The atom and the periodic table

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All substances are made of atoms. An atom is the smallest part of an element that can exist. Atoms of each element are represented by a chemical symbol, eg 'O' represents an atom of oxygen. There are about 100 different elements. Elements are shown in the periodic table. Compounds are formed from elements by chemical reactions. Chemical reactions always involve the formation of one or more new substances, and often involve a detectable energy change. Compounds contain two or more elements chemically combined in fixed proportions and can be represented by formulae using the symbols of the atoms from which they were formed. Compounds can only be separated into elements by chemical reactions. Chemical reactions can be represented by word equations or equations using symbols and formulae.	96-99	96-99	12-15	1
A mixture consists of two or more elements or compounds not chemically combined together. The chemical properties of each substance in the mixture are unchanged. Mixtures can be separated by physical processes such as filtration, crystallisation, simple distillation, fractional distillation and chromatography. These physical processes do not involve chemical reactions and no new substances are made.	100-103	100-102	16-18	1
New experimental evidence may lead to a scientific model being changed or replaced. Before the discovery of the electron, atoms were thought to be tiny spheres that could not be divided. The discovery of the electron led to the plum-pudding model of the atom. The plum-pudding model suggested that the atom was a ball of positive charge with negative electrons embedded in it. The results from the alpha particle scattering experiment led to the plum-pudding model being replaced by the nuclear model. Niels Bohr adapted the nuclear model by suggesting that electrons orbit the nucleus at specific distances. The theoretical calculations of Bohr agreed with experimental observations.	104-105	103-104	19-20	1

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Later experiments led to the idea that the positive charge of any nucleus could be subdivided into a whole number of smaller particles, each particle having the same amount of positive charge. The name proton was given to these particles.

The experimental work of James Chadwick provided the evidence to show the existence of neutrons within the nucleus.

The relative electrical charge of particles in atoms is:

<table>
<tr><th>Name of particle</th><th>Relative charge</th></tr>
<tr><td>Proton</td><td>+1</td></tr>
<tr><td>Neutron</td><td>0</td></tr>
<tr><td>Electron</td><td>-1</td></tr>
</table>

In an atom, the number of electrons is equal to the number of protons in the nucleus. Atoms have no overall electrical charge.

The number of protons in an atom of an element is its atomic number. All atoms of a particular element have the same number of protons.
Atoms of different elements have different numbers of protons.
</td>
<td>96</td>
<td>96</td>
<td>12</td>
<td>1</td>
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Atoms are very small, having a radius of about 0.1 nm (1 x 10^{-10} m).
The radius of a nucleus is less than 1/10 000 of that of the atom (about 1 x 10^{-14} m).

Most of the mass of an atom is in the nucleus.
The relative masses of protons, neutrons and electrons are:

<table>
<tr><th>Name of particle</th><th>Relative mass</th></tr>
<tr><td>Proton</td><td>1</td></tr>
<tr><td>Neutron</td><td>1</td></tr>
<tr><td>Electron</td><td>Very small</td></tr>
</table>

The sum of the protons and neutrons in an atom is its mass number.

Atoms of the same element can have different numbers of neutrons; these atoms are called isotopes of that element.

Atoms can be represented as shown in this example:
$$^{(Mass\ no.)\ \ 23}_{\ \ \ \ Na}$$
$$_{(Atomic\ no.)\ 11}$$
</td>
<td>96</td>
<td>96</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>The relative atomic mass of an element is an average value that takes account of the abundance of the isotopes of the element.</td>
<td>96-96</td>
<td>96-97</td>
<td>12-13</td>
<td>1</td>
</tr>
</table>

Before the discovery of protons, neutrons and electrons scientists attempted to classify the elements by arranging them in order of their atomic weights. The early periodic tables were incomplete and some elements were placed in inappropriate groups if the strict order of atomic weights was followed. Mendeleev overcame some of the problems by leaving gaps for elements that he thought had not been discovered and in some places changed the order based on atomic weights. Elements with properties predicted by Mendeleev were discovered and filled the gaps. Knowledge of isotopes made it possible to explain why the order based on atomic weights was not always correct. Elements that react to form positive ions are metals. Elements that react to form negative ions are non-metals. The majority of elements are metals. Metals are found to the left and towards the bottom of the periodic table. Non-metals are found towards the right and top of the periodic table.	106-107	105-106	21-22	1
The elements in Group 0 of the periodic table are called the noble gases. They are unreactive and do not easily form molecules because their atoms have stable arrangements of electrons. The noble gases have eight electrons in their outer energy level, except for helium, which has only two electrons. The boiling points of the noble gases increase with increasing relative atomic mass (going down the group).	111	110	26	1
The elements in Group 1 of the periodic table are known as the alkali metals and have characteristic properties because of the single electron in their outer shell.: In Group 1, the reactivity of the elements increases going down the group.	109	108	24	1
The elements in Group 7 of the periodic table are known as the halogens and have similar reactions because they all have seven electrons in their outer shell. The halogens are non-metals and consist of molecules made of pairs of atoms. In Group 7, the further down the group an element is, the higher its relative molecular mass, melting point and boiling point. In Group 7, the reactivity of the elements decreases going down the group. A more reactive halogen can displace a less reactive halogen from an aqueous solution of its salt.	110	109	25	1