



FHSST Authors

**The Free High School Science Texts:  
Textbooks for High School Students  
Studying the Sciences  
Chemistry  
Grades 10 - 12**

**Version 0  
November 9, 2008**

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## Chapter 18

# The Water Cycle - Grade 10

### 18.1 Introduction

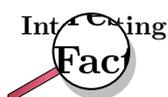
You may have heard the word 'cycle' many times before. Think for example of the word 'bicycle' or the regular 'cycle tests' that you may have at school. A cycle is a series of events that repeats itself. In the case of a bicycle, the wheel turns through a full circle before beginning the motion again, while cycle tests happen regularly, normally every week or every two weeks. Because a cycle repeats itself, it doesn't have a beginning or an end.

Our Earth is a **closed system**. This means that it can exchange *energy* with its surroundings (i.e. the rest of the solar system), but no new *matter* is brought into the system. For this reason, it is important that all the elements and molecules on Earth are recycled so that they are never completely used up. In the next two sections, we are going to take a closer look at two cycles that are very important for life on Earth. They are the **water cycle** and the **nitrogen cycle**.

### 18.2 The importance of water

For many people, it is so easy to take water for granted, and yet life on Earth would not exist were it not for this extraordinary compound. Not only is it believed that the first forms of life actually *started* in water, but most of the cells in living organisms contain between 70% and 95% water. Here in the cells, water acts as a solvent and helps to transport vital materials such as food and oxygen to where they are needed, and also removes waste products such as carbon dioxide and ammonia from the body. For many animals and plants, water is their home. Think for example of fish and amphibians that live either all or part of the time in rivers, dams and the oceans. In other words, if water did not exist, no life would be possible.

Apart from allowing life to exist, water also has a number of other functions. Water shapes the landscape around us by wearing away at rocks and also transports and deposits sediments on floodplains and along coastal regions. Water also plays a very important role in helping to regulate Earth's climate. We will discuss this again later in the chapter. As humans we use water in our homes, in industry, in mining, irrigation and even as a source of electricity in hydro-electric schemes. In fact, if we were able to view Earth from space, we would see that almost three quarters of our planet's surface is covered in water. It is because of this that Earth is sometimes called the 'Blue Planet'. Most of this water is stored in the oceans, with the rest found in ice (e.g. glaciers), groundwater (e.g. boreholes), surface water (e.g. rivers, lakes, estuaries, dams) and in the atmosphere as clouds and water vapour.



In the search for life on other planets, one of the first things that scientists look for is water. However, most planets are either too close to the sun (and therefore

too hot) for water to exist in liquid form, or they are too far away and therefore too cold. So, even if water were to be found, the conditions are unlikely to allow it to exist in a form that can support the diversity of life that we see on Earth.

## 18.3 The movement of water through the water cycle

The water cycle is the continuous movement of water over, above, and beneath the Earth's surface. As water moves, it changes phase between liquid (water), solid (ice) and gas (water vapour). It is powered by solar energy and, because it is a cycle, it has no beginning or end.



### Definition: The Water Cycle

The water cycle is the continuous circulation of water across the Earth. The water cycle is driven by solar radiation and it includes the atmosphere, land, surface water and ground-water. As water moves through the cycle, it changes state between liquid, solid, and gas phases. The actual movement of water from one part of the cycle to another (e.g. from river to ocean) is the result of processes such as evaporation, precipitation, infiltration and runoff.

The movement of water through the water cycle is shown in figure 18.1. In the figure, each process within this cycle is numbered. Each process will be described below.

#### 1. The source of energy

The water cycle is driven by the sun, which provides the heat energy that is needed for many of the other processes to take place.

#### 2. Evaporation

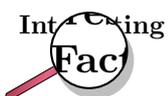
When water on the earth's surface is heated by the sun, the average energy of the water molecules increases and some of the molecules are able to leave the liquid phase and become water vapour. This is called evaporation. Evaporation is the change of water from a liquid to a gas as it moves from the ground, or from bodies of water like the ocean, rivers and dams, into the atmosphere.

#### 3. Transpiration

Transpiration is the evaporation of water from the aerial parts of plants, especially the leaves but also from the stems, flowers and fruits. This is another way that liquid water can enter the atmosphere as a gas.

#### 4. Condensation

When evaporation takes place, water vapour rises in the atmosphere and cools as the altitude (height above the ground) increases. As the temperature drops, the energy of the water vapour molecules also decreases, until the molecules don't have enough energy to stay in the gas phase. At this point, condensation occurs. Condensation is the change of water from water vapour (gas) into liquid water droplets in the air. *Clouds, fog and mist* are all examples of condensation. A cloud is actually a collection of lots and lots of tiny water droplets. This mostly takes place in the upper atmosphere but can also take place close to the ground if there is a significant temperature change.



Have you ever tried breathing out on a very cold day? It looks as though you are breathing out smoke! The moist air that you breathe out is much warmer than the air outside your body. As this warm, moist air comes into

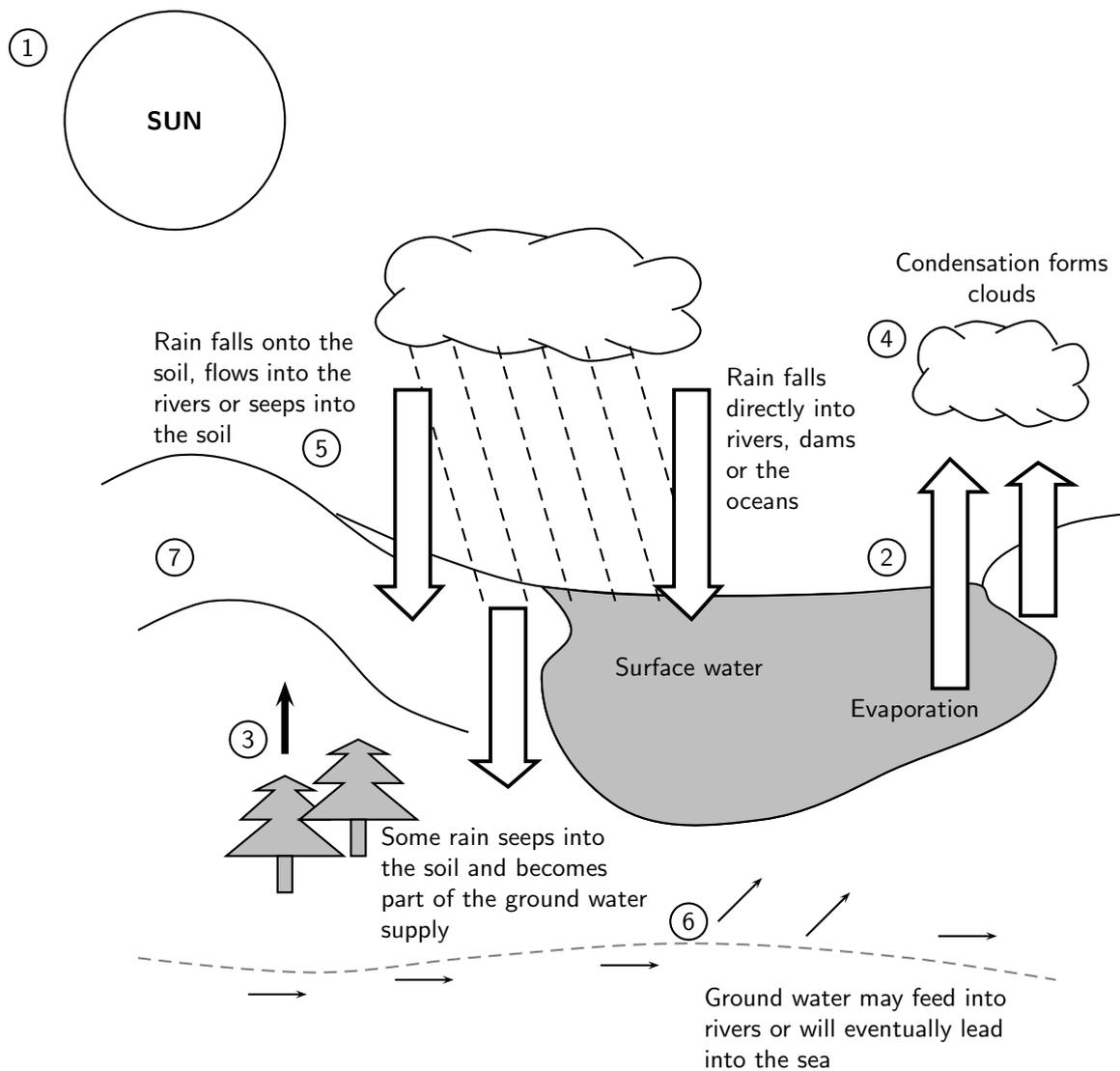


Figure 18.1: The water cycle

contact with the colder air outside, its temperature drops very quickly and the water vapour in the air you breathe out condenses. The 'smoke' that you see is actually formed in much the same way as clouds form in the upper atmosphere.

### 5. Precipitation

Precipitation occurs when water falls back to the earth's surface in the form of rain or snow. Rain will fall as soon as a cloud becomes too saturated with water droplets. Snow is similar to rain, except that it is frozen. Snow only falls if temperatures in the atmosphere are around freezing. The freezing point of water is  $0^{\circ}\text{C}$ .

### 6. Infiltration

If precipitation occurs, some of this water will filter into the soil and collect underground. This is called infiltration. This water may evaporate again from the soil at a later stage, or the underground water may seep into another water body.

### 7. Surface runoff

This refers to the many ways that water moves across the land. This includes *surface runoff* such as when water flows along a road and into a drain, or when water flows straight across the sand. It also includes *channel runoff* when water flows in rivers and streams. As it flows, the water may infiltrate into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.



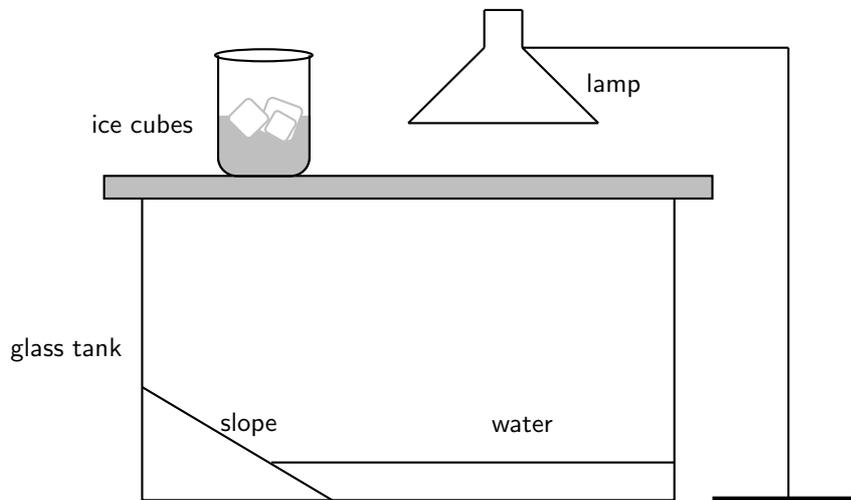
**Important:** It is important to realise that the water cycle is all about **energy exchanges**. The sun is the original energy *source*. Energy from the sun heats the water and causes evaporation. This energy is stored in water vapour as *latent heat*. When the water vapour condenses again, the latent heat is released, and helps to drive circulation in the atmosphere. The liquid water falls to earth, and will evaporate again at a later stage. The atmospheric circulation patterns that occur because of these exchanges of heat are very important in influencing climate patterns.

#### Activity :: Experiment : The Water Cycle

##### Materials:

Tile or piece of plastic (e.g. lid of ice-cream container) to make a hill slope; glass fish tank with a lid; beaker with ice cubes; lamp; water

Set up a model of the water cycle as follows:



1. Lean the plastic against one side so that it creates a 'hill slope' as shown in the diagram.
2. Pour water into the bottom of the tank until about a quarter of the hill slope is covered.
3. Close the fish tank lid.
4. Place the beaker with ice on the lid directly above the hill slope.
5. Turn the lamp on and position it so that it shines over the water.
6. Leave the model like this for 20-30 minutes and then observe what happens. Make sure that you don't touch the lamp as it will be very hot!

##### Observation questions:

1. Which parts of the water cycle can you see taking place in the model?
2. Which parts of the water cycle are *not* represented in the model?

3. Can you think of how those parts that are not shown *could* be represented?
  4. What is the energy source in the model? What would the energy source be in reality?
  5. What do you think the function of the ice is in the beaker?
- 

## 18.4 The microscopic structure of water

In many ways, water behaves very differently from other liquids. These properties are directly related to the microscopic structure of water, and more specifically to the *shape* of the molecule and its *polar nature*, and to the *bonds* that hold water molecules together.

### 18.4.1 The polar nature of water

Every water molecule is made up of one oxygen atom that is bonded to two hydrogen atoms. When atoms bond, the nucleus of each atom has an attractive force on the electrons of the other atoms. This 'pull' is stronger in some atoms than in others and is called the **electronegativity** of the atom. In a water molecule, the oxygen atom has a higher electronegativity than the hydrogen atoms and therefore attracts the electrons more strongly. The result is that the oxygen atom has a slightly negative charge and the two hydrogen atoms each have a slightly positive charge. The water molecule is said to be **polar** because the electrical charge is not evenly distributed in the molecule. One part of the molecule has a different charge to other parts. You will learn more about this in chapter 4.

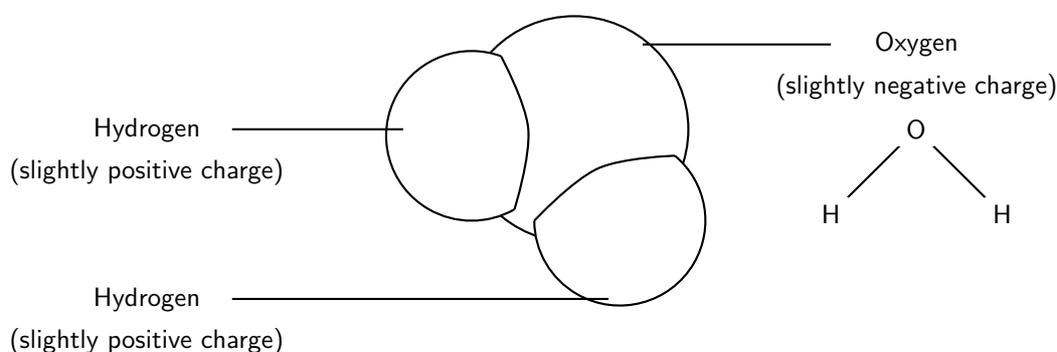


Figure 18.2: Diagrams showing the structure of a water molecule. Each molecule is made up of two hydrogen atoms that are attached to one oxygen atom.

### 18.4.2 Hydrogen bonding in water molecules

In every water molecule, the forces that hold the individual atoms together are called **intramolecular forces**. But there are also forces *between* different water molecules. These are called **intermolecular forces** (figure 18.3). You will learn more about these at a later stage, but for now it is enough to know that in water, molecules are held together by **hydrogen bonds**. Hydrogen bonds are a much stronger type of intermolecular force than those found in many other substances, and this affects the properties of water.

**Important:** Intramolecular and intermolecular forces

If you find these terms confusing, remember that 'intra' means *within* (i.e. the forces within a molecule). An **introvert** is someone who doesn't express emotions and feelings outwardly. They tend to be quieter and keep to themselves. 'Inter' means *between* (i.e. the forces between molecules). An **international** cricket match is a match between two different countries.

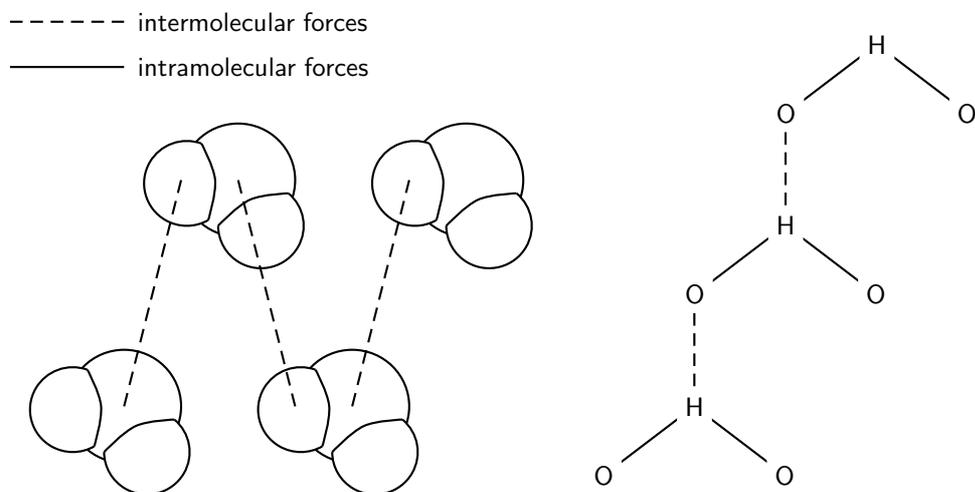


Figure 18.3: Intermolecular and intramolecular forces in water. Note that the diagram on the left only shows *intermolecular* forces. The intramolecular forces are between the atoms of each water molecule.

## 18.5 The unique properties of water

Because of its polar nature and the strong hydrogen bonds between its molecules, water has some special properties that are quite different to those of other substances.

### 1. Absorption of infra-red radiation

The polar nature of the water molecule means that it is able to absorb infra-red radiation (heat) from the sun. As a result of this, the oceans and other water bodies act as heat reservoirs, and are able to help moderate the Earth's climate.

### 2. Specific heat



#### Definition: Specific heat

Specific heat is the amount of heat energy that is needed to increase the temperature of a substance by one degree.

Water has a high specific heat, meaning that a lot of energy must be absorbed by water before its temperature changes.

#### Activity :: Demonstration : The high specific heat of water

- Pour about 100 ml of water into a glass beaker.
- Place the beaker on a stand and heat it over a bunsen burner for about 2 minutes.
- After this time, carefully touch the side of the beaker (Make sure you touch the glass very lightly because it will be very hot and may burn you!). Then use the end of a finger to test the temperature of the water.

What do you notice? Which of the two (glass or water) is the hottest?

---

You have probably observed this phenomenon if you have boiled water in a pot on the stove. The metal of the pot heats up very quickly, and can burn your fingers if you touch it, while the water may take several minutes before its temperature increases even slightly. How can we explain this in terms of hydrogen bonding? Remember that increasing the temperature of a substance means that its particles will move more quickly. However, before they can move faster, the bonds between them must be broken. In the case of water, these bonds are strong hydrogen bonds, and so a lot of energy is needed just to break these, before the particles can start moving faster.

It is the high specific heat of water and its ability to absorb infra-red radiation that allows it to regulate climate. Have you noticed how places that are closer to the sea have less extreme daily temperatures than those that are inland? During the day, the oceans heat up slowly, and so the air moving from the oceans across land is cool. Land temperatures are cooler than they would be if they were further from the sea. At night, the oceans lose the heat that they have absorbed very slowly, and so sea breezes blowing across the land are relatively warm. This means that at night, coastal regions are generally slightly warmer than areas that are further from the sea.

By contrast, places further from the sea experience higher maximum temperatures, and lower minimum temperatures. In other words, their *temperature range* is higher than that for coastal regions. The same principle also applies on a *global* scale. The large amount of water across Earth's surface helps to regulate temperatures by storing infra-red radiation (heat) from the sun, and then releasing it very slowly so that it never becomes too hot or too cold, and life is able to exist comfortably. In a similar way, water also helps to keep the temperature of the *internal* environment of living organisms relatively constant. This is very important. In humans, for example, a change in body temperature of only a few degrees can be deadly.

### 3. Melting point and boiling point

The melting point of water is  $0^{\circ}\text{C}$  and its boiling point is  $100^{\circ}\text{C}$ . This large difference between the melting and boiling point is very important because it means that water can exist as a liquid over a large range of temperatures. The three phases of water are shown in figure 18.4.

### 4. High heat of vaporisation

**Definition: Heat of vaporisation**

Heat of vaporisation is the energy that is needed to change a given quantity of a substance into a gas.

The strength of the hydrogen bonds between water molecules also means that it has a high heat of vaporisation. 'Heat of vaporisation' is the heat energy that is needed to change water from the liquid to the gas phase. Because the bonds between molecules are strong, water has to be heated to  $100^{\circ}\text{C}$  before it changes phase. At this temperature, the molecules have enough energy to break the bonds that hold the molecules together. The heat of vaporisation for water is  $40.65\text{ kJ/mol}$ . It is very lucky for life on earth that water does have a high heat of vaporisation. Can you imagine what a problem it would be if water's heat of vaporisation was much lower? All the water that makes up the cells in our bodies would evaporate and most of the water on earth would no longer be able to exist as a liquid!

### 5. Less dense solid phase

Another unusual property of water is that its solid phase (ice) is *less dense* than its liquid phase. You can observe this if you put ice into a glass of water. The ice doesn't sink to

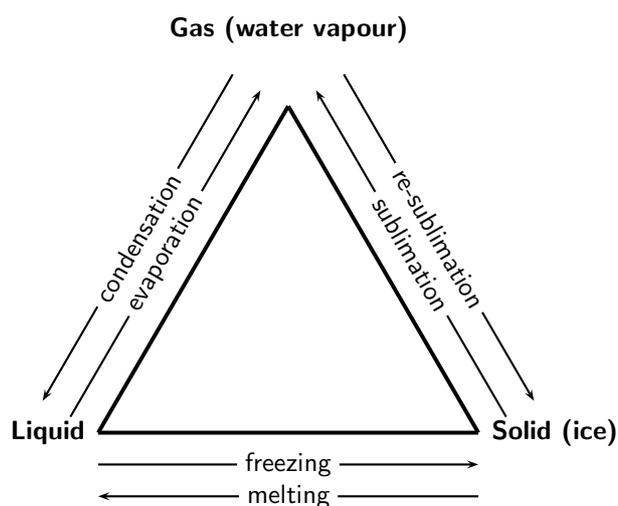


Figure 18.4: Changes in phase of water

the bottom of the glass, but floats on top of the liquid. This phenomenon is also related to the hydrogen bonds between water molecules. While other materials contract when they solidify, water expands. The ability of ice to float as it solidifies is a very important factor in the environment. If ice sank, then eventually all ponds, lakes, and even the oceans would freeze solid as soon as temperatures dropped below freezing, making life as we know it impossible on Earth. During summer, only the upper few inches of the ocean would thaw. Instead, when a deep body of water cools, the floating ice insulates the liquid water below, preventing it from freezing and allowing life to exist under the frozen surface.

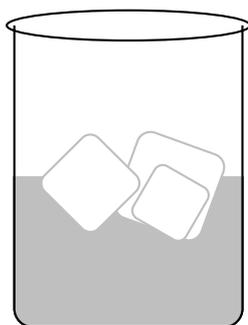
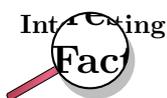


Figure 18.5: Ice cubes floating in water



Antarctica, the 'frozen continent', has one of the world's largest and deepest freshwater lakes. And this lake is hidden beneath 4 kilometres of ice! Lake Vostok is 200 km long and 50 km wide. The thick, glacial blanket of ice acts as an insulator, preventing the water from freezing.

Water is also a very good solvent, meaning that it is easy for other substances to dissolve in it. It is very seldom, in fact, that we find pure water. Most of the time, the water that we drink and use has all kinds of substances dissolved in it. It is these that make water taste different in different areas. So why, then, is it important that water is such a good solvent? We will look at just a few examples.

- Firstly, think about the animals and plants that live in aquatic environments such as rivers, dams or in the sea. All of these living organisms either need oxygen for respiration or carbon dioxide for photosynthesis, or both. How do they get these gases from the water in which they live? Oxygen and carbon dioxide are just two of the substances that dissolve easily in water, and this is how plants and animals obtain the gases that they need to survive. Instead of being available as gases in the atmosphere, they are present in solution in the surrounding water.
- Secondly, consider the fact that all plants need nitrogen to grow, and that they absorb this nitrogen from compounds such as nitrates and nitrites that are present in the soil. The question remains, however, as to how these nitrates and nitrites are able to be present in the soil at all, when most of the Earth's nitrogen is in a gaseous form in the atmosphere. Part of the answer lies in the fact that nitrogen oxides, which are formed during flashes of lightning, can be dissolved in rainwater and transported into the soil in this way, to be absorbed by plants. The other part of the answer lies in the activities of nitrogen-fixing bacteria in the soil, but this is a topic that we will return to in a later section.

It should be clear now, that water is an amazing compound, and that without its unique properties, life on Earth would definitely not be possible.



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#### Exercise: The properties of water

1. A learner returns home from school on a hot afternoon. In order to get cold water to drink, she adds ice cubes to a glass of water. She makes the following observations:
    - The ice cubes float in the water.
    - After a while the water becomes cold and the ice cubes melt.
    - (a) What property of ice cubes allows them to float in the water?
    - (b) Briefly explain why the water gets cold when the ice cubes melt.
    - (c) Briefly describe how the property you mentioned earlier affects the survival of aquatic life during winter.
  2. Which properties of water allow it to remain in its liquid phase over a large temperature range? Explain why this is important for life on earth.
- 

## 18.6 Water conservation

Water is a very precious substance and yet far too often, earth's water resources are abused and taken for granted. How many times have you walked past polluted rivers and streams, or seen the flow of water in a river reduced to almost nothing because of its extraction for industrial and other uses? And if you were able to test the *quality* of the water you see, you would probably be shocked. Often our water resources are contaminated with chemicals such as pesticides and fertilisers. If water is to continue playing all the important functions that were discussed earlier, it is vital that we reduce the impact of humans on these resources.

**Activity :: Group work : Human impacts on the water cycle**

Read the following extract from an article, entitled 'The Effects of Urbanisation on the Water Cycle' by Susan Donaldson, and then answer the questions that follow.

As our communities grow, we notice many visible changes including housing developments, road networks, expansion of services and more. These changes have an impact on our precious water resources, with *pollution* of water being one of many such impacts. To understand these impacts you will need to have a good knowledge of the water cycle!

It is interesting to note that the oceans contain most of earth's water (about 97%). Of the freshwater supplies on earth, 78% is tied up in polar ice caps and snow, leaving only a very small fraction available for use by humans. Of the available fresh water, 98% is present as groundwater, while the remaining 2% is in the form of surface water. Because our usable water supply is so limited, it is vitally important to protect water *quality*. Within the water cycle, there is no 'new' water ever produced on the earth. The water we use today has been in existence for billions of years. The water cycle continually renews and refreshes this finite water supply.

So how exactly does urbanisation affect the water cycle? The increase in hard surfaces (e.g. roads, roofs, parking lots) decreases the amount of water that can soak into the ground. This increases the amount of surface runoff. The runoff water will collect many of the pollutants that have accumulated on these surfaces (e.g. oil from cars) and carry them into other water bodies such as rivers or the ocean. Because there is less infiltration, peak flows of stormwater runoff are larger and arrive earlier, increasing the size of urban floods. If groundwater supplies are reduced enough, this may affect stream flows during dry weather periods because it is the groundwater that seeps to the surface at these times.

Atmospheric pollution can also have an impact because condensing water vapour will pick up these pollutants (e.g. SO<sub>2</sub>, CO<sub>2</sub> and NO<sub>2</sub>) and return them to earth into other water bodies. However, while the effects of urbanisation on water quality can be major, these impacts can be reduced if wise decisions are made during the process of development.

**Questions**

1. In groups, try to explain...
    - (a) what is meant by 'urbanisation'
    - (b) how urbanisation can affect water quality
  2. Explain why it is so important to preserve the quality of our water supplies.
  3. The article gives some examples of human impacts on water quality. In what *other* ways do human activities affect water quality?
  4. What do you think some of the *consequences* of these impacts might be for humans and other forms of life?
  5. Imagine that you are the city manager in your own city or the city closest to you. What changes would you introduce to try to protect the quality of water resources in your urban area?
  6. What measures could be introduced in rural areas to protect water quality?
- 

Apart from the *pollution* of water resources, the *overuse* of water is also a problem. In looking at the water cycle, it is easy sometimes to think that water is a never-ending resource. In a sense this is true because water cannot be destroyed. However, the *availability* of water may vary from place to place. In South Africa for example, many regions are extremely dry and receive very little rainfall. The same is true for many other parts of the world, where the scarcity of water

is a life and death issue. The present threat of **global warming** is also likely to affect water resources. Some climate models suggest that rising temperatures could increase the variability of climate and decrease rainfall in South Africa. With this in mind, and remembering that South Africa is already a dry country, it is vitally important that we manage our water use carefully. In addition to this, the less water there is available, the more likely it is that water *quality* will also decrease. A decrease in water quality limits how water can be used and developed.

At present, the demands being placed on South Africa's water resources are large. Table 18.1 shows the water requirements that were predicted for the year 2000. The figures in the table were taken from South Africa's *National Water Resource Strategy*, produced by the Department of Water Affairs and Forestry in 2004. In the table, 'rural' means water for domestic use and stock watering in rural areas, while 'urban' means water for domestic, industrial and commercial use in the urban area. 'Afforestation' is included because many plantations reduce stream flow because of the large amounts of water they need to survive.

Table 18.1: The predicted water requirements for various water management areas in South Africa for 2000 (million m<sup>3</sup>/annum)

Water management area	Irrigation	Urban	Rural	Mining and bulk industrial	Power generation	Afforestation	Total
Limpopo	238	34	28	14	7	1	322
Thukela	204	52	31	46	1	0	334
Upper Vaal	114	635	43	173	80	0	1045
Upper Orange	780	126	60	2	0	0	968
Breede	577	39	11	0	0	6	633
<b>Country total</b>	<b>7920</b>	<b>2897</b>	<b>574</b>	<b>755</b>	<b>297</b>	<b>428</b>	<b>12871</b>

### Activity :: Case Study : South Africa's water requirements

Refer to table 18.1 and then answer the following questions:

- Which water management area in South Africa has the highest need for water...
  - in the *mining and industry* sector?
  - for *power generation*?
  - in the *irrigation* sector?
  - Suggest reasons for each of your answers above.
- For South Africa as a whole...
  - Which activity uses the *most* water?
  - Which activity uses the *least* water?
- Complete the following table, by calculating the percentage (%) that each activity contributes to the total water requirements in South Africa for the year 2000.

Water use activity	% of SA's total water requirements
Irrigation	
Urban	
Rural	
Mining and bulk industry	
Power generation	
Afforestation	

Table 18.2: The available water yield in South Africa in 2000 for various water management areas (million m<sup>3</sup>/annum)

Water management area	Surface water	Ground	Irrigation	Urban	Mining and bulk industrial	Total local yield
Limpopo	160	98	8	15	0	281
Thukela	666	15	23	24	9	737
Upper Vaal	598	32	11	343	146	1130
Upper Orange	4311	65	34	37	0	4447
Breede	687	109	54	16	0	866
<b>Country total</b>	<b>10240</b>	<b>1088</b>	<b>675</b>	<b>970</b>	<b>254</b>	<b>13227</b>

Now look at table 18.2, which shows the amount of water *available* in South Africa during 2000. In the table, 'usable return flow' means the amount of water that can be reused after it has been used for irrigation, urban or mining.

---

### Activity :: Case Study : Water conservation

Refer to table 18.2 and then answer the following questions:

- Explain what is meant by...
    - surface water
    - ground water
  - Which water management area has the...
    - lowest surface water yield?
    - highest surface water yield?
    - lowest *total* yield?
    - highest *total* yield?
  - Look at the country's *total water requirements* for 2000 and the *total available yield*.
    - Calculate what percentage of the country's water yield is already being used up.
    - Do you think that the country's total water requirements will increase or decrease in the coming years? Give a reason for your answer.
  - South Africa is already placing a huge strain on existing water resources. In groups of 3-4, discuss ways that the country's demand for water could be reduced. Present your ideas to the rest of the class for discussion.
- 

## 18.7 Summary

- Water is critical for the survival of life on Earth. It is an important part of the cells of living organisms and is used by humans in homes, industry, mining and agriculture.
- Water moves between the land and sky in the **water cycle**. The water cycle describes the changes in phase that take place in water as it circulates across the Earth. The water cycle is driven by solar radiation.

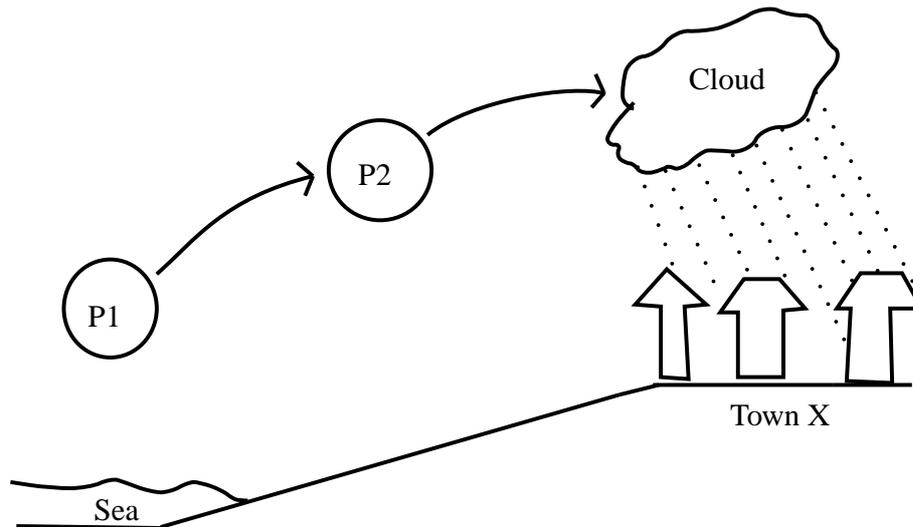
- Some of the important processes that form part of the water cycle are evaporation, transpiration, condensation, precipitation, infiltration and surface runoff. Together these processes ensure that water is cycled between the land and sky.
- It is the microscopic structure of water that determines its unique properties.
- Water molecules are **polar** and are held together by **hydrogen bonds**. These characteristics affect the properties of water.
- Some of the unique properties of water include its ability to absorb infra-red radiation, its high specific heat, high heat of vaporisation and the fact that the solid phase of water is less dense than its liquid phase.
- These properties of water help it to sustain life on Earth by moderating climate, regulating the internal environment of living organisms and allowing liquid water to exist below ice, even if temperatures are below zero.
- Water is also a good **solvent**. This property means that it is a good transport medium in the cells of living organisms, and that it can dissolve gases and other compounds that may be needed by aquatic plants and animals.
- Human activities threaten the quality of water resources through pollution and altered runoff patterns.
- As human populations grow, there is a greater demand for water. In many areas, this demand exceeds the amount of water available for use. Managing water wisely is important in ensuring that there will always be water available both for human use, and to maintain natural ecosystems.



---

### Exercise: Summary Exercise

1. Give a word or term for each of the following phrases:
  - (a) The continuous circulation of water across the earth.
  - (b) The change in phase of water from gas to liquid.
  - (c) The movement of water across a land surface.
  - (d) The temperature at which water changes from liquid to gas.
2. In each of the following multiple choice questions, choose the one correct answer from the list provided.
  - (a) Many of the unique properties of water (e.g. its high specific heat and high boiling point) are due to:
    - i. strong covalent bonds between the hydrogen and oxygen atoms in each water molecule
    - ii. the equal distribution of charge in a water molecule
    - iii. strong hydrogen bonds between water molecules
    - iv. the linear arrangement of atoms in a water molecule
  - (b) Which of the following statements is **false**?
    - i. Most of the water on earth is in the oceans.
    - ii. The hardening of surfaces in urban areas results in increased surface runoff.
    - iii. Water conservation is important because water cannot be recycled.
    - iv. Irrigation is one of the largest water users in South Africa.
3. The sketch below shows a process that leads to rainfall in town X. The town has been relying only on rainfall for its water supply because it has no access to rivers or tap water. A group of people told the community that they will never run out of rainwater *because it will never stop raining*.



- (a) List the processes labelled  $P_1$  and  $P_2$  that lead to rainfall in town X.
- (b) Is this group of people correct in saying that town X will never run out of rainwater? Justify your answer using the sketch.  
Recently, the amount of rainwater has decreased significantly. Various reasons have been given to explain the drought. Some of the community members are blaming this group who told them that it will never stop raining.
- (c) What scientific arguments can you use to convince the community members that this group of people should not be blamed for the drought?
- (d) What possible strategies can the community leaders adopt to ensure that they have a regular supply of water.
-

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