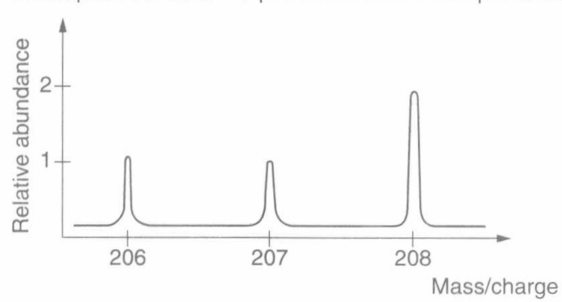
The spectrum for elements shows a different peak for each isotope. The height of the peak indicates the amount of each isotope.

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

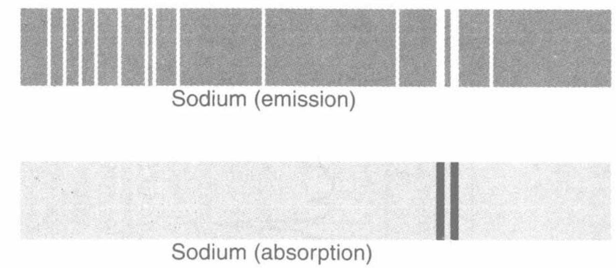
Emission spectra. A gaseous sample is excited with electrical or thermal energy. Ultraviolet or visible radiation is given out; this is focused into a beam and then split by a prism or diffraction grating; the radiation is then viewed through the telescope or detected photographically.

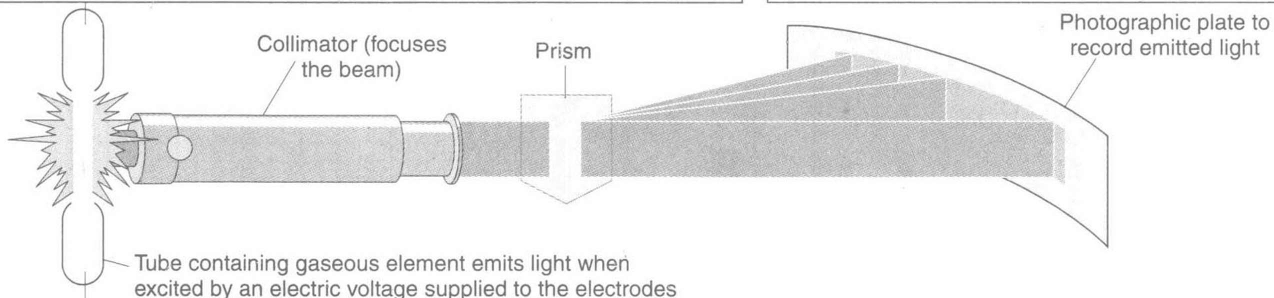
Absorption spectra. White light from a lamp is directed through a gaseous sample of the substance.

The spectrum

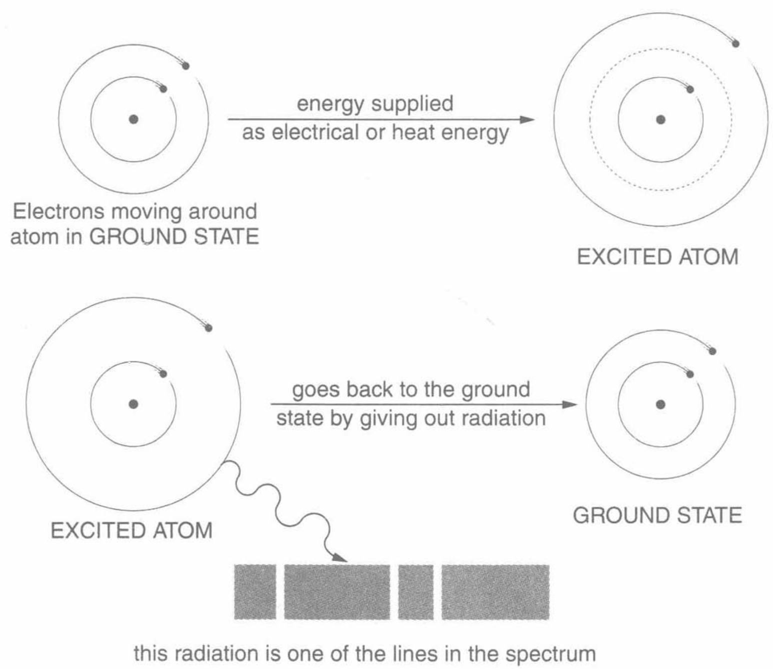
The spectrum produced differs from the normal spectrum of white light in two ways:

(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

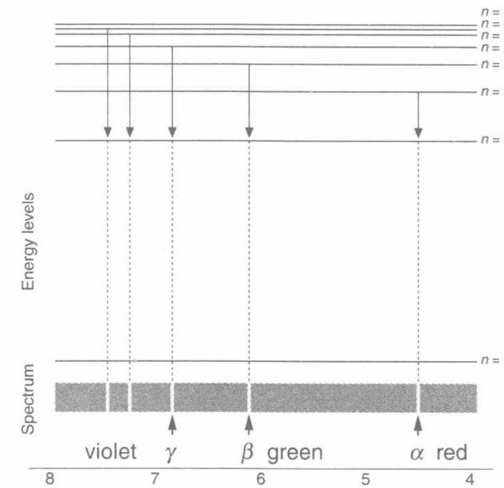


Electrons in an atom are each in a particular energy level. When a sample is excited, electrons in the atom take in the extra energy by either moving faster or moving out, away from the nucleus. So they move to a higher energy level. Sometime later, the energy is given out as radiation as the electrons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