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The Importance of Water and its Solid State

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Motivation

This document aims to analyze the interesting deed of the solid state of the water, admittedly known as ice. Furthermore, this folio examines some figures and facts extracted from Nature, where the goal is to discover the importance of the water in our planet due to its intrinsic properties.

As a personal reflection, I believe this document is impressive both for the audience to which it is written and also for the author, who is me. Indeed, people do not usually think about things which seem well established, however the human life is extremely bounded to water and its properties, and thus this molecule is analyzed among this paper.

Certainly, for the author, the most interesting part what it concerns to the solid state of water. Nevertheless, this documents goes through some background information about the nature of water and its presence in our planet, to then move onto the specific characteristics and relevance of ice.

Nature of the Water

Water is a chemical substance composed of hydrogen and oxygen in the ratio 2:1 respectively. Its molecule is denoted as H_2O , which is essential to any form of life on Earth, and in fact is present by a 71% on its surface. Figure 1 shows the structure of the water molecule.

As the water is matter, it has common physical properties to all matter, where one of those is the presence of itself as a liquid, solid or gas. Normally, water is present in Nature in liquid state, however this deed already makes of water a special substance, since all elements close to the oxygen in the periodic table are combined with hydrogen under normal conditions to form gas at normal temperature and pressure. [1]

The fact that the oxygen forms a liquid when it is bound to hydrogen is because it is more electronegative than its neighboring elements. Consequently, the oxygen pulls electrons with such a force so that a net dipole moment is generated. Eventually, the molecules of water stay closer to each other due to the properties of the dipole, being difficult for them to separate away, and thus raising the boiling point. [1]

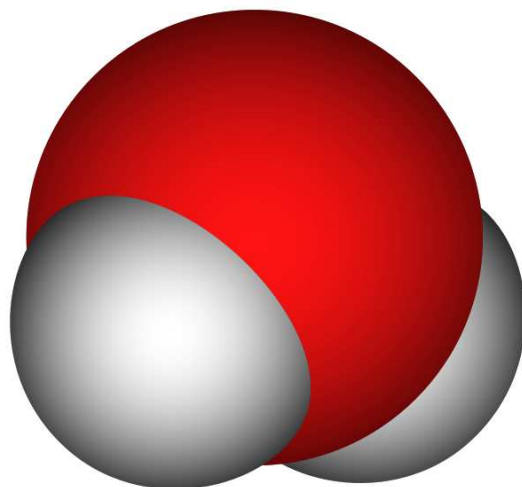


Figure 1: Water molecule.

Some of the most important and common properties are that water is *solvent*, *cohesive* and *adhesive*. All these properties are due to its polarity by nature, however there are some important features of the water that exists thanks to its solid state, *the ice*, which people may usually ignore. [1]

Water as a Vital Component

In principle, the Earth seems to be just a perfect place where life can be created and continued without problems. Astonishingly, if this planet was closer or further from the Sun, the conditions to allow the life on the planet would be unlikely to exist.

In modern science there are several models which try to address the uncertainty of how life was originated and, moreover, how it developed to become as intelligent as in human beings. Generally, all models tend to admit that some basic biomolecules were randomly generated meanwhile the stormy conditions of the primitive Earth, millions of years ago. One of the basic chemicals from which life was thought to be formed is H_2O among others. [2]

By and large, water is known to be necessary for any form of life. In fact, all living beings possess a body with a high concentration of water. Moreover, the most critical processes

carried out in plants, animals and humans, require enormous amounts of water, in order to be performed. For instance, dairy cows require up to an 88% of water in their bodies for their production of milk. Also plants require water for the photosynthesis process, which is one of the most important phenomena taking place on Earth. [3]

The explanation of this relevance in life is that the water is the medium where all chemical reactions occur in living bodies. Thanks to its properties, water can function as a transporter of feed, a helper in excretion, a temperature regulator and a pH stabilizer. Moreover, the relatively high specific heat capacity of water makes it a perfect temperature buffering agent for the body. [3]

Besides the importance of water as a fluid, there are some important aspects of its solid state which affect directly or indirectly the life on Earth. Due to the fact that the water is less dense when it is solid than when it is liquid, the ice is accumulated on the top of the water (e.g. glaciers), keeping itself in solid state. Otherwise, if ice would be drawn in oceans, then it would melt quickly, becoming lethal for life of all kind. This lethality is explained as the result of two environmental situations: first, the level of oceans and seas would increase until cover most of the planet; second, the salinity of salted waters would decrease drastically, exterminating any marine life.

Water in Solid State

The common name for water in solid state is **ice**. Ice can be presented in many different forms, which are crystalline structures formed depending on the actual pressure and temperature. A variant of ice, called *amorphous ice*, can be obtained by poring vapor at temperatures under $140^{\circ}K$.

Ice can be presented in white or blue, even colorless, but mostly in white. Its hardness is measured to be 1.5 and its density is about $0.99 \frac{g}{cm^3}$, just lower than the water, which is $1.0 \frac{g}{cm^3}$. Its crystal system is hexagonal, its fracture is conchoidal, its luster is vitreous, its translucent and its melting point its at $32^{\circ}F(0^{\circ}C)$. [4]

A brief list of the most common types of ice could be the following:

Ice caps Huge layers of ice which lay near the Earth poles. Their existence is due to the fact that those parts of the Earth receive so little sun beam that the average temperature during the whole year period is under 0 degrees.

Icebergs Large fragments of freshwater ice which have come off a glacier, floating in open waters.

Hailstones Small pieces of ice formed in a thunderstorm. They are formed due to the low temperature accumulated up in the center of the cloud, dropping hard-iced balls down to the surface.

Snowflakes Bunch of combined snow crystal.

Freezing rain Sample of rainwater which freezes on its way downwards forming soft crystals. In addition, there are the so-called *sleets*, which are components of the freezing rain which melt before reaching the ground.

[5]

Environmental Impact and Repercussions

General Impact

Climate is defined as *the average weather over a long period of time*. Furthermore, *weather* is the set of phenomena and conditions which, somehow, affects the life in our planet. Therefore, the ice plays a very important role, since it is always related to the climate, the weather, and their changes. [5]

As it was mentioned before, the fact that the ice floats over water is so important that it directly affects the existing of life on this planet, being crucial for the continuation of life on it. However, as it can be seen from the statistics nowadays, ice is rapidly melting on the North Pole (up in Greenland). Such deed has led into a situation where the polar bears are almost extinct, since they cannot cross to Canada to fetch food because the layer of ice does not reach the American continent, and hence they die in the try.

Further Consequences

Besides the environmental issue that it is clearly seen, there are more things which come in consequence. For instance, global warming performs such tremendous changes in temperature that even the melting ice is not enough to cool up the oceans on the surface of the Earth. Actually, as recently studies have shown, since the Antarctica is surrounded by water, the warmer the water the greater the evaporation from the surface and hence the more possibility of heavy snow moisture from the sky. Finally, this would lead into a very cold and long winter, extinguishing many races, if not all, on the Earth. [6]

In addition, far away from Global Warming, hailstones are often a cause of disaster, which can generate losses of thousands of euros, by provoking traffic accidents, even killing people and much more.

The Importance of Sea Ice

Sea ice is, basically, frozen regions of water in the ocean. In fact, it is formed, developed and extinguished in ocean waters, not as icebergs or glaciers which are originated on land. Sea ice exists both in Arctic and Antarctic waters, growing during the winter time and melting during the summer period. As a key, consider that 15% of ocean waters are covered by sea ice during the winter period. [7]

The importance of sea ice comes in relation with the Global Warming issue and the fact of absorption of light. The surface of the sea ice is cool white, which reflects all the sun beam straight back to the space (so-called **albedo**), keeping the temperature of the poles quite low. However, when the sea ice starts melting due to the global increase of temperature in our planet, there is less surface to reflect those sun rays, entering in an exponential loop where the faster the ice melts the warmer the climate becomes, and hence the much faster the ice melts. [7]

Another problem, which has been slightly mentioned before, is the sink of the ice under the water. This deed leads into a situation where the difference in concentration of salt is so, that the drawn ice starts to melt, due to the well known osmosis process. As a matter of fact, too much or too little sea ice could mean an enormous problem for the climate, putting in trouble life on the surface of the Earth. [7]

In order to understand our climate and improve the conditions of it, we must understand how climate is originated and carried out. Therefore, it is must to know that oceans and atmosphere are the responsible of this task. On one hand, atmosphere transports heat with low-pressure systems and storms; on the other hand, oceans transports heat towards poles in a more relaxed way. The cycle of heat-transport is described in figure 2.

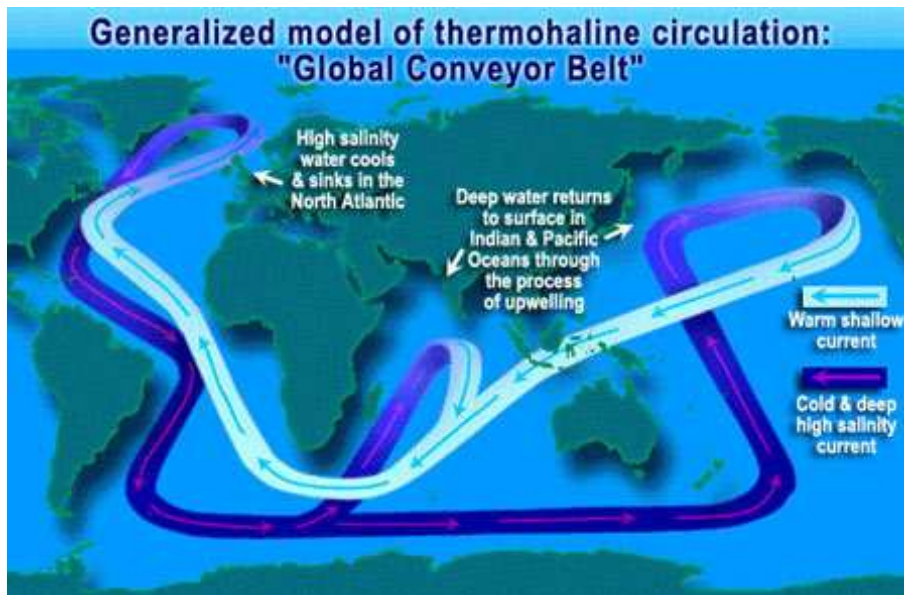


Figure 2: Thermohaline circulation. Courtesy of NASA GSFC. [8]

As can be seen from figure 2, oceans transport hot water from the equator to the poles through a process which involves heat and salt, called **thermohaline circulation**. When water cools up, it becomes heavy and therefore it sinks, traveling back towards south and emerging near the equator (when it becomes hot again), completing the cycle. This process, in conjunction with the atmospheric processes, takes care of keeping our climate in balance. [7]

Conclusion

As a brief conclusion based on this paper, it could be said that *ice always affects life on Earth in one or another way*. Hence, and since it is only water in a different state than liquid, it is so important in our lives, making possible to live, but also affecting it so, that it could let life or take it away.

In terms of learning, this paper has not been difficult to write, however it has been very interesting for the author to, somehow, rediscover the properties of water and analyze why it behaves in such a way. After all, all the deeds and facts were explained by the polarity of the molecule, thanks to its intrinsic polarity. And, furthermore, the exploration of how ice affects our climate and our planet in general, has been a challenging and exciting task.

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