Teacher Notes

Chemistry of Swimming

Sport: Swimming

Age group: 14 - 16

These notes are designed as a guide on how to lead the session, and are written in a script format. If you wish to lead the session in a different way please feel free to do so.

The **red text** indicates what each slide includes, while the **blue text** highlights the key points being discussed in each slide. The **owl symbol** demonstrates where students are required to perform a task (eg questions, experiment, etc). These are used to help you observe the students learning and recap any information which the students have found difficult to understand.

Depending on the level of student understanding this module may require two lessons to complete.

Slide 1

Opening slide containing an action picture of swimming, visually introducing the sport.

Slide 2

An introduction to the sports held in the swimming pool, including a brief history of competitions.

Drawings of people swimming date back to the Stone Age, where it would have been used as a survival mechanism.

As people developed their ability and technique, a swimming competition naturally followed. It was the Ancient Greeks who first practiced swimming as a sport, often building swimming pools at their public baths. However, swimming was not a sport in the ancient Olympic Games.

At first there were endurance contests which were used to determine peoples' stature. An example of this was in Japan where swimming was one of the noble skills of the Samurai and during the Middle Ages; swimming in armour was one of the seven agilities knight's had to accomplish

Swimming was one of only 5 sports competed in at the first Modern Olympic Games in 1896. Up until the Games held in London in 1912 the swimming events were held in open bodies of water. such an example was the River Seine for the 1900 Olympic Games held in Paris.

A variety of unusual events have been present in the Olympic Games including underwater swimming (1900), 200 m obstacle swimming (1900) and plunge for distance (1904)! However, in 1908 rules were established and the more commonly known events were determined.

Swimming is not the only sport which takes place in the pools during the Olympic Games. Sports including water polo, diving and synchronized swimming also take place in the pool. As recently as Sydney 2000 new events have been added to the pool programme; these were women's water polo and synchronized diving.

Slide 3

Linking swimming to chlorine and introduction to the halogen group.

Probably the most recognised link between swimming pools and chemistry is the element chlorine. It is associated with the 'chlorine' smell many people have experienced at the swimming pool. At the end of the module we will learn how chlorine is actually used in pools but before that we will look at chlorine and the periodic group it belongs to. We will also start to explore electron configurations and ionic bonding.

Chlorine is a halogen and is in group 7 of the Periodic Table. Other halogens that are commonly encountered are fluorine, bromine and iodine. The table below compares the appearances of these four elements at room temperature.

Halogen	Appearance
Fluorine, F	Pale yellow gas
Chlorine, Cl	Yellowy green gas
Bromine, Br	Reddish brown volatile liquid
Iodine, I	Dark grey/purple crystalline solid

The halogens are regularly found in molecular form. An example of this is fluorine gas, F_2. The two fluorine atoms are bonded covalently and share a pair of electrons in their outer energy level or shell.

Slide 4

Halogen and metal bonding to form salts using sodium and chlorine as the example.

The halogens form ionic compounds with metal elements, an example of which is sodium chloride. Halogens react with metals to form salts - the name 'halogen' means salt producer. Chlorine forms chlorides, bromine forms bromides and iodine forms iodides. Ionic compounds are produced through ionic bonding. Ionic bonding occurs when a bond is formed between 2 atoms, one losing an electron and the other gaining that electron. One atom will thus become a positive ion and the other a negative ion. Group 1 elements, such as sodium, will lose one electron when they react to form a positive ion. In sodium's case this would be written as Na^+. The halogens gain an electron where possible and become negative ions. In chlorine's case this would be written as Cl^-. As group 1 elements lose an electron and group 7 elements gain an electron it stands to reason that these elements regularly form ionic bonds with each other. Halogens also react with other metals and another example is the reaction between chlorine and iron.

$$2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3$$

$$\text{iron + chlorine} \longrightarrow \text{iron(III) chloride.}$$

Distribute the 'student handout worksheet' and allocate 10 minutes for the student to attempt the questions on the worksheet. The questions are related to the first four slides.

Slide 5 - 6 Answers to worksheet

Using these two slides go through the answers with the students. Recap any areas which students have particularly struggled with to ensure learning takes place.

Slide 7 & 8

Introduction to energy levels.

This includes extension material which will require an advanced level of understanding by students and may not be suitable for all abilities.

Why do some elements lose electrons and some gain electrons to form ionic compounds? The answer to this question lies in understanding energy levels which surround the nucleus of an atom. Every atom consists of protons, neutrons and electrons - except hydrogen which is a special case as it does not have any neutrons. The nucleus of the atom is made up of the protons and neutrons but the electrons reside in what are known as energy levels. (These energy levels are sometimes known as shells). The electrons move around the nucleus extremely rapidly in these energy levels. Each energy level can only hold a specific number of electrons.

- The first energy level can hold 2 electrons

  (Once this level is full electrons start to fill the second energy level)

- The second energy level can hold 8 electrons

  (The second energy level is filled after the first energy level but before the third energy level)

- The third energy level can hold 18 electrons

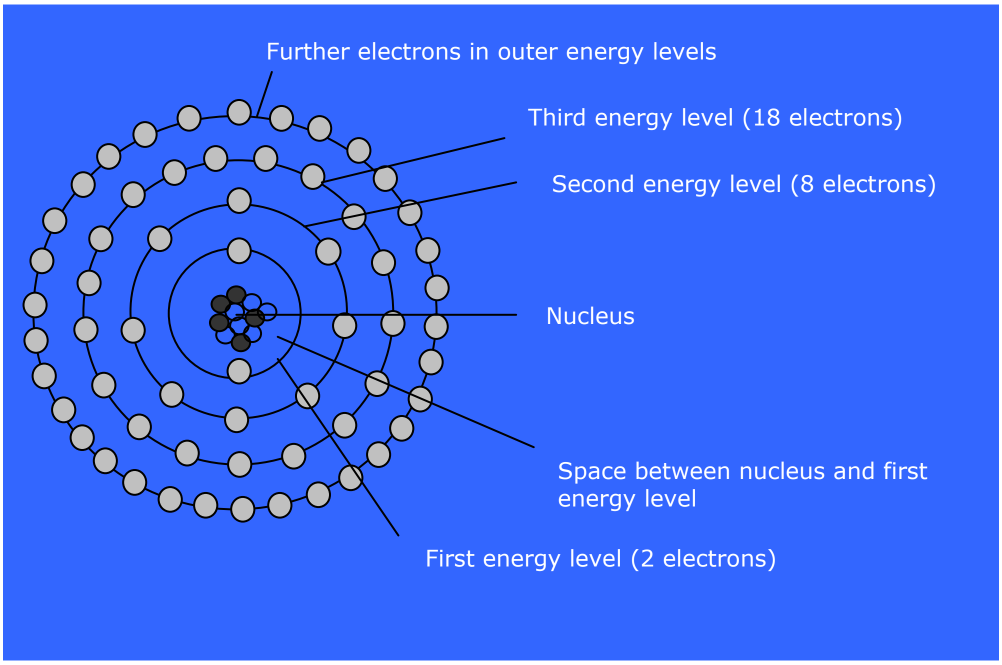
  (When the third energy level contains 8 electrons there is some degree of stability and the next 2 electrons go into the fourth energy level, following which any further electrons then go back into the third energy level until this contains the maximum 18 electrons.

Table 2 (on slide 6) shows the number of protons, neutrons and electrons in the principal isotopes (the most commonly found forms of the atoms) of the first 20 elements. The arrangement of electrons 2,8,3 denotes 2 electrons in the first energy level, 8 in the second and 3 in the third. This is known as the electron arrangement or electron configuration of the atom.

Slide 9 Energy levels continued

Figure 1 shows the energy levels surrounding a nucleus. The atom is unidentified but the first 3 energy levels are complete:

Figure 1



Slide 10 - 11

Slide 9 Table showing atomic number, mass number, breakdown of protons, neutrons and electrons and also the electron arrangement of the first 20 elements

Element	Atomic number	Mass number	Number of			Electron arrangement
			p	n	e	
Hydrogen	1	1	1	0	1	1
Helium	2	4	2	2	2	2
Lithium	3	7	3	4	3	2,1
Beryllium	4	9	4	5	4	2,2
Boron	5	11	5	6	5	2,3
Carbon	6	12	6	6	6	2,4
Nitrogen	7	14	7	7	7	2,5
Oxygen	8	16	8	8	8	2,6
Fluorine	9	19	9	10	9	2,7
Neon	10	20	10	10	10	2,8
Sodium	11	23	11	12	11	2,8,1
Magnesium	12	24	12	12	12	2,8,2
Aluminium	13	27	13	14	13	2,8,3
Silicon	14	28	14	14	14	2,8,4
Phosphorus	15	31	15	16	15	2,8,5
Sulfur	16	32	16	16	16	2,8,6
Chlorine	17	35	17	18	17	2,8,7
Argon	18	40	18	22	18	2,8,8
Potassium	19	39	19	20	19	2,8,8,1
Calcium	20	40	20	20	20	2,8,8,2

Slide 10
Explanation of ionic bonding with diagram of electron movement between a sodium and a chlorine atom in the formation of sodium chloride.

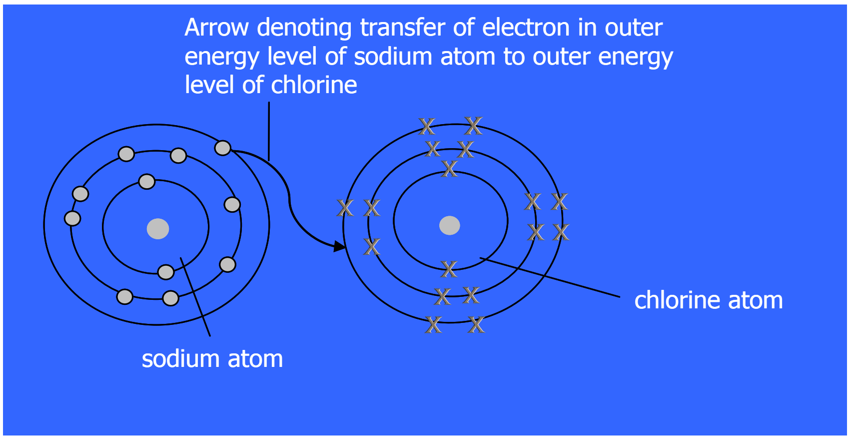
It is not essential to learn the table as it is possible to work out the information it contains from the Periodic Table as long as you know the atomic number and mass number of the element.

Notice the 2 highlighted elements in the table, fluorine and chlorine, the first 2 elements of the halogen series. Their outer energy levels are both one electron short of being full. Fluorine's electron arrangement is 2,7 a full second energy level would have 8 electrons in it. Chlorine's electron arrangement is 2,8,7 – notice the 7 electrons in the third energy level. Although the third energy level can hold a maximum of 18 electrons it has a degree of stability at 8 electrons, thus the 7 electrons present in the third energy level of chlorine is one short of the stable 8 arrangement.

For both fluorine and chlorine the gain of an extra electron would allow stability in the outer energy levels to be reached. They will both therefore readily accept electrons from other atoms. Group 1 elements have 1 electron in their outer energy levels and thus, for stability reasons, readily lose that electron to other atoms. This is why group 1 elements readily form ionic bonds with group 7 elements, seeking electrons, such as chlorine.

The ionic bonding between sodium and chlorine is shown in the diagram on the next page. It is important to show that there has been a complete transfer of the electrons in ionic bonding, these electrons are not shared or swapped! It is also important not to talk of a sodium chloride molecule as this would assume that one sodium ion has joined with one chloride ion. Sodium chloride is, in fact, a giant ionic structure.

Diagram showing the electron transfer between a sodium atom and a chlorine atom in the formation of sodium chloride



Slide 12

The use of chlorine in a pool environment. A brief look at chloroamines

Chlorine, probably the most recognised of the halogens, is commonly associated with swimming pools. People believe that there is a 'chlorine' smell at the swimming pool which is often found to be quite unpleasant. Chlorine is used at the swimming pool as a sanitiser. It is used to kill harmful germs and bacteria. Chlorine can be delivered to the water in several forms but rarely is it pumped in as a gas. When chlorine (Cl_2) is added to water the following disproportionation reaction occurs:

$$Cl_2(aq) + H_2O(l) \longrightarrow HOCl(aq) + HCl(aq)$$

HOCl is called chloric(I) acid and is the main sanitising agent found in pool water. This isn't normally introduced into the pool water as pure chlorine as indicated by the equation. It is more commonly added to the water in the form of sodium or calcium hypochlorite. The compound is unstable and easily dissociates in water to form the desired HOCl or 'free chlorine'.

It is this 'free chlorine' that can then break down bacteria by entering the cell wall and disrupting protein and enzyme functions. Chloric(I) acid also reacts with ammonia, something present in both sweat and urine, to form chloroamines.

It is in fact dichloroamine that has the disagreeable taste and odour - that familiar 'chlorine' smell of swimming pools. In order to remove the smell the chloroamines need to be broken down. This is done by adding more chlorine.

This is known as shock treatment where a large dose of free chlorine is added to break down unwanted compounds such as the chloroamines and leave a slight excess of chlorine. Interestingly, the smell that many people find unpleasant at swimming pools and attribute to there being too much chlorine present is actually caused by there being too little chlorine in the water. It is the excess amounts of dichloroamine causing the smell and by adding more chlorine this would be broken down and thus the smell would be removed!

Distribute the 'student revision handout' and allocate 30 minutes for the student to attempt questions on the worksheet. This could be set as homework. The questions are related to whole module.

Slides 13 - 17

Go through the answers to the revision questions with the students with the use of these two slides. Any areas which students have particularly struggled recap to ensure learning takes place.