**01. Chemistry and the body**

Chemistry is the study of matter - what it is, how it behaves, and how it changes. All matter is made of tiny particles called atoms. Atoms are the fundamental building blocks of life.

Atoms are all around us; in the air we breathe, the houses we live in, the clothes we wear, the food we eat and even the water we drink. In fact, the world and everything in it, including the human body, is made up of atoms.

**TOPIC 1: THE STRUCTURE OF THE ATOM**

**THE ATOM**

An atom is a particle of matter. It is the smallest particle of matter that exists in a stable form. The different types of matter that atoms make are called the chemical elements. Elements, such as carbon, iron, oxygen and hydrogen, are made of only one type of atom, and the atom uniquely defines that element. The atom of an element also determines the characteristics - how it behaves when it is on its own and when it comes into contact with other elements.

The human body is formed largely of four elements: carbon, hydrogen, oxygen and nitrogen. These elements are taken into the body by breathing, drinking and eating.

Different elements are represented by different letters. Carbon is C, hydrogen H, oxygen O, and sodium Na.

**SUB-ATOMIC PARTICLES**

Atoms are themselves made up of smaller particles called protons, electrons and neutrons. Protons carry a positive electrical charge, electrons carry a negative electrical charge and neutrons carry no electrical charge at all. Because they have opposite charges, the positively charged protons, and negatively charged electrons are drawn together. In an atom, there are equal numbers of protons and electrons, leaving atoms electrically neutral overall.

**The nucleus**

The protons and neutrons cluster together in the central part of the atom, called the nucleus. Each element has a different number of protons in the nucleus of its atoms. The different number of protons in the nucleus determines what element the atom forms. It also gives the atomic number. A carbon atom, for example, has six protons in its nucleus, and its atomic number is 6.

**Electrons**

A good way to visualise the structure of the atom is to think of the electrons orbiting around the nucleus in a number of concentric circles. Each circle can only hold a certain number of electrons before it becomes full. The innermost circle can hold a maximum of two electrons, the second circle a maximum of eight electrons, and the subsequent circles are each able to hold increasing numbers of electrons. However, there are never more than 32 electrons orbiting around the nucleus in the atom outermost circle.

**TOPIC 2: MOLECULES AND COMPOUNDS**

**REACTIVE AND UNREACTIVE ELEMENTS**

Atoms can react and combine with one another to produce molecules and compounds. The body uses molecules and compounds to maintain its systems and their functions.

We know that the atoms of each element have a specific number of electrons circling around the nucleus. When the number of electrons in the outermost circle of an atom is either the maximum number allowed in that circle, or a whole fraction of this number, the element is described as chemically unreactive, or inert i.e. it will not combine with other elements.

An atom is reactive when it does not have a full or stable number of electrons in its outer circle. It may therefore donate, receive or share electrons with one or more other atoms to make itself stable.

**WHAT IS A MOLECULE?**

When two or more reactive atoms donate and receive, or share electrons in their outer circles they join together to form a molecule. Some molecules are made from atoms of the same element; for example, a molecule of oxygen in the air we breathe (O2) is formed when two oxygen atoms are joined together. Other molecules are made from two or more different elements. For example, a water molecule (H2O) consists of two hydrogen atoms and an oxygen atom.

**ORGANIC AND INORGANIC COMPOUNDS**

When different elements join together as a molecule the substance formed is called a compound.

Compounds are divided into two groups, inorganic and organic compounds. The primary difference between inorganic and organic compounds is that organic compounds contain carbon while inorganic compounds do not. The human body requires both types of compound to function effectively.

**Inorganic compounds**

These are small compounds such as water, sodium chloride, and ammonia. Sodium chloride is made of one sodium atom and one chlorine atom, and its general name is salt. In the human body, water and salt are required for fluid balance and for many activities of cells. Ammonia is made of one nitrogen atom and three hydrogen atoms (NH3). It is used by the liver to produce urea, which is essential for the excretion of waste.

**Organic compounds**

Organic compounds are more complicated groups of several elements. One of the elements in the group is always carbon. Organic compounds are vital for life. Carbohydrates (sugars) in food are composed of carbon, hydrogen and oxygen and provide energy for the body. Lipids (fats) are compounds of the same three elements and are used by the body to store energy and form the membrane of cells.

**HOW DO ATOMS JOIN TOGETHER?**

* **Covalent bonds**

When atoms share electrons to form molecules and compounds, that sharing is called a covalent bond. Most molecules are held together with this type of bond, which forms a strong link between the atoms. The hydrogen and oxygen atoms in a water molecule are joined together by covalent bonds. The two hydrogen atoms each have one electron circling around the nucleus. The maximum number of electrons allowed in this circle is two, so each hydrogen atom gives itself the full number of electrons by sharing an electron with the oxygen atom. An atom of oxygen has two circles of electrons with six electrons in its second, outermost circle. The maximum number of electrons in the second circle is eight. By sharing the electrons with the two hydrogen atoms the oxygen outer circle of electrons is now eight and therefore complete.

* **Ionic bonds**

When an atom donates an electron to another atom, the resulting compound has an ionic bond. For example, the one electron in the outer electron circle of a sodium atom can be donated to the seven electrons in the outer circle of a chlorine atom. Because the sodium atom has lost an electron and the chlorine atom has gained an electron, the number of electrons and protons in each atom is no longer equal and the atoms are now charged. By losing an electron, sodium is positively charged. Because it has gained an electron, chlorine becomes negatively charged. In this charged state the atom is called an ion. These oppositely charged elements, or ions, attract each other and form an ionic bond. The resulting compound, sodium chloride, is electrically neutral overall. Ionic bonds are weaker than covalent bonds and break apart more easily.

**ANIONS, CATIONS AND ELECTROLYTES**

When a compound with ionic bonds is put in water, the bond between the atoms breaks and they separate. Because the atoms are now electrically charged, the water contains charged ions rather than neutral particles. A negatively charged ion is called an anion, and a positively charged ion

is called a cation. The solution can now conduct electricity and it is called an electrolyte. The presence of electrolytes in the body enable electrical signals to be conducted along the nerve cell, and are also necessary for the function of muscles.

**TOPIC 3: ACIDS ALKALIS AND THE pH SCALE**

**HOW ACIDS AND ALKALIS ARE FORMED**

The amount of hydrogen ions (depicted as H+) in a solution determines its acidity. The amount of hydrogen ions present is called the potential hydrogen, or pH. Acid substances release hydrogen ions when in solution, whereas an alkaline substance will accept hydrogen ions and lower the amount.

**THE pH SCALE**

The pH scale measures how acidic or alkaline a substance is. The scale ranges from 0 to 14, the midpoint being neutral.

A pH reading below 7 indicates an acid solution, while readings above 7 indicate alkalinity. A pH of 7 is neutral A neutral substance (such as water) is neither acidic nor alkaline. Each whole pH value below 7 is ten times more acidic than the next higher value. For example, pH 4 is ten times more acidic than pH 5 and 100 times (1O times 10) more acidic than pH 6. The same holds true for pH values above 7, each of which is ten times more alkaline than the next lower whole value. For example, pH 10 is ten times more alkaline than pH 9 and 100 times more alkaline than pH 8.

**pH VALUES IN THE BODY**

A key factor in maintaining the stable internal environment is the control of hydrogen ion levels in body fluids. If the pH is not correctly balanced, systems and organs cannot function effectively or assimilate essential nutrients in food. The body contains defences to keep the pH of fluids within narrow ranges. These defences, or buffers, are themselves weak acids and alkalis. The alkalis accept hydrogen ions if the fluid becomes too acidic, and the acids release hydrogen ions when it is too alkaline. In addition, electrolytes help to maintain the levels of water in the body and resist pH changes.

**The pH scale**

* **Blood:** blood has a pH of approximately 7.4, which is very slightly alkaline. This near neutral level must be maintained to prevent damage to tissues in the body that can be caused by levels at either end of the pH scale.

* **Saliva:** the pH of saliva is between 6.2-7.4. With this pH the saliva can begin the process of the digestion of starches in food. A higher acidity would cause damage to minerals in the teeth.
* **Gastric juice:** gastric juice in the stomach has a pH between 1.5 and 3.5. This highly acid pH destroys harmful bacteria that may be present in food. When stomach acid gets beyond the protective sphincter in the oesophagus, heartburn and a sour taste may be experienced. The burning sensation is caused by acidic damage to the tissue in the oesophagus.

**Summary**

Chemistry and the body:

* The human body is made of atoms with common properties called elements
* Atomic elements join together to form compounds: the body uses and breaks apart these compounds to perform its functions
* When in solution some atoms make acids and alkalis: these are vital for the stability of body systems.