# Teacher Notes:

## Sport & Water – the chemistry of solutions

**Sport: Water sports - mixed**

**Age group: 11-14**

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. Contains title of session and visual introduction to sport on and in water.

The first slide provides the title of the session.

The objectives for the session are for students to:

- Be able to describe what a solution is
- Explain when a solution is fully saturated
- Explain why an object will float, sink or be partially submerged in a solution

### Slides 2 & 3 – Introduction to a range of water sports

A brief introduction to a range of water sports, with emphasis on open water swimming.

Water sports, or at least activities in and on water, have existed for as long as human beings have, in one shape or another, but it is only more recently that they have become the ruled competitions that they are now.

Swimming – the most recognisable of all water sports has been an activity that was part of daily life for our ancestors and was popular with the Romans and Ancient Greeks. Swimming wasn't part of the Ancient Olympic Games however, as all of these events were land based.

Swimming, as a sport, was not widely practised until the early 19$^{th}$ century. Around this time the National Swimming Society of Great Britain was founded, organising the first competitions in 1837. The sport has been held in the Modern Summer Olympic Games since 1896, although it has seen many changes since its introduction. At the Summer Olympic Games in Athens in 1896 all the swimming events took place in the sea. At the 1900 Summer Olympic Games in Paris, the swimming events took place in the river Seine. It was not until the Summer Olympic Games of 1908, in London, that events moved to the pool. The pool was 100 m long. 100 years later, at the Beijing Olympic Games, a swimming event again returned to the open water with the introduction of the 10km open water event. (Swimming in open water was also included in the Summer Olympic Games in Sydney in 2000 and Athens 2004, as part of the triathlon event).

Open water swimming is considered to be harder than swimming in a swimming pool because the participants have to cope with weather conditions, currents, tides and in certain places, such as lakes and seas, have to swim in water that has significant amounts of substances dissolved and suspended in them. These factors coupled with the water normally being of a lower temperature and poorer visibility, than that in the heated and cleaned pools, means many people consider open water swimming to be far more challenging than pool swimming.

Many other sports also take place on or in water including; sailing, rowing, water polo, diving, water skiing, scuba diving, windsurfing, surfing and synchronised swimming to name a few. Water and some of its properties allow many of these sports to operate in the way that they do but there is much more to the water, especially in lakes and seas, than we may realise and this module will explore some of the interesting properties that water has and how this can affect the sports that take place on or in it.

### Slides 4 & 5 – The link between water sports and chemistry

The link between chemistry and sports in water through introducing the topic of solutions.

State is also revised briefly.

Having mentioned some of the many water sports that exist, it may be unclear where the link between chemistry and water sports can be found. Although many of the sports are filled with chemistry and the advances science has brought to the sports, through the development of specialised equipment to improve performance and even the use of chlorine in swimming pools to keep them safe from harmful bacteria and germs, it is in fact the water or 'solution' itself that this module will be exploring.

As we know, substances can be classified into three states – solids, liquids and gases. Using water as our example the three states we find it in are as a solid - ice, a liquid – water, or the gaseous state which is water vapour or steam. The state of a substance is dependant on the temperature of the environment the substance is in and the pressure being exerted on that substance.

**Key Point**
When something is considered to be under normal conditions then the pressure is normal atmospheric pressure and the temperature of the surrounding environment is 'room temperature' – normally 25 °C.

Commonly when we think of a substance, it is under normal conditions, i.e. normal atmospheric pressure and room temperature. If someone asked you to think of water you would, no doubt, think of it in its normal state as a clear liquid, as this is how we encounter it during our everyday lives.

It is possible to dissolve a solid substance in a liquid which gives the affect of changing that substances state. Using the sea as the biggest liquid, or more accurately solution, source in the World we can explore some of the chemistry and science behind solutions and perhaps explain why water sports can be affected by some of this science.

## Slide 6 – Definitions associated with solutions

Definitions associated with liquids/solutions.

**Key Points:**
When a liquid has a substance dissolved in it, it is known as a **solution**.
The dissolved substance is the **substrate**, the liquid dissolving that substrate is the **solvent**.

To explore the effects of some of the properties of liquids and solutions on our water sports, we first need to examine some definitions associated with liquids. Water, our most common liquid, can help us illustrate some of these terms.

When water is in its purest form it is a completely clear liquid made up of only water molecules, containing two hydrogen atoms and one oxygen atom chemically bonded together. These molecules are held together through attractive forces between each other known as hydrogen bonds. These bonds are not as strong as ionic or covalent bonds but are strong enough to give the water its flowing property. Water is tasteless and does not smell.

Sea water is not pure, in fact it has thousands of different substances dissolved and suspended in it. When a liquid has a substance dissolved in it it is known as a **solution**. The substance dissolved in the solution is known as the **substrate** and the liquid within which that substance has dissolved is known as the **solvent.** Water is the most common solvent in the world and is often referred to as the **universal solvent**.

## Slide 7 – Salt and sea water

A brief look at salts with a chemical definition before a closer look at common salt.

**Key Point**
Common salt, used in cooking and found in the sea is sodium chloride (NaCl).

Sea water is 'salty' as it has a large amount of salts dissolved in it. The actual definition of a salt, in chemistry, is the product formed from the neutralisation reaction of acids and bases. When salts are dissolved in water they are called electrolytes. These solutions can conduct electricity, a property shared with molten salts. Common salt, which is found in cooking, is sodium chloride (NaCl), this can also be found in abundance in the seas of the World, although there are hundreds of other salts also present.

So a liquid becomes a solution when it has a substance or substances dissolved in it.

**Possible Experiment – Resources needed: Salt, sand, beaker, water, spoon. (Instructions on experiment in body of text below)**

## Slide 8 – Dissolving substances in a liquid

An introduction behind the terms associated with dissolving substances in a liquid.

**Key Point**
When no more substrate will dissolve in a solvent the solution is **fully saturated** and is known as a **saturated solution**.

Substances which will dissolve in a solvent are known as **soluble**, ones that won't dissolve are known as **insoluble**.

A simple experiment that you can do to make a solution is to take a beaker, or glass, of water and add a table spoon of salt to it. Stir the water until all the salt has dissolved. The salt looks as though it has disappeared. Keep repeating this one table spoon at a time. Eventually you will notice that a point is reached where no more salt will dissolve. The solution may appear cloudy for a short time but if left the solution will become clear and the salt which will not dissolve will form a layer at the bottom of the glass or beaker. The water cannot dissolve anymore salt and is known to be **fully saturated**. The solution is called a **saturated solution**.

Not all solids dissolve. If you were to carry out the same experiment but use sand instead of salt you will notice that no sand dissolves. When a substance dissolves it is said to be **soluble**, when a substance does not dissolve it is said to be **insoluble**. Some substances dissolve very quickly, others may take a far greater amount of time. The amount of time it takes for a substance to dissolve can be affected by temperature. This is because when a solid dissolves, the regular arrangement of particles breaks down and these particles spread out amongst the solution. The particles fill the spaces between the molecules making up the solution. If heat is added to the solvent the solid is dissolving in, more energy is given to the dissolving particles and so they move faster (spread out faster) and thus dissolve in a shorter time.

## Slides 9 - 11 – Exploring solutions and their physical properties

These slides are used to explore density and how the saturation of a liquid affects this.

**Key Point**
The higher the level of saturation of a solution the more dense that solution is.

Having now examined the terms associated with liquids and solutions how does this relate to water sports? In general terms, when a substance is dissolved or suspended in a solution the solution has the properties of being slightly thicker. (In fact the solution has become denser). An object moving through a liquid encounters resistance, the force the liquid applies on the object moving through that liquid opposite to the direction of travel of that object. In water this is often referred to as water resistance or drag. The thicker the liquid, the greater the resistance encountered.

In terms of our water sports this means that the object, swimmer, boat or diver, for example, will have a greater resistance they have to over come to move through a thicker liquid. For a sport such as swimming this means that more energy is required to move at the same speed as if in a liquid with less resistance. It would therefore stand to reason that swimmers in salt water encounter more resistance from the salt water than if they were swimming in pool water, where there is a lower saturation level of substances. The swimmers should therefore be able to swim faster in pool water than in sea water if swimming with the same effort.

Advances in sports wear have tried to combat the affects of water resistance such as the sharkskin suit seen now regularly on the world's top swimmers. Traditionally swimmers would shave all their body and head hair off on occasion to try and reduce drag.

## Slides 12 & 13 – Buoyancy and Slide 14 – The Dead Sea

Slides 12 & 13 are used to briefly explore buoyancy whilst slide 14 focuses on the Dead Sea and the increased buoyancy swimmers feel when in the Dead Sea due to the far higher than normal levels of salt dissolved in its' waters.

It is not just water resistance that can affect our swimmer, boat or diver in the water. The affect of water resistance slowing the swimmer or boat down can be countered by another scientific property of saturated solutions.

Objects tend to have greater buoyancy, 'float better' in saturated solutions compared to non-saturated solutions. This is again due to a force that the solution produces on an object. When an object is dropped into a solution it either floats, sinks or is partially submerged. Gravity pulls the object downwards whilst the solution produces a force in the opposite direction known as up thrust, pushing the object back up. These forces, combined with a number of other factors, determine whether an object floats, sinks or is partially submerged in a solution. Other factors include the surface tension of the solution, the shape of the object and the density of both the object and the solution. Objects tend to float better, or sit higher in a solution, if submerged or partially submerged, the more dense the solution is.

The Dead Sea is a great example of where a high saturation level of sea water causes greater buoyancy. The sea is known as the Dead Sea because of the extremely high levels of salt dissolved in the sea water. It is the World's second saltiest body of water, after Lake Asal in Djibouti. The Dead Sea is 8.6 times saltier than the oceans and nine times saltier than the Mediterranean Sea, consisting of roughly 31.5% salt. The sea is best known for the buoyancy swimmers feel when swimming in it compared to other bodies of water. This high concentration of dissolved salt gives the sea water a greater density than normal sea water meaning that objects are more buoyant when placed in it.

Returning to the original point, if our swimmer or boat has greater buoyancy in the water, then less of that swimmer or boat is submerged and thus when moving through the solution the swimmer or boat encounters less resistance and can thus move faster. This goes some way to counteract the affect of the greater resistance encountered by the submerged part of our boat or swimmer, slowing their movement through the water, that we discussed earlier. A water sport that is based on utilising and often having to overcome the affects of buoyancy is synchronised swimming. Here the participants have to submerge themselves, float and sometimes almost come entirely out of the water.

## Slides 15 - Summary

The summary slide reminds the students of the topics covered, drag, saturation levels and buoyancy before highlighting the fact that other factors such as the weather can have a huge affect on water

Although we may not always see the role that the chemical and physical properties of a solution play on water sports, even by just exploring the basic chemistry behind saturation and buoyancy, it is clear that chemistry can and does affect performances of equipment and participants in this sporting field. Chemistry, of course, is also integral to the design and composition of equipment and in fact without chemistry, water sports would not exist or function in any recognisable way.

It is also important to remember that water sports in open water are affected by a range of external factors and not only the chemical and physical properties of the solutions. The weather, tidal conditions, wind, water temperature and visibility all play a huge role in the performance of Sportsmen and women and their equipment when taking part in water sports in open water.

**Distribute the 'student handout worksheet' and allocate 25 minutes for the students to attempt the questions on the worksheet. The questions are related to the all of the slides.**

## Slides 16 - 18 - Questions & answers from worksheet

Go through the answers to the worksheet, with the students, with the use of these slides. Recap any areas where students have particularly struggled, to ensure learning takes place.

The slides can be used to cover the answers to the questions in a group situation or can be printed off and kept by the students for revision purposes.

A solution is a liquid which has a substance dissolved in it. What is a liquid that will dissolve a solid called?

A liquid that will dissolve a solid is called a solvent.

What does the term soluble mean and what is the opposite of the term soluble?

The term soluble is given to a solid that will dissolve in a solvent. The opposite of the term soluble is the term insoluble which means something that will not dissolve in a solvent.

When a solution will dissolve no more solid it is said to be fully saturated.

*(fill in the missing word).*

What is the universal solvent and why is it known as this?

Water is known as the universal solvent and it is called this because so many substances will dissolve in it.

What is another term for water resistance?

Another term for water resistance is drag.

Does the density of a solution increase or decrease with an increase in the saturation level of a solution?

The higher the saturation level of a solution the more dense the solution becomes.

What factors can you suggest for why a swimmer may be faster in a pool than in the sea, if swimming with the same effort? (Include buoyancy and water resistance in your answer as well as two other factors).

The saturation level of sea water is higher than that of pool water due to the amount of salts dissolved in it. This means that a swimmer has to swim through a more dense solution when swimming in the sea, so encounters more water resistance or drag, thus slowing the swimmer down, however the swimmer would be more buoyant which would counteract this affect slightly. Other, and probably more important, factors include weather conditions, tidal effects and differences in temperature and visibility of the pool water compared to the sea water.