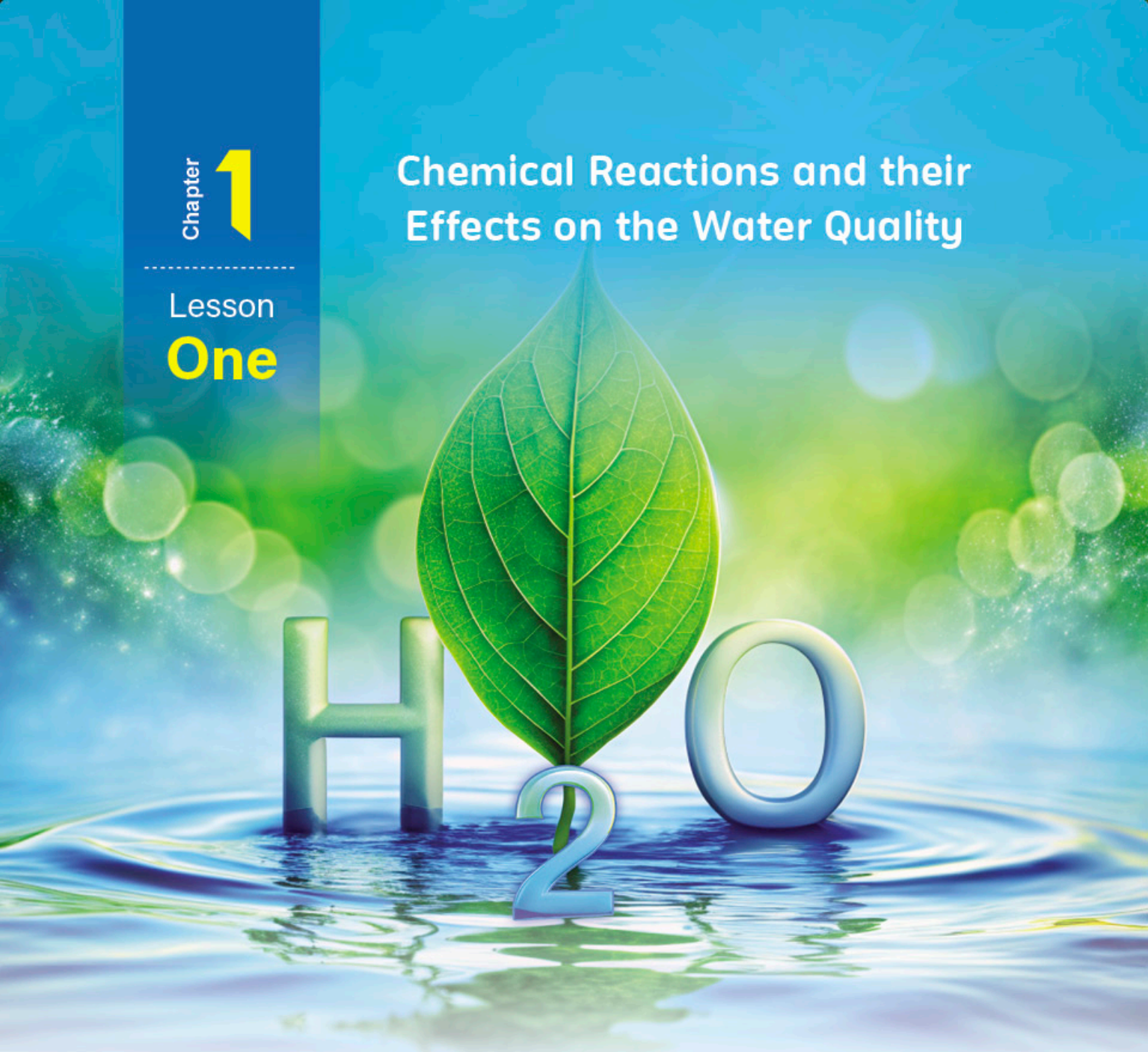
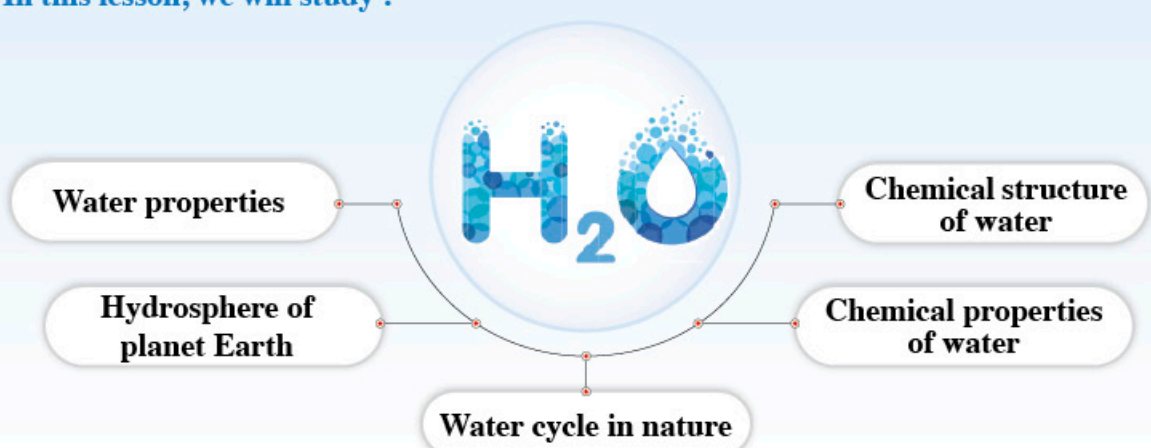
Chapter 1

Lesson One

Chemical Reactions and their Effects on the Water Quality



★ **In this lesson, we will study :**

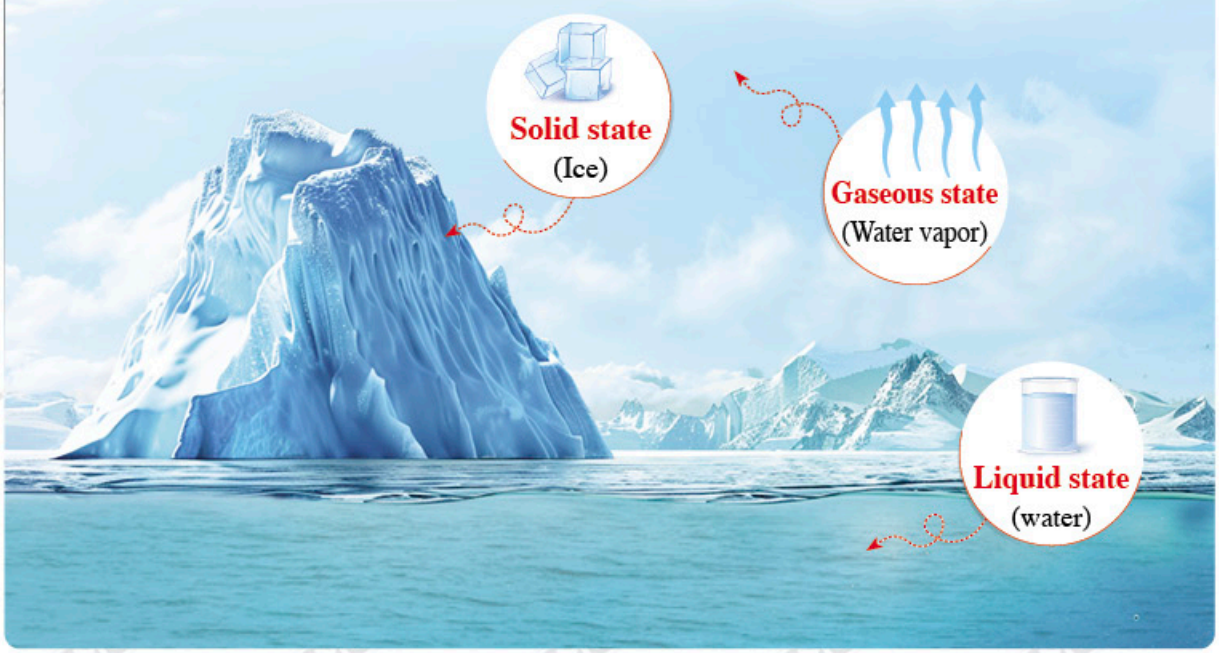


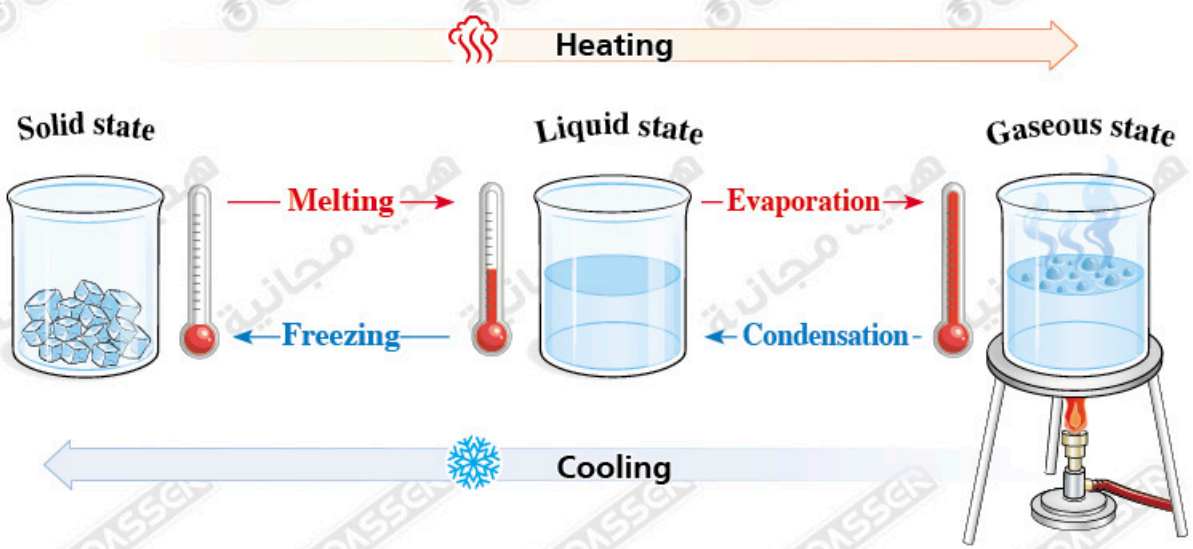
Water :

It is a transparent liquid that represents a medium at which many chemical compounds react, which affects the water quality and the living organisms' health depending on that water.

Water is characterized by unique chemical properties, **such as :**

1. It can dissolve many chemical substances.
2. It also can be found in three states (solid - liquid - gaseous) within the known range of temperatures on Earth.



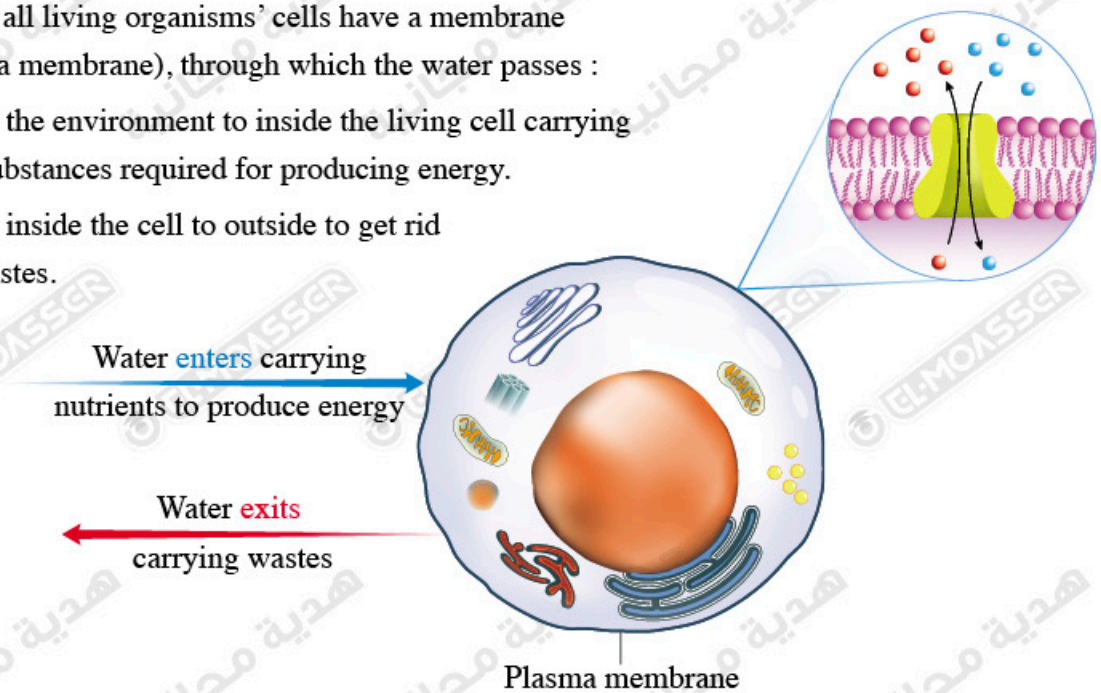


Physical changes among the three states of water

Water is necessary for the continuity of life on Earth :

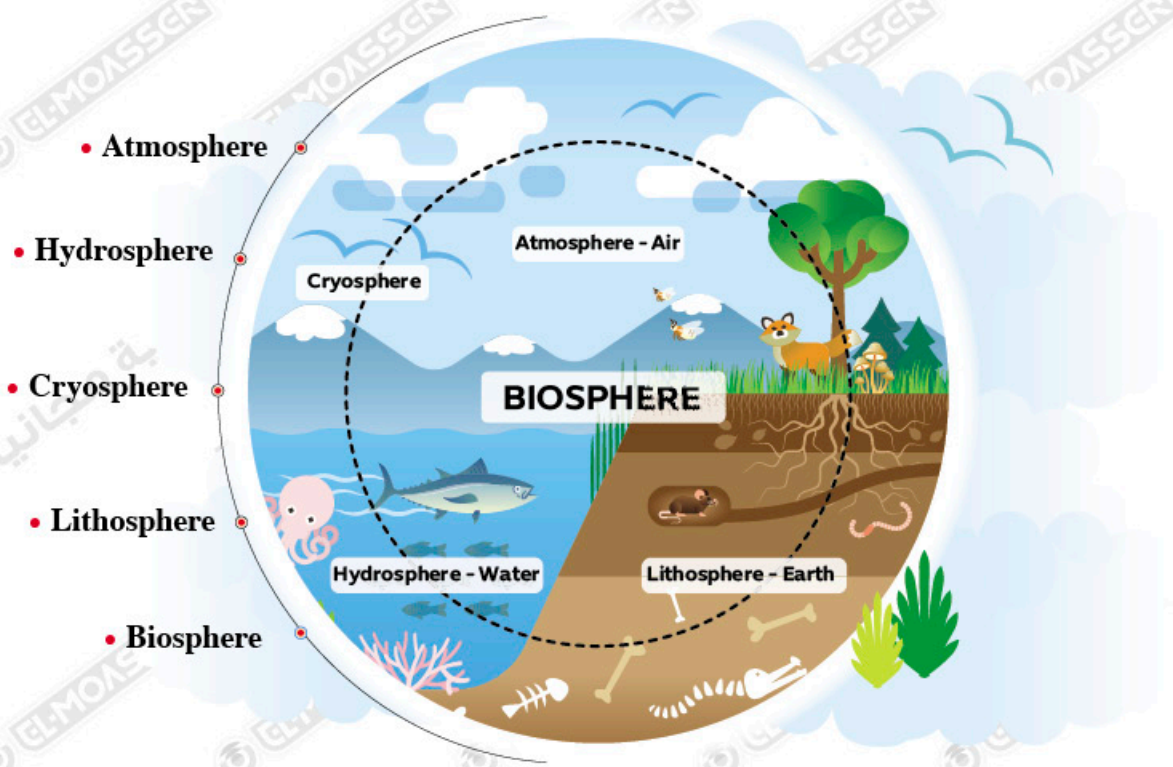
Where all living organisms' cells have a membrane (plasma membrane), through which the water passes :

- From the environment to inside the living cell carrying the substances required for producing energy.
- From inside the cell to outside to get rid of wastes.



Different spheres on Earth

★ **Earth is composed of many spheres which are :**



Hydrosphere

* Hydrosphere characterizes Earth from the other planets in the solar system.
* Water covers about 70% of the Earth's surface which is distributed as follows :

Saltwater (about 97%)

represented in :

- Oceans.
- Seas.
- Salty lakes.

Fresh water (about 1%)

represented in :

- Rivers.
- Fresh lakes.
- Groundwater.

Remained part is frozen water (Cryosphere)

represented in :

- Polar regions.
- Mountaintops.
- Glaciated rivers.

Aquatic systems in Egypt :

* Egypt is featured by the diversity of its aquatic-environment that includes :

① **Fresh water** which includes :

- Nile River.
- Fresh lakes.

② **Saltwater** which includes :

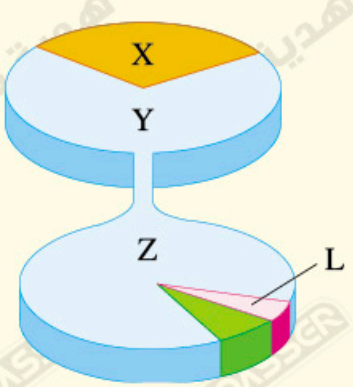
- Red Sea.
- Mediterranean Sea.
- Suez gulf.
- Aqaba gulf.
- Salty lakes.

Test yourself 1

Answered

Choose the correct answer :

The opposite figure shows the distribution of water on the Earth's surface, which of the following choices in the table is correct ?



	(X)	(Y)	(Z)	(L)
ⓐ	Land	Ice	Fresh water	Saltwater
ⓑ	Land	Ice	Saltwater	Fresh water
ⓒ	Fresh water	Ice	Saltwater	Land
ⓓ	Land	Water	Saltwater	Fresh water

Water cycle in nature

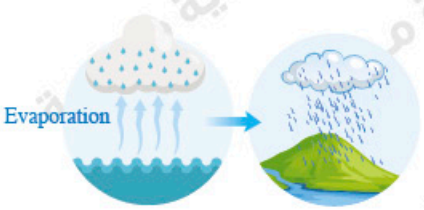
Water cycle (Hydrological cycle) :

It is a nearly closed system in which water (that is present on the Earth's surface or near to it) moves continuously from one place to another through many different pathways where get changed among its three states.

★ **Water cycle in nature includes mainly many processes such as :**

1 Evaporation process

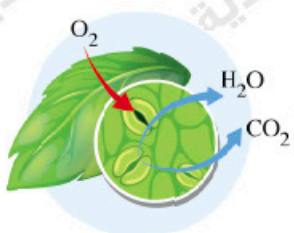
Evaporation of water from water surfaces which contributes to the formation of clouds and falling of rains and snow.



2 Biological processes

Such as :

* Transpiration in plants.
* Respiration in plants and animals.

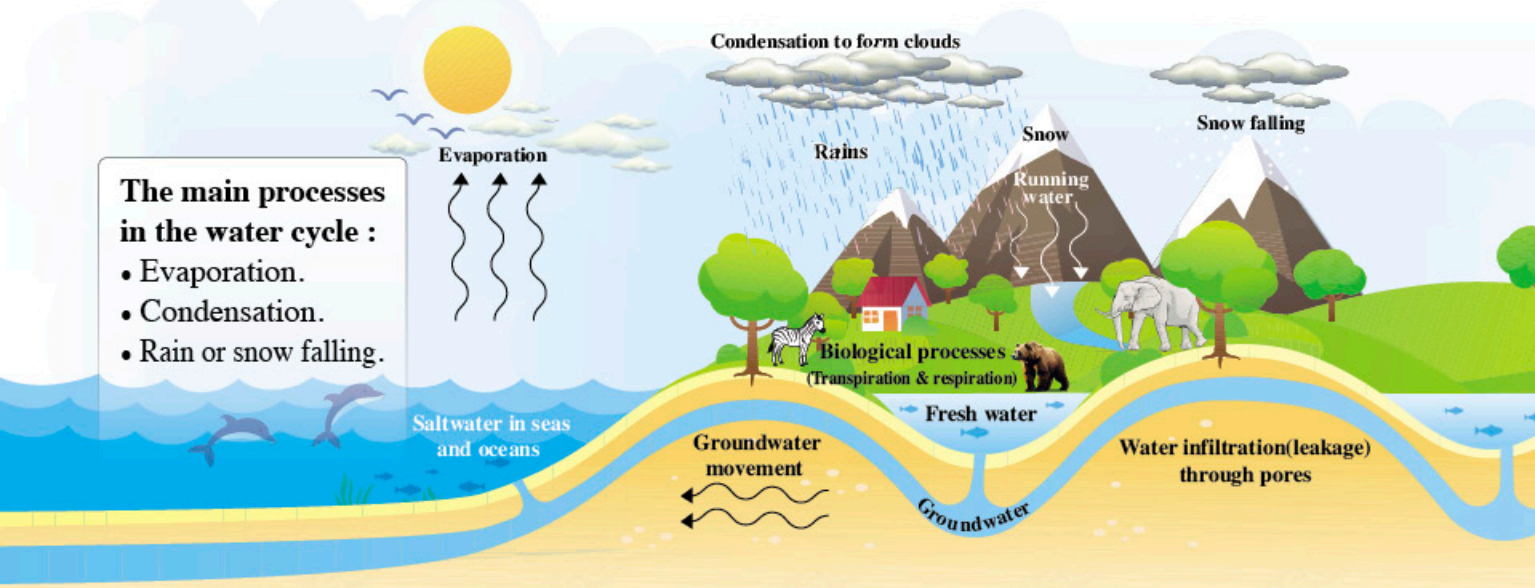


3 Water infiltration (leakage) process

Water leaks through the pores of soil and sedimentary rocks to form the groundwater.

The main processes in the water cycle :

- Evaporation.
- Condensation.
- Rain or snow falling.



Water cycle in nature

Scientific background

* **Vaporization process :** It is a process of converting the substance (water) from liquid state to gaseous state at the boiling point.
* **Evaporation process :** It is a process of converting the substance (water) from liquid state to gaseous state at any temperature.
* **Condensation state :** It is a process of converting the substance (water) from gaseous state to liquid state.
* **Transpiration process :** It is a process of water loss by plant in the form of vapour.

★ The effect of water cycle in nature :

Water cycle is a system that can change the Earth's surface physically, chemically and biologically.

Note :

Water vapour may react chemically with the compounds that are present in air, forming some acids that fall as acidic rains that act on rock decomposition.

Scientific background

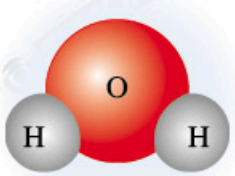
* The geologic structures are formed on the Earth's surface, due to the fragmentation and breaking down of rocks.

And this is through many factors :

1. **Physical factors :** As wind intensity, water streaming or changes in temperature through day and night.
2. **Chemical factors :** As the reaction of rocks with acid rains or with the minerals that are found in the groundwater.
3. **Biological factors :** As the growth of the plants' roots through rocks.

The Chemical structure of water

* **Water is composed of two elements which are oxygen and hydrogen.**



Water molecule

Hydrogen differs from oxygen in water molecule at which :

Volume

- The volumetric percentage of hydrogen = **66.67%**
- The volumetric percentage of oxygen = **33.33%**

} **in an amount of water**

i.e. Ratio of Hydrogen : Oxygen

2 : 1

Mass

- The mass percentage of hydrogen = **11.11%**
- The mass percentage of oxygen = **88.89%**

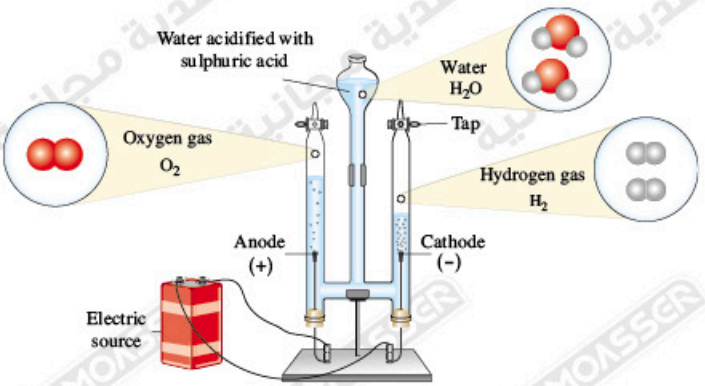
} **in water molecule**

i.e. Ratio of Hydrogen mass : Oxygen mass

1 : 8

Scientific background

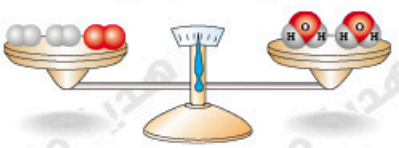
* Electrolysis of water acidified with sulphuric acid by using Hofmann voltmeter shows that the volume of hydrogen gas forming water is double the volume of oxygen gas.



Electrolysis of water

* **Water is composed of its two elements according to the following equation,**

$$2\,H_2 + O_2 \longrightarrow 2\,H_2O$$



* By knowing the atomic masses of (O = 16 and H = 1)

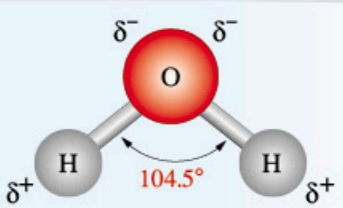
$$2\,(1 \times 2) + (16 \times 2) \longrightarrow 2\,(1 \times 2 + 16)$$

$$4 + 32 \longrightarrow 36$$

i.e. 4 g of hydrogen react with 32 g of oxygen by a ratio 1 : 8 respectively.

Nature of bond in water molecule :

- Each hydrogen atom is attached to the oxygen atom by a single covalent bond (*i.e.* two covalent bonds are formed in the molecule).
- The two covalent bonds form an angle which equals about 104.5°



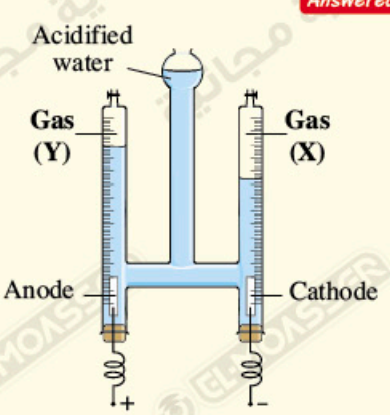
The angle between the two covalent bonds of water molecule

Test yourself 2

Answered

Choose the correct answer :

The opposite figure shows Hofmann voltmeter that is used in the electrolysis of water. What is the ratio of the volume of gas (X) that is collected at the cathode to the volume of gas (Y) that is collected at the anode ?



(a) $\frac{1}{2}$ (b) $\frac{2}{1}$

(c) $\frac{4}{1}$ (d) $\frac{1}{8}$

Chemical properties of water

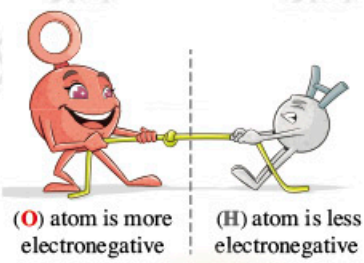
* Water doesn't exist on the Earth's surface in a pure form, where it contains many ions and chemical substances that react with it in different ways.

Hereinafter, we will discuss three main properties of water :

Chemical properties of water ⟶ **1** Polarity of water ⟶ **2** Hydrolysis of water ⟶ **3** Acid-base balance

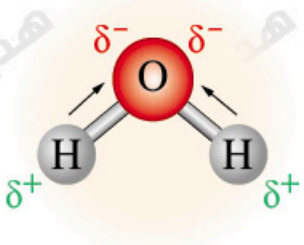
1 Polarity of water

The electronegativity of oxygen atom **>** The electronegativity of hydrogen atom



(O) atom is more electronegative | (H) atom is less electronegative

Therefore, the electrons of the covalent bond are pulled towards the oxygen atom, which leads to the formation of :



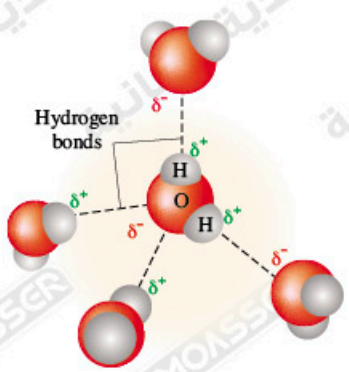
δ⁻ Partial negative charge on the oxygen atom.

δ⁺ Partial positive charge on the hydrogen atom.

And this what is known as **"Water polarity"**.

The water polarity results in :

1. Attaching water molecules together by **hydrogen bonds** which is considered a main reason for elevating the boiling point of water to 100℃ (in case of pure water and under normal atmospheric pressure), comparing to the boiling point of other substances that resemble it in the structure.



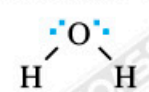
Hydrogen bonds among water molecules

Scientific background

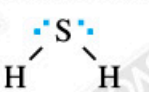
* **Electronegativity :** it is a measurement for the atom's ability in the molecule to attract the electron of the chemical bond towards itself.
* **Hydrogen bond :** A bond that arises among molecules containing hydrogen atom bound to another atom of higher electronegativity.

Note :

The boiling point of hydrogen sulphide is -61°C, although its structure is the same to water molecule, and this is due to the absence of hydrogen bonds.



Water molecule



Hydrogen sulphide molecule

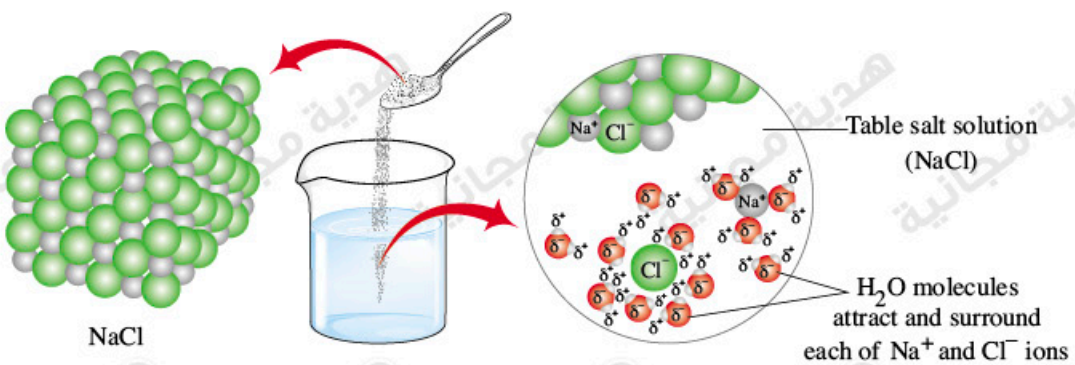
From the previous, we can hold the following comparison, as follows :

P.O.C	Water (H_2O)	Hydrogen sulphide (H_2S)
1 Type of bonds between the atoms in the molecule	Covalent	Covalent
2 Hydrogen bonds among molecules and each other	Present	Absent
3 Boiling point (at normal atmospheric pressure)	100°C	– 61°C

2 Attaching of water molecules with other polar molecules.

3 The ability of water to dissolve many salts and dissociating them into hydrated ions (i.e. any ions surrounded by water molecules).

Example : Dissolving sodium chloride (NaCl) in water.



Dissolving sodium chloride (NaCl) in water

$$NaCl_{(s)} \xrightarrow{H_2O} Cl^-_{(aq)} + Na^+_{(aq)}$$

Scientific background

When writing chemical equations, symbols are put to show the physical states of the reactants and products of the equation, **for example :**

(s) → Solid (ℓ) → Liquid (aq) → Aqueous solution

2 Hydrolysis of water

Only a small percentage of water molecules are found in the form of

Positive hydrogen ions (H^+) **Negative hydroxide ions** (OH^-)

Scientific background

Hydration : It is the process in which the ions are surrounded by water molecules without breaking down the bonds, such as surrounding the Na^+ and Cl^- ions with water molecules.

Hydrolysis : It is the binding of ions with water by breaking down the bonds, such as binding the NH_4^+ and HCO_3^- ions with water.

On adding some salts to water, the following may occur

The solution becomes neutral

For example :

On adding table salt (NaCl) to water, **no hydrolysis takes place**, but it will dissociate only into :

- Sodium ions (Na^+).
- Chloride ions (Cl^-).

Which are surrounded with water molecules in the solution without any chemical binding.

↓

So, the concentration of hydrogen ions **(H^+)** . will be **equal to** the concentration of hydroxide ions **(OH^-)**.

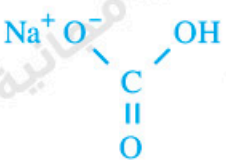
↓

Which makes the solution **neutral**.

The solution becomes alkaline (basic)

For example :

On adding sodium bicarbonate ($NaHCO_3$) in water.



Hydrolysis takes place and leads to :

- **A decrease** in the concentration of hydrogen ions **(H^+)**.
- **An increase** in the concentration of hydroxide ions **(OH^-)**.

↓

Which makes the solution **alkaline**.

The solution becomes acidic

For example :

On adding ammonium chloride salt (NH_4Cl) in water.

Hydrolysis takes place and leads to :

- **A decrease** in the concentration of hydroxide ions **(OH^-)**.
- **An increase** in the concentration of hydrogen ions **(H^+)**.

↓

Which makes the solution **acidic**.

Due to the water chemical reactions with different compounds → Hydrolysis occurs to some salts that are found in natural water. → This affects the balance of these ions. → As the unequal concentrations of hydrogen ions (H^+) and hydroxide ions (OH^-), leads to the acidity or alkalinity of the solution.

3 Acid-base balance

* **The acid-base balance in water depends on the relation between :**

The concentration of hydrogen ions H^+ "Responsible for the acidic characters" **and** The concentration of hydroxide ions OH^- "Responsible for the basic characters"

* **We can identify this relation through what is known by "The pH value of the solution".**

The pH value :

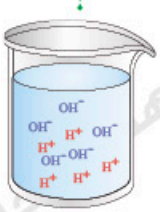
It is a graduated measurement from 0 to 14 that expresses the acidity, alkalinity or neutrality of the solution.

Types of solutions

Acidic solution

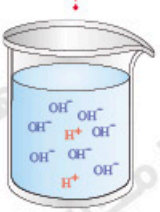
The concentration of (H^+) > The concentration of (OH^-) and the **pH** is less than 7

Neutral solution

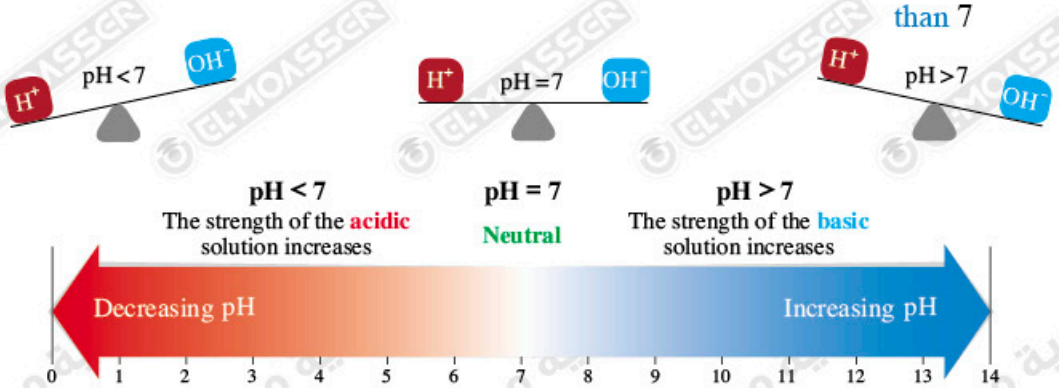


The concentration of (H^+) = The concentration of (OH^-) and the **pH** equals 7

Basic solution



The concentration of (OH^-) > The concentration of (H^+) and the **pH** is greater than 7



The relationship between the pH value and the solution nature

* **Pure water** has pH around **7**, and this is considered to be neutral.

But this number may differ for water in natural environments, which affects the living organisms that live in it.

* **The pH values of water from different sources are different according to :**

1. Different environmental factors.
2. Human activities in this region.

That consequently may affect the pH value of the formed clouds or rainwater.

* The pH value of water from different sources :

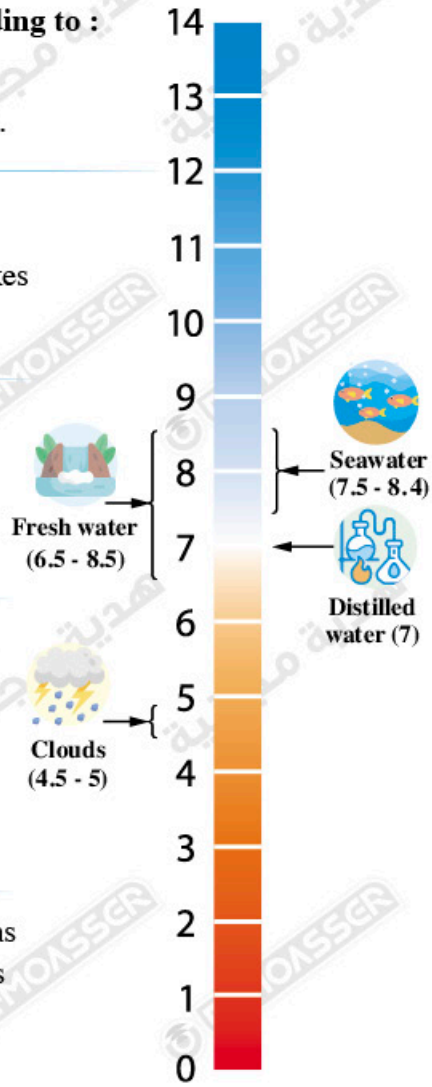
1 Seawater →
Its pH value ranges from 7.5 to 8.4 **according to :**
① The geographic location of the sea.
② The surrounding environmental factors.

2 Fresh water (Rivers & lakes) →
The pH values of rivers and freshwater lakes normally range between 6.5 : 8.5

3 Distilled water →
Its pH value equals about 7, because it is devoid of most impurities and ions that share in the acidity or alkalinity of the other natural sources of water.

4 Groundwater →
- Its pH values may be neutral or alkaline.
- It differs according to the rock structure of the area where the groundwater is found, due to the exposure to some rock salts such as calcium or magnesium carbonate.

5 Clouds →
The pH value of clouds is slightly acidic, as the values range between 4.5 : 5 and this is due to the dissolution of substances in the water drops as :
① Carbon dioxide gas.
② Other acidic gases.



Practical activity — Measuring the pH values of different water samples

Required Tools

- Water samples (seawater, river water and spring water).
- pH meter or pH test paper tapes.
- Sample cups.
- Distilled water (for calibration).
- Stirring rod.

Procedure **In case of using :**

The pH meter	The pH test paper tapes

Calibration

Calibrate the pH meter according to the manufacturing factory instructions by using distilled water.

The pH meter

Check the validity of the paper tapes by distilled water.

The pH test paper tape

Preparing samples

- Label the cups according to the type of water samples that will be measured.
- Put a little amount of each water sample in a separated cup.

Examination

- Immerse the calibrating electrode of the pH meter in each sample.
- Record the reading of each sample once settled.

- Immerse the paper in each sample for a few seconds.
- Compare its color with the measuring sheet of pH to determine the approximate pH value.

Observation and conclusion

If the device reading is :

- **Greater than 7 :** the sample is alkaline (basic).
- **Less than 7 :** the sample is acidic.
- **Equal to 7 :** the sample is neutral.

If the tape color is :

- The sample will be alkaline (basic).
- The sample will be acidic.
- The sample will be neutral.

The following table summarizes the pH values of water from different sources :

Water type	The pH value	Acidity or alkalinity	Reasons
① Seawater	7.5 : 8.4	Alkaline	According to the geographic region, where the sea is located and the surrounding environmental factors
② Fresh water (Rivers and lakes)	6.5 : 8.5	Acidic, neutral or alkaline	
③ Distilled water	7	Neutral	Because it is devoid of most impurities and ions that share in the acidity or alkalinity of the other natural sources of water.
④ Groundwater	It depends on the rock structure of the ground	Neutral – Alkaline	As the groundwater is exposed to the salts of some rocks such as calcium or magnesium carbonate.
⑤ Clouds water	4.5 : 5	Weak acidic	Due to the dissolving of carbon dioxide gas and other acidic gases in the water drops that form the clouds.

Water conservation and living organisms' health measures

Salt hydrolysis affects the water chemistry and leads to probable negative effects on the water quality and the living organisms' health. **And to reduce these effects it is necessary to :**

1. Monitor the salinity levels in water closely.
2. Monitor the change in the ionic composition inside the natural water surfaces continuously.
3. **Follow healthy and right activities to get rid of wastes, which contributes to :**
   - Reduce adding harmful salts to the water surfaces.
   - Keep the water quality for all the habitats of wildlife and human consumption purposes.

Test yourself 3

Answered

Choose the correct answer :

1 The opposite table shows the concentrations of (H^+) and (OH^-) ions in the concentration unit (M) for three different solutions (X), (Y) and (Z). Which of the following choices is correct about these solutions ?

Solution	Concentrations of (H^+) M	Concentrations of (OH^-) M
(X)	10^{-3}	10^{-11}
(Y)	10^{-9}	10^{-5}
(Z)	10^{-7}	10^{-7}

ⓐ Solution (X) is alkaline.
ⓑ Solution (Y) is alkaline.
ⓒ Solution (Z) is acidic.
ⓓ Solution (Y) is acidic.

2 Which of the following increases the pH value of the solution when dissolved in distilled water ?

ⓐ Sodium chloride salt.
ⓑ Sodium bicarbonate salt.
ⓒ Ammonium chloride salt.
ⓓ CO_2 gas.

Questions

Chapter 1 | Lesson 1

Answered

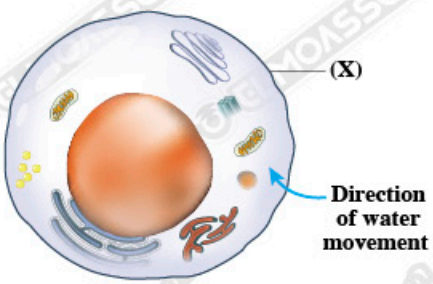
Chemical Reactions and their Effects on the Water Quality

First Multiple Choice Questions

Interactive test

Water properties

1 **The opposite figure represents a living cell, what is the role of structure (X) on passing water through it in the direction illustrated in the figure ?**



ⓐ Producing energy.
ⓑ Passing nutrients.
ⓒ Passing wastes.
ⓓ Protecting the cell.

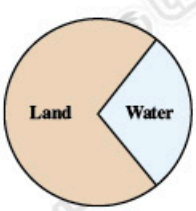
2 **Which of the following properties makes water a suitable medium for completing many chemical reactions ?**

ⓐ Its various physical states.
ⓑ Its ability to dissolve other substances.
ⓒ Its transparency.
ⓓ Its high boiling point.

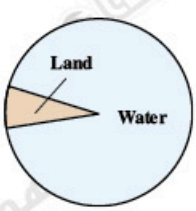
Hydrosphere of planet Earth

3 **Which of the following figures is considered a correct distribution for water on Earth ?**

ⓐ



ⓑ



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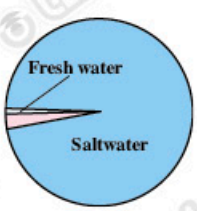


ⓓ

4 **What are the states of matter at which water exists in the spheres of planet Earth ?**

ⓐ Solid and liquid.
ⓑ Solid, liquid and gaseous.
ⓒ Solid and gaseous.
ⓓ Liquid and gaseous.

5 **What is the percentage that oceans, seas and salty lakes represent from the total area of liquid water covering the Earth's surface ?**

ⓐ 70%
ⓑ 97%
ⓒ 3%
ⓓ 30%

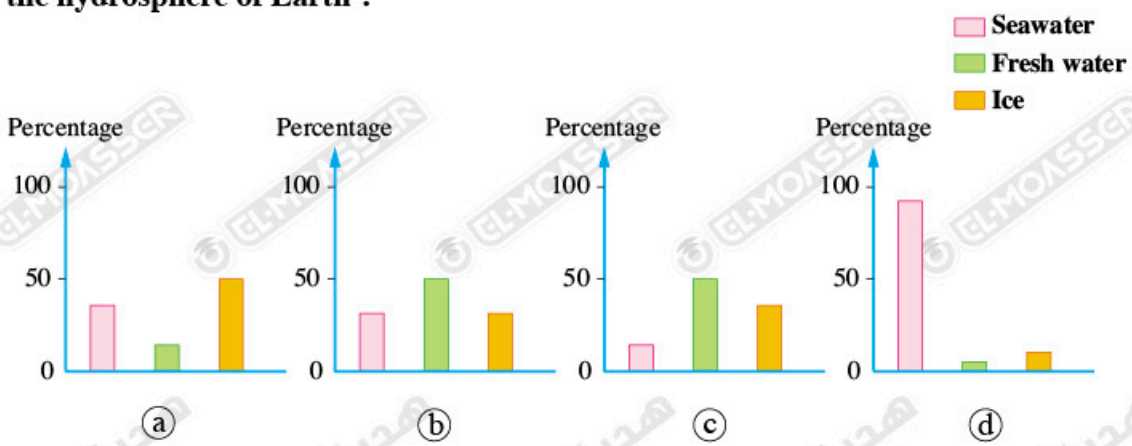
6 **Which of the following represents the largest source of water on the Earth's surface ?**

ⓐ Oceans.
ⓑ Fresh lakes.
ⓒ Groundwater.
ⓓ Glaciated rivers.

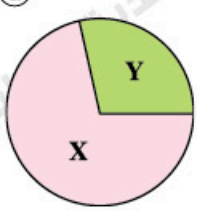
7 **What is the ratio of the area occupied by water to the area of land on the Earth's surface ?**

ⓐ $\frac{3}{7}$ ⓑ $\frac{7}{10}$ ⓒ $\frac{3}{10}$ ⓓ $\frac{7}{3}$

8 **Which of the following graphs represents the water distribution approximately in the hydrosphere of Earth ?**



9 **From the opposite figure that represents the surface area of Earth, the area denoted by (Y) may represent the surface area of .....**



ⓐ deserts. ⓑ land.
ⓒ rivers. ⓓ forests.

10 **Which of the following represents the percentage of cryosphere in the hydrosphere ?**

ⓐ 1% ⓑ 2% ⓒ 70% ⓓ 97%

11 **Type of water surfaces in Egypt are represented in .....**

ⓐ river, oceans and seas. ⓑ river, lakes and seas.
ⓒ lakes, groundwater and gulfs. ⓓ river, seas and groundwater.

The role of water in nature

12 **Which of the following statements isn't applied to the water cycle in nature ?**

ⓐ It includes water movement through many pathways.
ⓑ Living organisms have a role in its continuity.
ⓒ It keeps the constancy of the Earth's surface.
ⓓ It represents a nearly closed system.

13 **Which of the following contribute greatly to the formation of clouds ?**

ⓐ Evaporation of water from the water surfaces.
ⓑ Transpiration in plants.
ⓒ Respiration in animals.
ⓓ Respiration in plants.

14 **Which of the following processes may be a direct source of groundwater ?**

ⓐ Water evaporation. ⓑ Respiration in human.
ⓒ Transpiration in plants. ⓓ Water infiltration (leakage).

15 **When the clouds water react chemically with the acidic oxides of gases that exist in air, thus the falling rains would act on the .....**

ⓐ disintegration and decomposition of rocks.
ⓑ flourishing of the vegetation growth.
ⓒ formation of fresh lakes.
ⓓ increasing the pH value of groundwater.

16 **What is the process in which the plant loses a part of its water content to the atmosphere ?**

ⓐ Photosynthesis. ⓑ Transpiration.
ⓒ Diffusion. ⓓ Osmosis.

17 **What is the biological process that the living organism performs, and shares through it in the water cycle in nature ?**

ⓐ Respiration. ⓑ Transpiration. ⓒ Photosynthesis. ⓓ Growth.

18 **The water cycle in nature is known as ..... cycle.**

ⓐ hydrogen ⓑ biogeochemical ⓒ hydro-electric ⓓ hydrological

19 **How water returns from land to oceans ?**

ⓐ By evaporation. ⓑ By flowing.
ⓒ By condensation. ⓓ By volatility.

20 **Which of the following processes is opposite to the condensation process in the water cycle in nature ?**

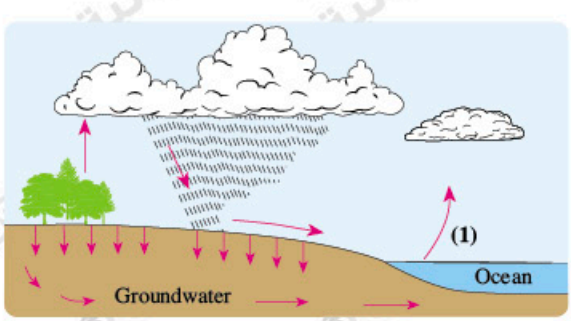
ⓐ Water infiltration (leakage) through the soil pores.
ⓑ Evaporation from water surfaces.
ⓒ Rain falling.
ⓓ Ice melting.

21 **Which of the following processes leads water to reach the underground ?**

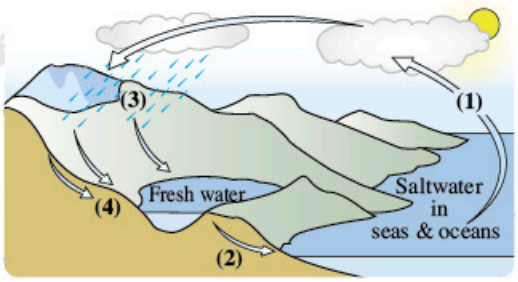
ⓐ Rivers run-off.
ⓑ Evaporation.
ⓒ Water infiltration (leakage) through the soil pores.
ⓓ Rain falling.

22 **The opposite figure represents a part of the water cycle in nature. So, process no. (1) participates in ..... directly.**

ⓐ rain falling
ⓑ clouds formation
ⓒ plants respiration
ⓓ snow falling



23 The opposite figure illustrates some processes in the water cycle in nature :



(1) Which of the following processes directly precedes the condensation process ?

ⓐ (1) ⓑ (2)
ⓒ (3) ⓓ (4)

(2) Which of the following processes doesn't take place by the action of gravity ?

ⓐ (1) ⓑ (2) ⓒ (3) ⓓ (4)

---

24 Which of the following processes doesn't result in increasing the percentage of water vapor in the atmosphere ?

ⓐ Transpiration in plants.
ⓑ Water infiltration (leakage) through sedimentary rocks.
ⓒ Animals respiration.
ⓓ Seawater evaporation.

---

25 What is the direct role of transpiration process in the hydrological cycle ?

ⓐ Water infiltration (leakage) through sedimentary rocks.
ⓑ Condensation of water vapor forming clouds.
ⓒ Increasing CO_2 gas percentage in the atmosphere.
ⓓ Increasing the water vapor in the atmosphere.

The chemical structure of water

26 What is the type of bonds in the water molecules ?

ⓐ Hydrogen bond. ⓑ Covalent bond.
ⓒ Ionic bond. ⓓ Metallic bond.

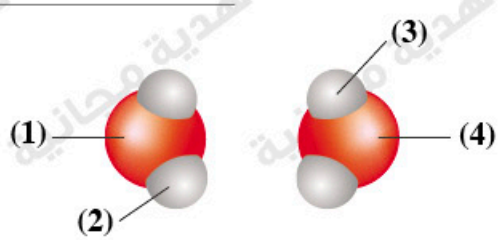
---

27 What is the value of the angle between the two bonds in the water molecule ?

ⓐ 10.45° ⓑ 104.5° ⓒ 105.4° ⓓ 10.54°

---

28 The opposite figure shows two water molecules, where a hydrogen bond is formed between the two atoms .....



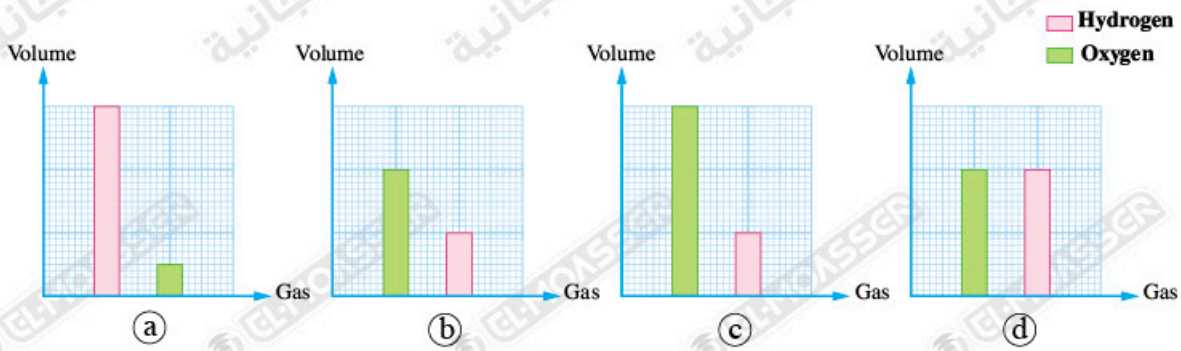
ⓐ (1) and (2). ⓑ (2) and (3).
ⓒ (2) and (4). ⓓ (1) and (4).

---

29 What are the bonds that exist in one molecule of water ?

ⓐ Two covalent bonds.
ⓑ Two hydrogen bonds.
ⓒ One covalent bond and one hydrogen bond.
ⓓ One double covalent bond.

30 **Which of the following graphs illustrates the volumes of hydrogen and oxygen gases respectively, when an amount of acidified water is electrolyzed by using Hofmann voltmeter ?**



31 **Which of the following represents the mass and volume of the gases forming water when electrolyzed an amount from it in the range of pressure and temperature ?**

ⓐ O_2 is lighter in mass and larger in volume.
ⓑ O_2 is heavier in mass and smaller in volume.
ⓒ H_2 is smaller in mass and volume.
ⓓ H_2 is greater in mass and volume.

32 **What is the approximate ratio of oxygen mass to hydrogen mass in water molecule ?**

ⓐ $\frac{1}{8}$ ⓑ $\frac{1}{2}$ ⓒ $\frac{2}{1}$ ⓓ $\frac{8}{1}$

33 **What is the mass of hydrogen in a sample of distilled water whose mass is 200 g ?**

ⓐ 177.78 g ⓑ 88.89 g ⓒ 11.11 g ⓓ 22.22 g

Chemical properties of water

34 **What is the main reason for the polarity of water molecule ?**

ⓐ The difference in electronegativity between the atoms of its elements.
ⓑ The difference in the atomic mass between its elements.
ⓒ The difference in the atomic volume between its elements.
ⓓ The type of covalent bonds between its atoms.

35 **Water polarity causes** .....

ⓐ dissolving many substances in water. ⓑ decreasing the water density.
ⓒ the acidic effect of water. ⓓ the basic effect of water.

36 **On heating a sample of pure water till boiling,** .....

ⓐ the covalent bonds are broken and water molecules are released in the form of water vapor.
ⓑ the covalent bonds are broken and hydrogen atoms are separated from oxygen atoms.
ⓒ the hydrogen bonds are broken and water molecules are released in the form of water vapor.
ⓓ the hydrogen bonds are broken and hydrogen atoms are separated from oxygen atoms.

37 **Hydrogen bond is originated among water molecules, due to the attraction between .....**

ⓐ oxygen atom of water molecule with oxygen atom of another water molecule.
ⓑ hydrogen atom of water molecule with hydrogen atom of another water molecule.
ⓒ oxygen atom of water molecule with hydrogen atom of another water molecule.
ⓓ oxygen atom with hydrogen atom in the same water molecule.

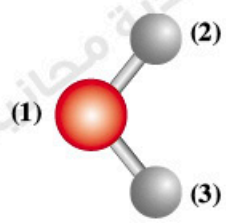
38 **What is the reason of forming hydrogen bonds among water molecules ?**

ⓐ Volume of (O) atom > Volume of (H) atom
ⓑ Mass of (O) atom > Mass of (H) atom
ⓒ Density of (O) atom > Density of (H) atom
ⓓ Electronegativity of (O) atom > Electronegativity of (H) atom

39 **Which of the following represents the volumetric percentages of hydrogen and oxygen respectively, when a sample of water is electrolyzed ?**

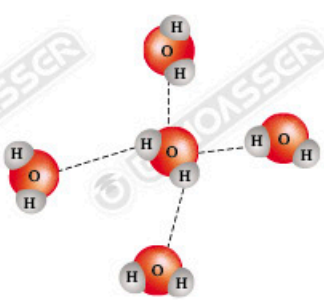
ⓐ 33.33% / 66.67%
ⓑ 66.67% / 33.33%
ⓒ 11.11% / 88.89%
ⓓ 88.89% / 11.11%

40 **The opposite figure illustrates the structure of water molecule, which atoms carry a partial positive charge ?**



ⓐ Atoms (1) and (2).
ⓑ Atoms (1) and (3).
ⓒ Atoms (2) and (3).
ⓓ Atoms (1), (2) and (3).

41 **The opposite figure represents a number of water molecules. What is the number of hydrogen and covalent bonds respectively ?**

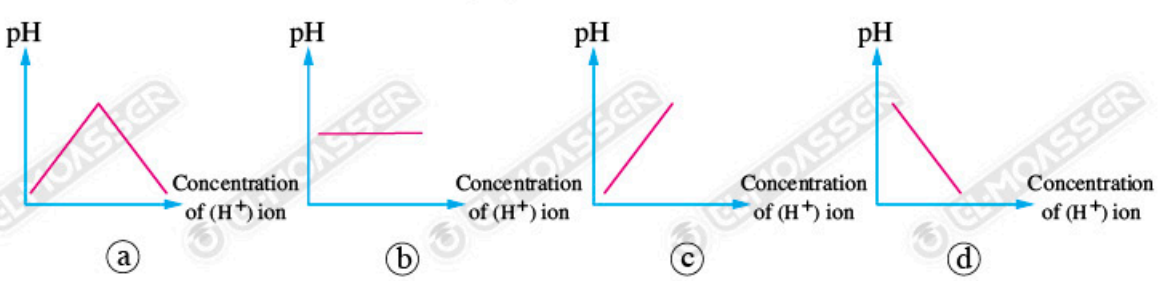


ⓐ 4 / 10
ⓑ 5 / 4
ⓒ 4 / 5
ⓓ 10 / 4

42 **Water resembles hydrogen sulphide in .....**

ⓐ the molecule polarity.
ⓑ the boiling point.
ⓒ the presence of hydrogen bonds.
ⓓ the molecule structure.

43 **Which of the following graphs illustrates the relation between the pH value of the solution and the concentration of (H^+) ions in it ?**



44 **The solution at which the concentration of (H^+) ions in it is less than the concentration of (OH^-) ions is** .....

ⓐ acidic solution and its pH value is less than 7
ⓑ acidic solution and its pH value is higher than 7
ⓒ basic solution and its pH value is less than 7
ⓓ basic solution and its pH value is higher than 7

45 **On diluting a concentrated hydrochloric acid HCl, the pH value increases because of** .....

ⓐ increasing the concentration of Cl^- ions.
ⓑ decreasing the concentration of Cl^- ions.
ⓒ increasing the concentration of H^+ ions.
ⓓ decreasing the concentration of H^+ ions.

46 **On adding drops of sodium hydroxide solution (NaOH) to hydrochloric acid (HCl) (pH = 3), the pH value of the produced solution is** .....

ⓐ 1 ⓑ 4 ⓒ 3 ⓓ 2

47 **On dissolving ammonium chloride salt in water,** .....

ⓐ hydrolysis takes place and the solution becomes acidic.
ⓑ hydrolysis takes place and the solution becomes basic.
ⓒ the salt dissociates but no hydrolysis takes place.
ⓓ the salt doesn't dissociate and no hydrolysis takes place.

48 **What is the pH value of a sample of soda that has a percentage of carbon dioxide ?**

ⓐ 4 ⓑ 7 ⓒ 8 ⓓ 9

49 **You have a solution of an unknown salt whose pH is 5.3. So, it is probable that the solution is for** ..... **salt.**

ⓐ sodium chloride ⓑ sodium bicarbonate
ⓒ ammonium chloride ⓓ sodium hydroxide

50 **Which of the following solutions have the highest pH value ?**

ⓐ Sodium chloride solution. ⓑ Acetic acid solution.
ⓒ Lithium hydroxide solution. ⓓ Nitric acid solution.

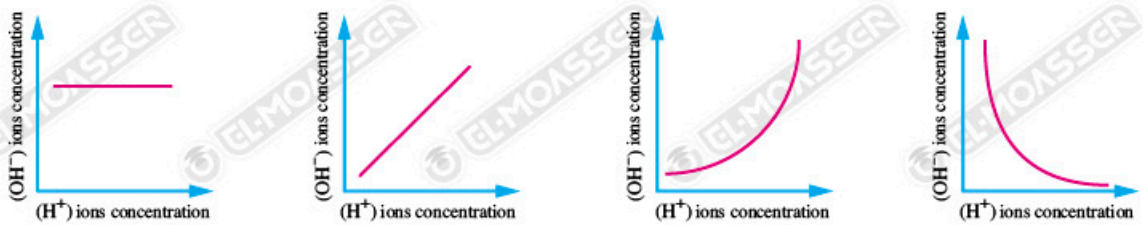
51 **The patient who suffers from severe heartburn (stomach acid reflux) is advised to** .....

ⓐ use a suitable treatment that decreases the pH
ⓑ use a suitable treatment that increases the pH
ⓒ eat food that increases the (H^+) ions concentration.
ⓓ drink soda that contains percentage of CO_2

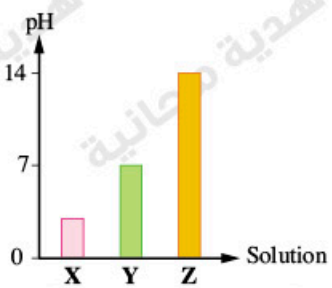
52 **On adding drops of sulphuric acid to an amount of distilled water, the pH value of the resulted solution becomes .....**

ⓐ 12 ⓑ 2 ⓒ 7 ⓓ 8

53 **Which of the following graphs is considered the correct relation between the concentration of each of (H^+) and (OH^-) ions with the continuous dissolution of excess ammonium chloride in water ?**



54 **The opposite graph represents the pH values of three solutions (X, Y and Z). Which of the following is correct about the concentration of (H^+) and (OH^-) ions ?**



ⓐ In solution (X), the concentration of (H^+) ion = the concentration of (OH^-) ion.

ⓑ In solution (Y), the concentration of (H^+) ion > the concentration of (OH^-) ion.

ⓒ In solution (Z), the concentration of (H^+) ion < the concentration of (OH^-) ion.

ⓓ In solution (X), the concentration of (OH^-) ion > the concentration of (H^+) ion.

55 **When dissolving potassium carbonate salt in a suitable amount of distilled water, the pH of the solution increases because of .....**

ⓐ increasing the concentration of (H^+) ions.

ⓑ increasing the concentration of (OH^-) ions.

ⓒ decreasing the concentration of (OH^-) ions.

ⓓ decreasing the concentration of each (H^+) and (OH^-) ions.

56 **The ratio of (H^+) ions concentration in an acidic solution to their concentration in an alkaline solution is .....**

ⓐ greater than 1 ⓑ equals 1

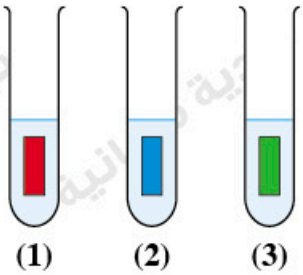
ⓒ less than 1 ⓓ equals 7

57 **On dissolving sodium carbonate salt in water, the solution becomes .....**

ⓐ acidic. ⓑ basic.

ⓒ neutral. ⓓ amphoteric.

58 **Three litmus papers were immersed in solutions (1), (2) and (3), as in the opposite figure. Which of the following choices is correct ?**



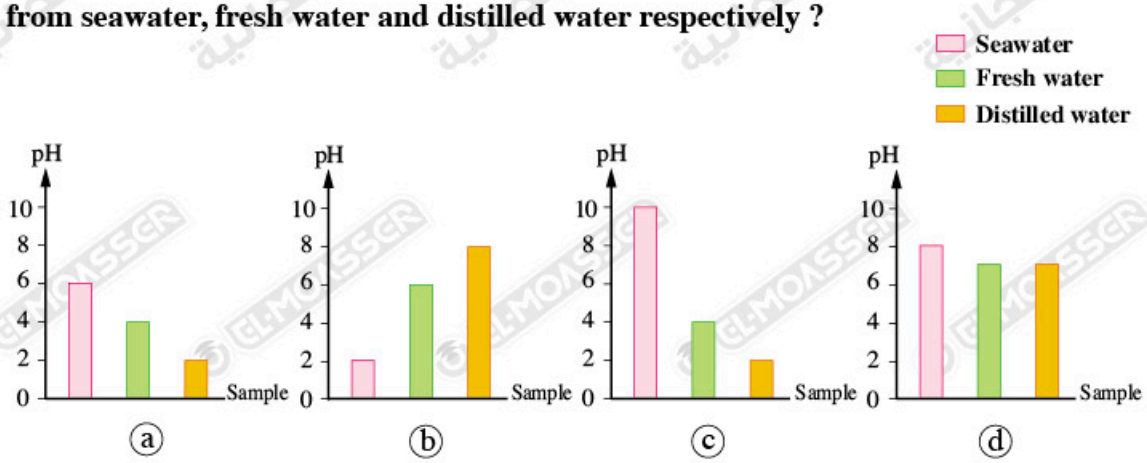
	Solution (1)	Solution (2)	Solution (3)
(a)	Ammonium chloride	Sodium bicarbonate	Sodium chloride
(b)	Sodium chloride	Ammonium chloride	Sodium bicarbonate
(c)	Sodium bicarbonate	Sodium chloride	Ammonium chloride
(d)	Sodium chloride	Sodium bicarbonate	Ammonium chloride

59 **Which of the following when added to a sample of seawater always decreases its pH value ?**

(a) Sodium bicarbonate salt. (b) Sodium chloride salt.

(c) Distilled water. (d) Groundwater.

60 **Which of the following graphs expresses the pH values of water samples that taken from seawater, fresh water and distilled water respectively ?**



61 **The boiling point of compound H_2X is less than that of compound H_2Y and both have the same structure. Which of the following is correct ?**

	The electronegativity of element (X)	The polarity of compound (H_2Y)
(a)	Greater than the electronegativity of element (Y)	Less than the polarity of compound (H_2X)
(b)	Greater than the electronegativity of element (Y)	Greater than the polarity of compound (H_2X)
(c)	Less than the electronegativity of element (Y)	Less than the polarity of compound (H_2X)
(d)	Less than the electronegativity of element (Y)	Greater than the polarity of compound (H_2X)

62 **The ratio between the pH values of the clouds water and distilled water respectively is .....**

ⓐ less than 1 ⓑ greater than 1 ⓒ equals 1 ⓓ zero.

63 **From the opposite pH-meter reading, we deduce that the solution may be .....**

ⓐ diluted hydrochloric acid.

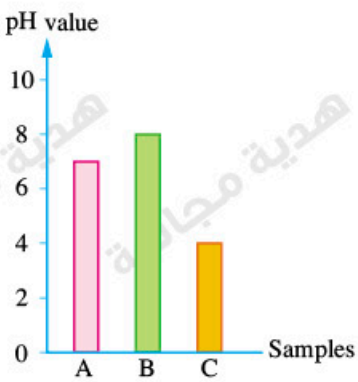
ⓑ seawater.

ⓒ fresh water.

ⓓ sodium hydroxide solution.

64 **The following graph represents the pH values of three different samples (A), (B) and (C). Which of the following choices is correct ?**

	Sample (A)	Sample (B)	Sample (C)
ⓐ	Seawater	Distilled water	Sulphuric acid
ⓑ	Distilled water	Seawater	Sulphuric acid
ⓒ	Sulphuric acid	Distilled water	Seawater
ⓓ	Seawater	Sulphuric acid	Distilled water



65 **Which of the following resulted from the dissolution of sodium bicarbonate in water ?**

ⓐ The concentration of (OH^-) ions decreases.

ⓑ The concentration of (H^+) ions increases.

ⓒ The pH value decreases.

ⓓ The pH value increases.

66 **When immersing the pH paper test tape in a sample of concentrated solution of NaOH, the tape colour becomes .....**

ⓐ red. ⓑ orange. ⓒ yellow. ⓓ blue.

67 **At normal atmospheric pressure, the boiling point of water is greater than that of hydrogen sulphide by .....**

ⓐ 100°C ⓑ –61°C ⓒ 39°C ⓓ 161°C

68 **The dissolution of an unknown salt in water leads to a decrease in the concentration of (H^+) ions. What is your conclusion about the nature of the formed salt solution ?**

ⓐ Acidic. ⓑ Basic. ⓒ Neutral. ⓓ Amphoteric.

69 **Which of the following expresses the ratio between the concentration of (H^+) ions and the concentration of (OH^-) ions respectively in pure water and sodium chloride solution ?**

	Pure water	Sodium chloride solution
(a)	1 : 1	1 : 2
(b)	2 : 1	1 : 1
(c)	2 : 1	2 : 1
(d)	1 : 1	1 : 1

70 **On dissolving a crystal of NaCl in water, ... occur.**

(a) the hydration of Na^+ ions and the hydrolysis of Cl^- ions

(b) the hydration of Cl^- ions and the hydrolysis of Na^+ ions

(c) the hydration of both Na^+ and Cl^- ions

(d) the hydrolysis of Na^+ and Cl^- ions

71 **Which of the following expresses the relation between the concentration of (OH^-) ions and the concentration of (H^+) ions in each of ammonium chloride solution and sodium bicarbonate solution ?**

	Ammonium chloride solution	Sodium bicarbonate solution
(a)	$(OH^-) > (H^+)$	$(OH^-) < (H^+)$
(b)	$(OH^-) < (H^+)$	$(OH^-) > (H^+)$
(c)	$(OH^-) > (H^+)$	$(OH^-) = (H^+)$
(d)	$(OH^-) = (H^+)$	$(OH^-) > (H^+)$

Second Miscellaneous Questions

1 **Write the scientific term for each of the following statements :**

(a) A nearly closed system that can change the Earth's surface chemically, physically and biologically through a continuous change in the three states of water.

(b) The fresh water that is formed due to the infiltration (leakage) of water within the pores of soil through sedimentary rocks.

(c) The rains that are resulted from the chemical reaction of water in clouds with the compounds that exist in air.

(d) The type of chemical bond that arises between the hydrogen atom and oxygen atom in water molecule.

(e) A bond that arises among water molecules, where it causes the elevation of the boiling point of water.

(f) * A measurement that expresses the concentrations of hydrogen and hydroxide ions in the solution.
* A graduated measurement of values from 0 to 14, that expresses the acidity or alkalinity of solutions or fluids.

(g) The solution where the concentration of hydrogen ions equals the concentration of hydroxide ions.

(h) The solution where the concentration of hydrogen ions is less than the concentration of hydroxide ions.

(i) The solution where the concentration of hydrogen ions is higher than the concentration of hydroxide ions.

---

2 Give reason for :

(a) Water has an important role inside the living organisms' cells.

(b) Water is a polar compound.

(c) * The elevation of the boiling point of pure water.
* Water is liquid but hydrogen sulphide is gas, despite having similar chemical structure.

(d) The solution that is produced from the dissociation of sodium chloride salt in water is neutral.

(e) The solution that is produced from the hydrolysis of sodium bicarbonate salt in water is alkaline.

(f) The solution that is produced from the hydrolysis of ammonium chloride salt in water is acidic.

(g) The clouds water above industrial regions are acidic.

(h) The pH value of distilled water is 7

---

3 What happens in each case of the following :

(a) The reaction of water vapor with carbon and sulphide oxides in air "**according to :** rains".

(b) The infiltration (leakage) of water through the pores of soil and sedimentary rocks through time ?

(c) Adding table salt to water "**according to :** the water pH value".

(d) Adding sodium bicarbonate salt to water "**according to :** the water pH value".

(e) Adding ammonium chloride salt to water "**according to :** the water pH value".

(f) The falling of acid rains on rocks.

---

4 Compare between each of :

(a) Saltwater **and** fresh water on the Earth's surface "**according to :** percentage – distribution".

(b) Water **and** hydrogen sulphide "**according to :** chemical structure – boiling point".

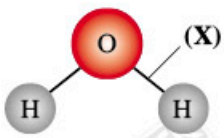
(c) Table salt, sodium bicarbonate **and** ammonium chloride when dissolving each of them in water "**according to :** the pH of the solution – hydrolysis – the relation between the concentration of (OH^-) and (H^+) in the solution".

(d) Seawater **and** fresh water "**according to :** the pH value range".

(e) Distilled water **and** clouds water "**according to :** the pH value range".

5 **Explain how** the clouds are formed ? **And what** is the importance of this process in the water cycle in nature ?

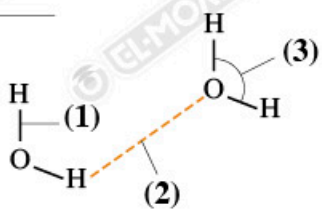
6 **Study the opposite figure, then answer :**



(a) **What** is the type of bond (X) ?

(b) **Determine** the places of the partial positive and partial negative charges on the figure.

7 **The opposite figure shows two types of bonds :**



(a) **What** is the type of bonds (1) & (2) ?

(b) **What** is the value of angle (3) ?

8 **Why** the dissolution of table salt in water is considered a hydration process ?

9 **What** are the main processes that are included in the water cycle in nature ?

10 **How** the gases that are produced from the industrial activities affect the water cycle in nature ?

11 **Show a difference between :** the covalent bond **and** the hydrogen bond in water.

12 There are three samples of the same volume from seawater, fresh water and distilled water. **Explain how can you use the pH-meter to distinguish them ?**

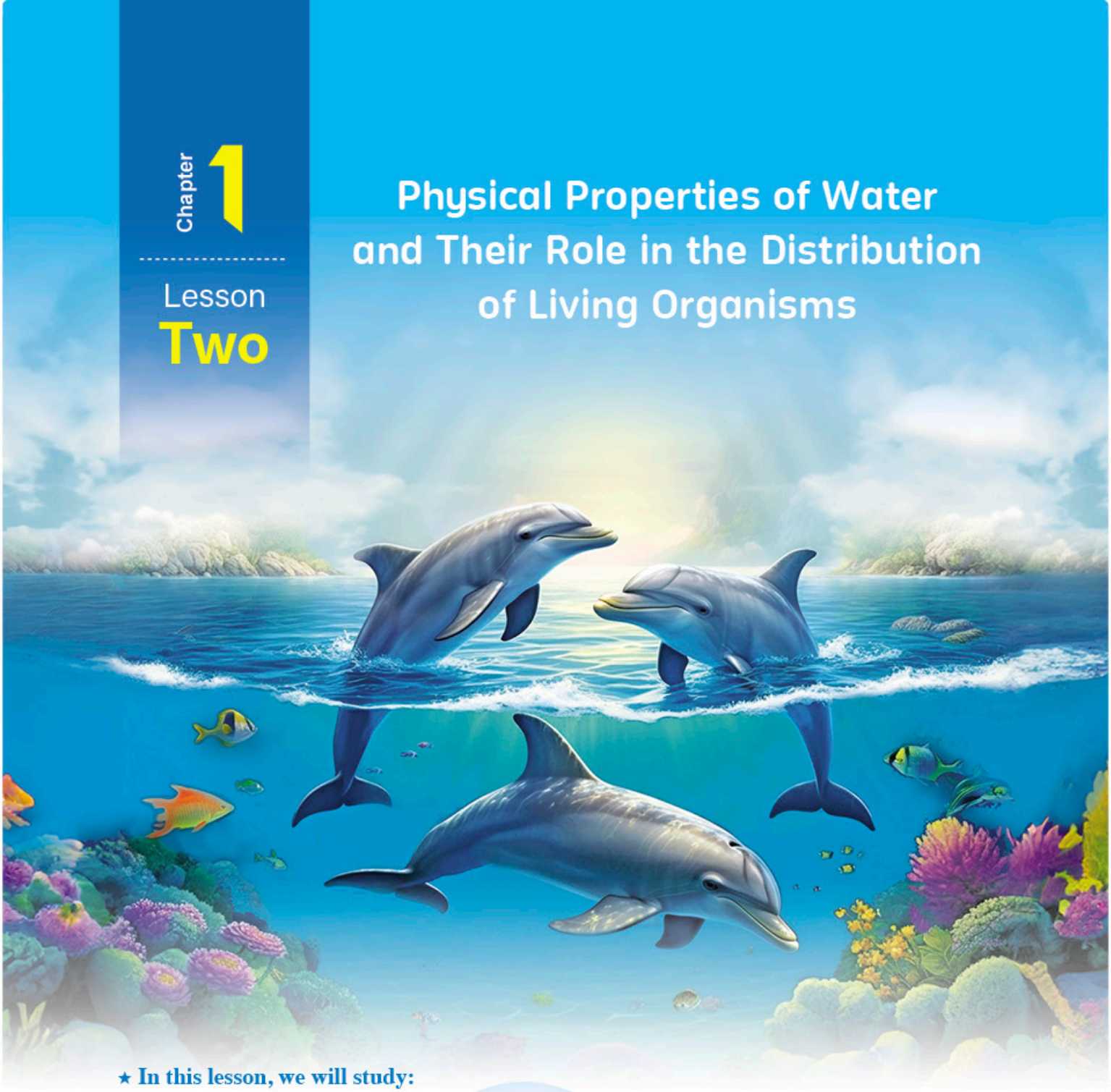
13 In front of you three solutions (ammonium chloride – sodium carbonate – sodium chloride). **How can you distinguish them by using the pH-meter ?**

14 **Why** should we monitor the salinity levels and the changes that occur in the ionic structures inside the natural water surfaces continuously ?

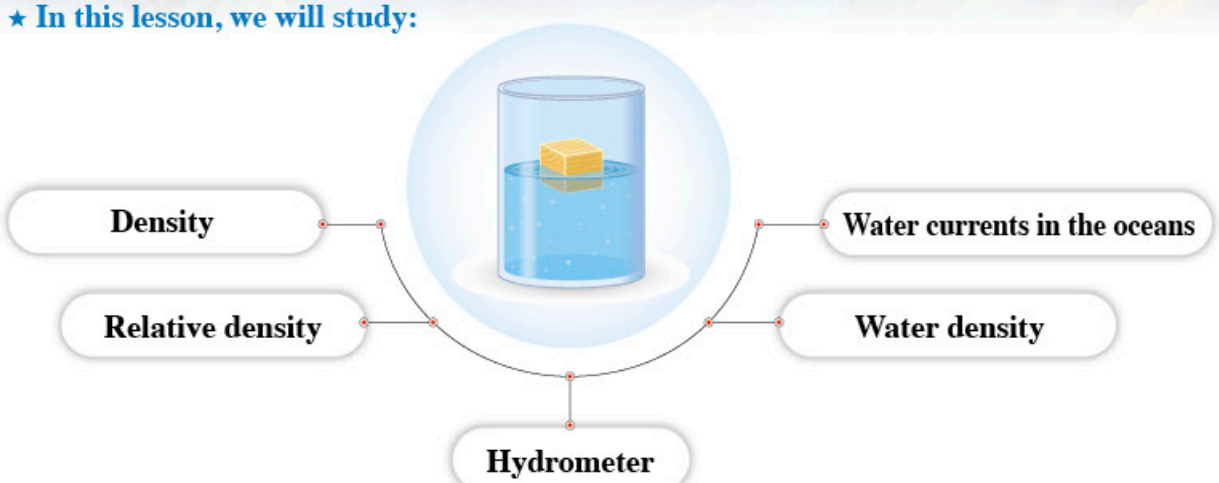
Chapter 1

Lesson Two

Physical Properties of Water and Their Role in the Distribution of Living Organisms



★ In this lesson, we will study:



Water has unique physical properties that distinguish it from other fluids, **such as :**

1. The decrease of its density when reducing its temperature from 4°C to 0°C.
2. Its high specific heat.

These unique physical properties of water influence :

1. The distribution of living organisms in aquatic environments.
2. Many other natural phenomena.

Fluid

Any substance that can flow and does not have a fixed shape but takes the shape of its container, such as liquids and gases.

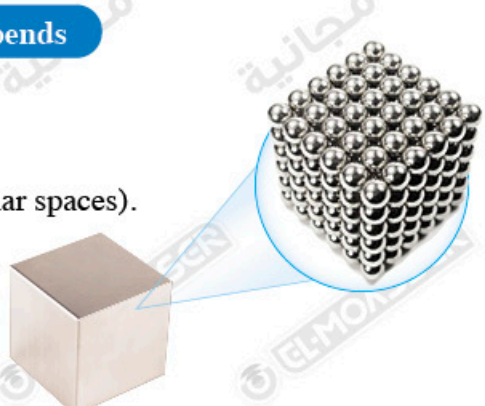
TO STUDY THESE UNIQUE PROPERTIES OF WATER, WE MUST FIRSTLY STUDY SOME CONCEPTS, INCLUDING DENSITY.

Density

Definition	The mass of a unit volume of matter at a given temperature
Mathematical formula	$\rho = \frac{m}{V}$ **Where :** (ρ) is density, (m) is mass and (V) is volume.
Measuring units	* SI unit : kg/m^3 * Other units : g/cm^3, g/L **To convert between these units :** $1\ g/cm^3 = 1000\ kg/m^3 = 1000\ g/L$
The device of measuring liquids densities	The hydrometer

The factors on which the density of a substance depends

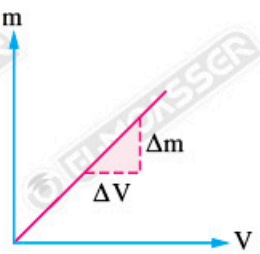
1. The mass of its molecules.
2. The distances between its molecules (intermolecular spaces).
3. The purity of the substance (the percentage of impurities it contains).
4. Temperature.



From the previous, it is clear that

- The density of pure substance does not change with the change of the mass or the volume of the sample taken from it. **This is because** the density of a pure substance is a characteristic physical property for the substance, so its value is constant at constant pressure and temperature.

- The relation between the mass (m) and the volume (V) for a group of bodies of the same substance is represented graphically by a straight line starting from the origin and inclined at an angle on the horizontal axis as shown in the opposite graph, hence the density of the substance of these bodies can be determined by finding the slope of the straight line:



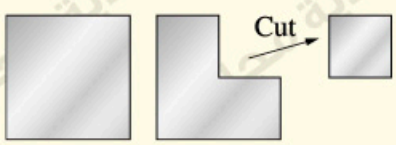
$$\text{Slope} = \frac{\Delta m}{\Delta V} = \rho$$

Test yourself 1

Answered

Choose the correct answer :

A square metallic sheet has a quarter of it cut off as shown in the opposite figure, so the density of the remaining part of the sheet ..... .



(a) increases (b) decreases

(c) remains unchanged (d) cannot be determined

Relative density

* **The relative density of a substance can be defined as follows:**

The relative density of a substance

It is the ratio of the density of the substance to the density of pure water at the same temperature.

* **Therefore, the relative density of any substance can be determined from the following relationships:**

Relative density of substance

$$= \frac{\textbf{Density of the substance} \text{ at a certain temperature}}{\textbf{Density of water} \text{ at the same temperature}}$$

$$= \frac{\textbf{Mass of a definite volume of the substance} \text{ at a certain temperature}}{\textbf{Mass of the same volume of water} \text{ at the same temperature}}$$

* The relative density has no unit of measurement **because** it is a ratio between two physical quantities of the same unit of measurement.
* The value of the relative density of a substance equals the value of its density in g/cm^3.
* **The density of a substance can be determined by knowing its relative density from the relation:**

$$\rho_{substance} = \rho_{relative} \times \rho_{water}$$

Example 1 **Choose :** A tank is containing a quantity of gasoline of mass 3450 kg and volume 5 m^3, so the density of the gasoline equals ..... .

ⓐ 720 kg/m^3 ⓑ 690 kg/m^3 ⓒ 3.455 kg/m^3 ⓓ 17.25 kg/m^3

Solution

$m = 3450\ kg$ $V = 5\ m^3$ $\rho = ?$

$\rho = \frac{m}{V} = \frac{3450}{5} = 690\ kg/m^3$ ∴ The correct answer is ⓑ

Example 2 **Choose :** If the density of aluminum and the density of water at the same temperature are 2700 kg/m^3 and 10^3 kg/m^3 respectively, the relative density of aluminum equals ..... .

ⓐ 0.27 ⓑ 0.54 ⓒ 2.7 ⓓ 5.4

Solution

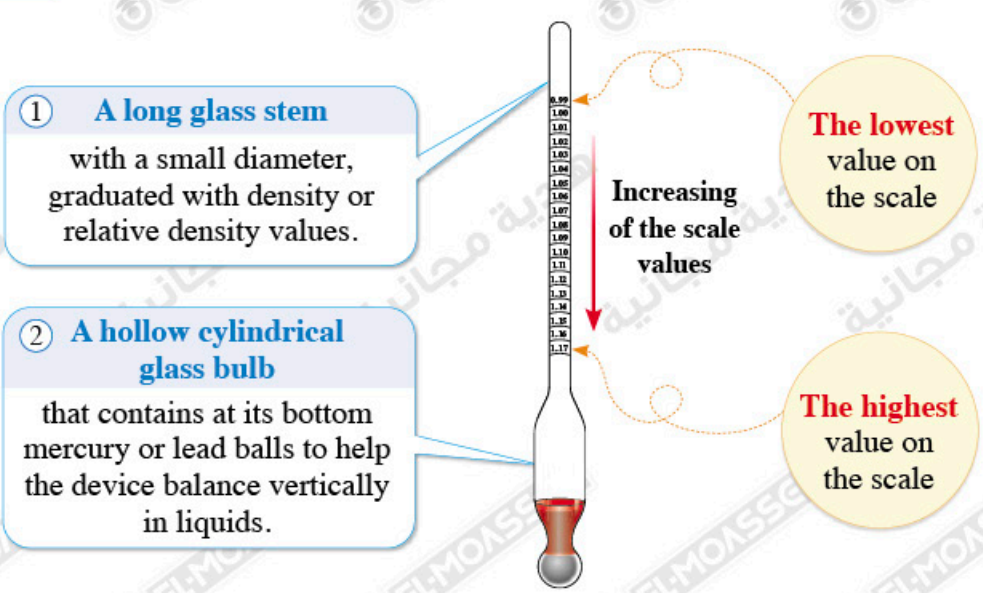
$\rho_{Al} = 2700\ kg/m^3$ $\rho_w = 10^3\ kg/m^3$ $(\rho_{Al})_{relative} = ?$

$(\rho_{Al})_{relative} = \frac{\rho_{Al}}{\rho_w} = \frac{2700}{10^3} = 2.7$ ∴ The correct answer is ⓒ

Hydrometer

Uses : ① Measuring the density of liquids. ② Measuring the relative density of liquids.

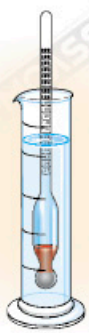
Structure :



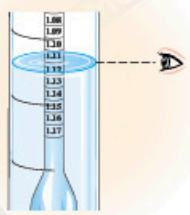
How it works :

① **Pour** a suitable amount of the liquid whose density is needed to be measured into a proper cylinder.

② **Put** the hydrometer gently into the liquid and leave it until it stabilizes, ensuring it floats freely and does not touch the sides of the cylinder.

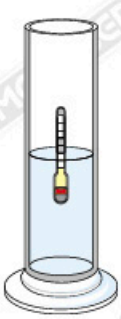


③ After stabilization, **read** the scale on the stem at the level of the liquid surface. This reading represents the density or relative density of the liquid.



Notes :

① After putting the hydrometer in the liquid, it partially sinks depending on the density of the liquid.



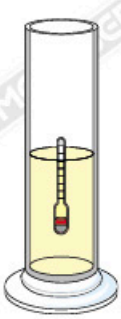
In the liquids of

High density

A larger part of the hydrometer floats.

Low density

A larger part of the hydrometer sinks.



② The hydrometer is used to predict the presence of dissolved pollutants in water by measuring the density of the water.
If the density measured by the hydrometer **differs** from the known density of water, **this indicates** the presence of dissolved pollutants in the water.

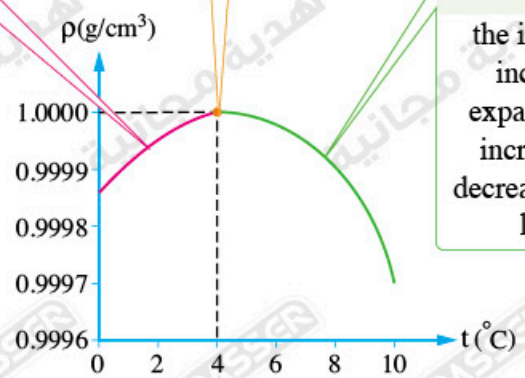
Water density

* Generally, the density of a liquid decreases with the increase in its temperature such that when increasing the temperature of a liquid, the intermolecular distances in it increase, resulting in an increase in the volume of the liquid while its mass remains constant, hence its density decreases.
* When studying the effect of temperature change on the density of pure water, it is found that its behavior between 0°C and 4°C **deviates** from the behavior of all other liquids. This **unique behavior** of water can be illustrated graphically as follows:

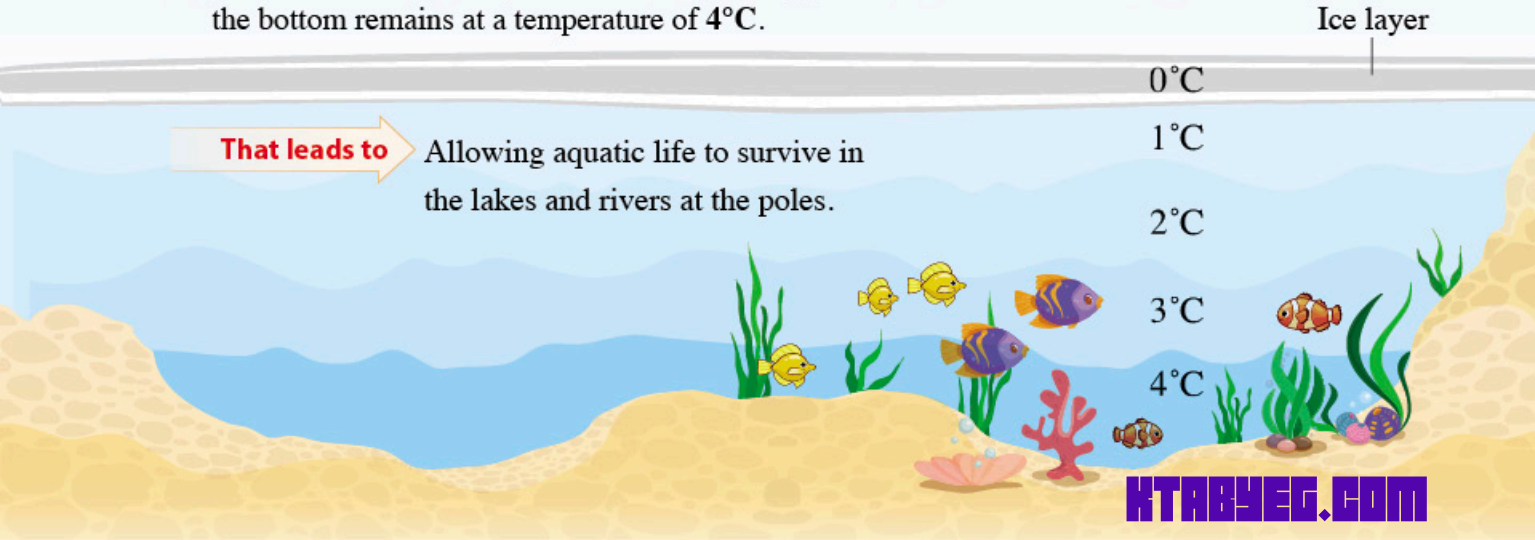
At a temperature of 4°C,
pure water reaches its maximum density, which is equal to 1000 kg/m^3 or 1 g/cm^3

When the temperature of pure water decreases from 4°C to 0°C,
the water **expands instead of shrinking** and its density decreases. This unique behavior distinguishes water from other liquids.

When the temperature of pure water is raised above 4°C,
the intermolecular spaces increase so that water expands where its volume increases and its density decreases, starting to behave like other liquids.



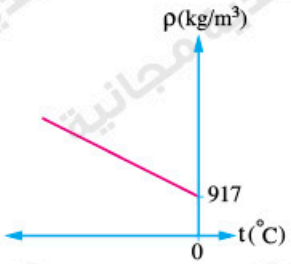
* **The previous section explains why** bodies of water in polar regions begin to freeze from the surface rather than the bottom where :
  - When the temperature of water decreases from **4°C** to **0°C**, the water layer of the surface expands and becomes less dense, causing the water of less than **4°C** to remain floating above the warmer layers of water below.
  - As the temperature continues to decrease, the surface layer freezes and the ice remains floating on the surface because its density is less than the density of the water layers below it.
  - The ice layer acts as a thermal insulator for the water below it and that prevents the entire body of water from freezing, hence the water near the bottom remains at a temperature of **4°C**.



That leads to Allowing aquatic life to survive in the lakes and rivers at the poles.

Scientific background

* The opposite graph represents the relationship between the density of ice (ρ) and its temperature (t).
* **By comparing the opposite graph with the graph of water, we can notice:**
  - The density of ice at 0°C is less than the density of pure liquid water at 0°C.
  - As the temperature of ice decreases, its density increases.



Practical Experiment

for demonstrating the effect of the difference in density on the movement of water

Steps

1. **Prepare** two identical colored ice cubes by freezing pure water after adding to them some food dye for making the observation of the melting process of the ice cubes and the movement direction of water after melting easier.
2. **Bring** two cups containing equal quantities of water at room temperature, one contains freshwater and the other contains saltwater with salinity close to that of seawater.
3. **Place** one ice cube in each cup.
4. **Observe** the movement of the water around the ice cubes.

Observation

1. The ice cube placed in freshwater melts faster than the ice cube placed in saltwater.
2. **During the melting of the ice cube in:**

Freshwater

The color of the dye from the ice cube spreads **throughout the water.**

Saltwater

The color of the dye from the ice cube spreads mostly **on the surface of the water.**

Explanation

- When the ice cube starts to melt in freshwater, the cold water resulting from melting sinks to the bottom while the warmer water rises to the surface, since the density of cold water is greater than the density of warm water.
- When the ice cube starts to melt in saltwater, the cold water remains on the surface.

This is due to that the cold water resulting from the melting of the ice cube is less dense than the saltwater, so it remains floating on the surface of the saltwater,

Which leads to the formation of a layer of cold water around the ice cube, slowing down its melting process.

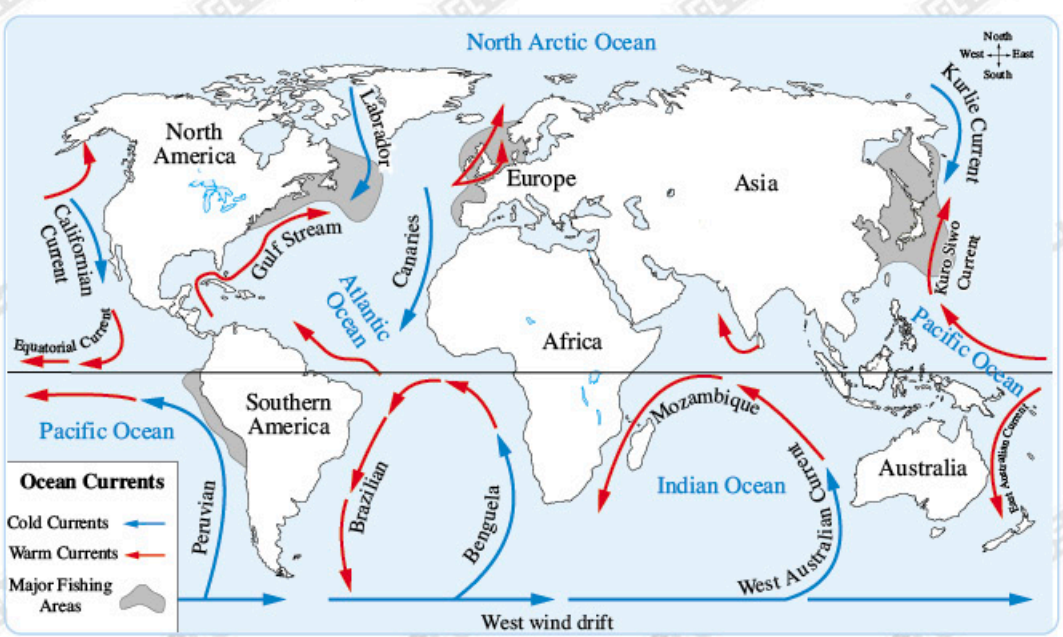
Note :

When freshwater from melting icebergs or glaciers enters the ocean (saltwater), that freshwater spreads on the surface of the ocean and does not sink where this freshwater might freeze on the surface forming a thermal insulator between the deeper parts of the ocean and the cold atmospheric air above.

Water currents in the oceans

* **Ocean currents are the movement of water from one region to another, carrying with them:**

1	2	3
Heat and salt from the tropics to the poles of the Earth.	**Nutrients** with the convection currents from the deep ocean to the surface.	**Freshwater** from rivers or melting glaciers to different places when these currents travel around the globe.



* The differences in water density at different parts of oceans are one of the causes of water currents in oceans where the density of water in different regions in oceans depends on the following factors:

1 Water pressure

The pressure on seawater increases, as depth increases, where at great depths, water molecules come slightly closer together, hence the volume decreases and the density increases a little.

2 Water temperature

When the temperature of water decreases:
- till reaching 4°C, the intermolecular distances decreases and the volume decreases leading to increasing the density of water.
- from 4°C to 0°C, the intermolecular distances increases and the water density decreases.

3 Water salinity

- Salinity represents the amount of dissolved salt in water.
- The normal salinity of ocean water is 35 g/L (equivalent to two teaspoons of salt per a cup of water).
- The higher the salinity of water, the higher its density.

Test yourself 2

Answered

Choose the correct answer :

The opposite diagram illustrates dropping ice cubes into pure water at 4°C. What happens to the density of the water during the melting of ice?

ⓐ Increases. ⓑ Decreases.

ⓒ Remains unchanged. ⓓ Cannot be determined.

Questions

Chapter 1 | Lesson 2

Answered

Physical Properties of Water and Their Role in the Distribution of Living Organisms

First Multiple Choice Questions

Interactive test

Density - Relative density - Hydrometer

1 The ability of a substance to flow and not take a fixed shape is a characteristic of ..... .

ⓐ solids and liquids ⓑ solids and gases

ⓒ liquids and gases ⓓ solids, liquids and gases

2 One of the units of density measurement is ..... .

ⓐ $N.m^{-3}$ ⓑ $g.mm^{-1}$ ⓒ $kg.cm^{-1}$ ⓓ $g.L^{-1}$

3 In the opposite figure, there are two solid cylinders made of the same metal and have the same diameter, one of them is longer than the other at the same temperature, so both cylinders have the same ..... .

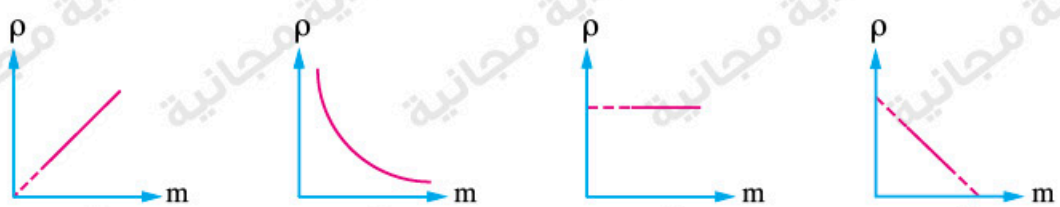
ⓐ mass ⓑ density

ⓒ volume ⓓ weight

4 In an experiment to measure the degree of pollution in a swimming pool, two samples, A and B, were taken at the same time from the swimming pool with volumes of 10 cm^3 and 40 cm^3 respectively, so the ratio of the density of water in sample B to the density of water in sample A is expected to be ..... .

ⓐ $\frac{1}{1}$ ⓑ $\frac{2}{1}$ ⓒ $\frac{4}{1}$ ⓓ $\frac{1}{4}$

5 The graph that represents the relationship between density (ρ) of pure water and mass (m) of samples from it at a temperature of 50°C is ..... .



ⓐ ⓑ ⓒ ⓓ

6 Given that the relative density of mercury is higher than the relative density of alcohol at the same temperature, then the ratio of the mass of 1 cm^3 of mercury to the mass of the same volume of alcohol is ..... .

ⓐ greater than 1 ⓑ less than 1 ⓒ equal to 1 ⓓ indeterminable

7 Two containers contain two different amounts of water. A thermometer is used to measure the temperature of water in each of them, as shown in the following figures:

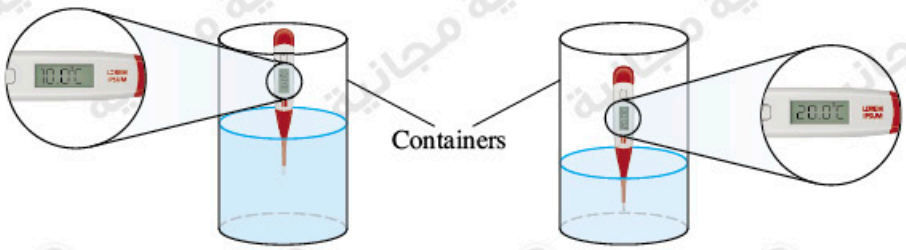


Figure (1) **Figure (2)**

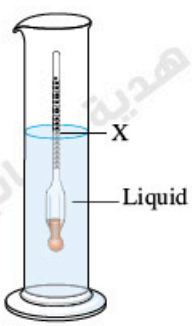
In which of the two figures (1) or (2) are the intermolecular distances between water molecules greater?

ⓐ In figure (1). ⓑ In figure (2).

ⓒ Equal in both figures. ⓓ Zero in both figures.

---

8 When a hydrometer is placed in a beaker containing a liquid, the free surface of the liquid intersects the hydrometer at the mark (X), as shown in the figure. When adding more of the same liquid at the same temperature until the beaker gets full, the free surface of the liquid will be ..... .



ⓐ still at the mark (X)

ⓑ above the mark (X)

ⓒ below the mark (X)

ⓓ above the hydrometer completely

---

9 Three glass containers, each containing a liquid. Three hydrometers were used to measure the densities of the three liquids so that their positions at equilibrium were as shown in the following figures:

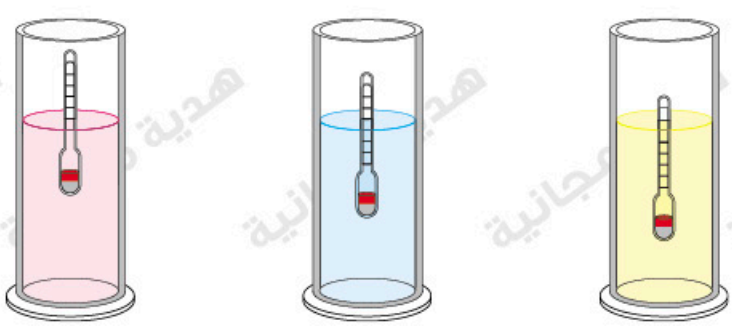


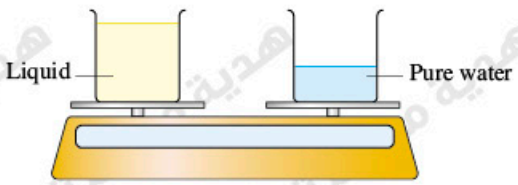
Figure (1) **Figure (2)** **Figure (3)**

So, the correct order of these figures according to the density of the liquid in each container is .....

ⓐ (1) < (2) < (3) ⓑ (1) < (3) < (2)

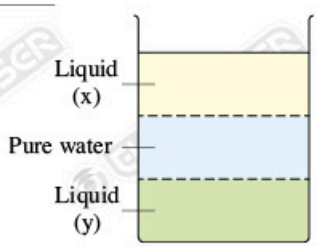
ⓒ (3) < (2) < (1) ⓓ (2) < (3) < (1)

10 The figure shows two similar beakers, one contains pure water while the other contains another liquid, placed on the two pans of a balance, so if the pans are balanced at the same horizontal level, the relative density of the liquid is ..... .



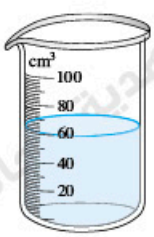
ⓐ greater than 1 ⓑ less than 1 ⓒ equal to 1 ⓓ indeterminable

11 The opposite figure shows three immiscible liquids in one container, so the ratio between the density of liquid (x) and that of liquid (y) is ..... .



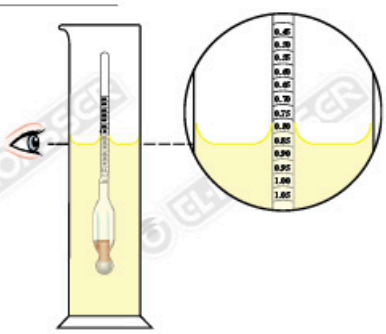
ⓐ greater than 1 ⓑ less than 1
ⓒ equal to 1 ⓓ indeterminable

12 The opposite figure shows a graduated beaker containing a sample of canal water. When a hydrometer is placed in the sample, it shows that the relative density of the sample is 1.02. What is the mass of the canal water sample in the beaker?



ⓐ 60.2 g ⓑ 61.2 g
ⓒ 72.4 g ⓓ 120.6 g

13 The opposite figure shows the measurement of the relative density of a sample of a liquid. If the relative density of pure water is 1 g/cm^3, the density of the liquid equals ..... .

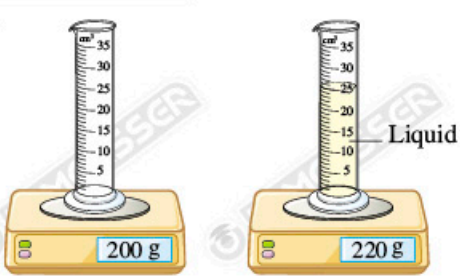


ⓐ 0.85 kg/m^3 ⓑ 118 kg/m^3
ⓒ 850 kg/m^3 ⓓ 8500 kg/m^3

14 The opposite figure shows a solid cube with a side length of 2 cm. When placed on a balance, the balance reading was 21.6 g, so the density of the cube material is ..... .

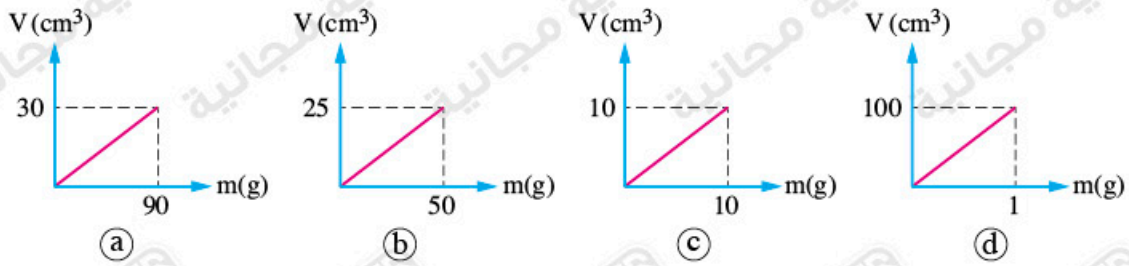
ⓐ 2700 kg/m^3 ⓑ 3600 kg/m^3
ⓒ 5400 kg/m^3 ⓓ 10800 kg/m^3

15 The opposite figure shows an experiment to determine the density of a liquid, so the density of the liquid equals ..... .



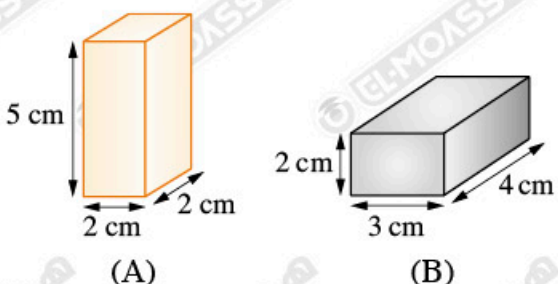
ⓐ 600 kg/m^3 ⓑ 700 kg/m^3
ⓒ 800 kg/m^3 ⓓ 1000 kg/m^3

16 Which of the following graphs represents the relation between the volume (V) in cm^3 and mass (m) in grams for samples of pure water of density 1000 kg/m^3?



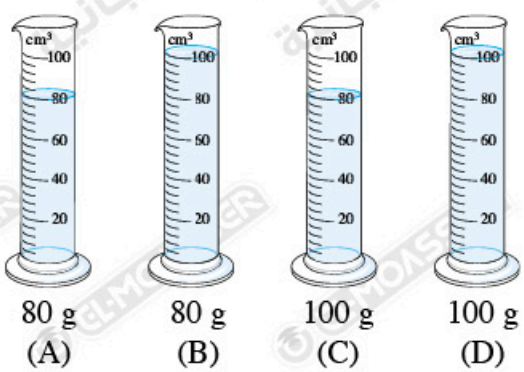
17 The opposite figure shows the dimensions of two solid bodies, A and B, having the same mass, so which body is made of the material of the higher density?

ⓐ Body A
ⓑ Body B
ⓒ Both bodies have the same material density.
ⓓ The answer cannot be determined.



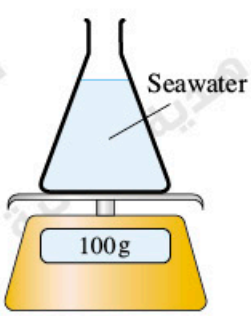
18 The opposite figure shows four graduated cylinders A, B, C and D, each containing a liquid where the mass of each liquid is shown below its cylinder. All the cylinders are in the same room at a temperature of 25°C, so the two cylinders that contain the same liquid are ..... .

ⓐ A and D ⓑ B and C
ⓒ A and C ⓓ B and D



19 A flask containing a sample of seawater was placed on the pan of a balance. The reading of the balance for the water and the flask together was 100 g, as shown in the figure. Knowing that the density of seawater is 1030 kg/m^3, what do you expect the volume of the sample to be?

ⓐ Greater than 97 cm^3 ⓑ Equal to 97 cm^3
ⓒ Less than 97 cm^3 ⓓ Cannot be determined.



20 The lead balls in the hydrometer ..... .

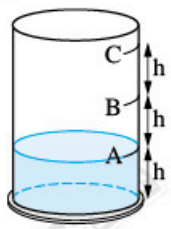
ⓐ is the reason for the immersed part of the hydrometer
ⓑ react with the substance to be measured
ⓒ balance with temperature of the liquid
ⓓ helps floating of the hydrometer

21 The density of an ice cube can be measured using ..... .

ⓐ hydrometer ⓑ a balance and a thermometer

ⓒ a ruler and a balance ⓓ a ruler and a thermometer

22 The opposite figure shows a container containing an amount of liquid X of relative density 2 with a mass m. If an amount of liquid Y of relative density 1 is added to the container with a mass m and does not mix with the first liquid, the surface level of liquid Y will settle ..... .



ⓐ at level B ⓑ at level C

ⓒ between levels A and B ⓓ between levels B and C

Water density - Water currents in the oceans

23 The density of pure water reaches its maximum value at ..... .

ⓐ 0°C ⓑ 4°C ⓒ 100°C ⓓ 104.5°C

24 The density of pure water at 4°C in SI units is ..... .

ⓐ 1000 g/m^3 ⓑ 1 g/cm^3 ⓒ 1000 kg/m^3 ⓓ 1000 kg/cm^3

25 The relative density of 500 g of pure water at 4°C is ..... .

ⓐ 500 g/cm^3 ⓑ 1 g/cm^3 ⓒ 1000 kg/m^3 ⓓ 1

26 If you left a closed glass bottle filled completely with water in the freezer, ...

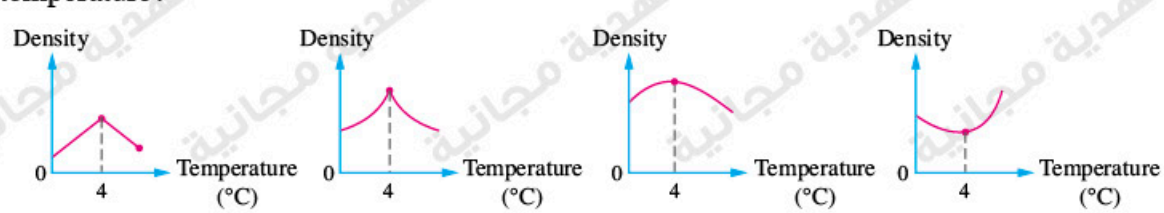
ⓐ it gets broken because water expands when it freezes

ⓑ the water shrinks when it freezes leaving some space in the bottle

ⓒ the water remains in the liquid state no matter how long it is left in the freezer

ⓓ the glass bottle expands so it doesn't get broken

27 Which of the following graphs represents the change in the density of pure water with temperature?



28 What happens to the molecules of pure water when its temperature decreases from 4°C to 0°C?

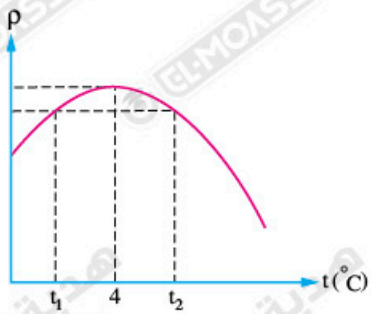
ⓐ They get closer to each other. ⓑ They get away from each other.

ⓒ They remain consistent in their positions. ⓓ Their volumes decrease.

29 A quantity of pure water of temperature 3°C is placed in a refrigerator. What happens to the mass and volume of the water when it freezes?

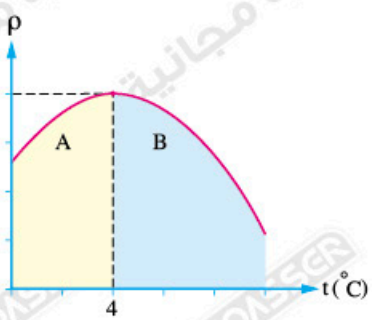
	Mass	Volume
ⓐ	Doesn't change	Doesn't change
ⓑ	Doesn't change	Increases
ⓒ	Increases	Doesn't change
ⓓ	Increases	Increases

30 The opposite graph represents the change in the density of pure water (ρ) with temperature (t), so the ratio of the volume of 1 g of water at temperature t_1 to the volume of 1 g of water at temperature t_2 is ..... .



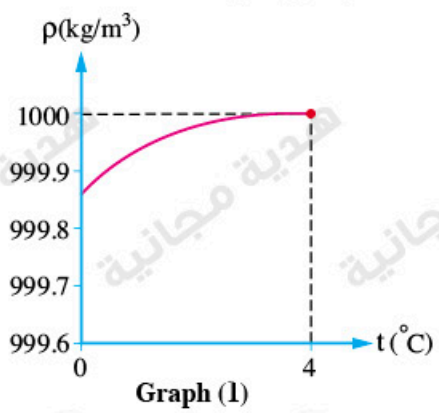
ⓐ greater than 1 ⓑ less than 1
ⓒ equal to 1 ⓓ indeterminable

31 The opposite graph represents the relation between density (ρ) of pure water and temperature (t). Which of the regions, A or B, on the graph represents the anomaly of water compared to other liquids when cooled? And why?

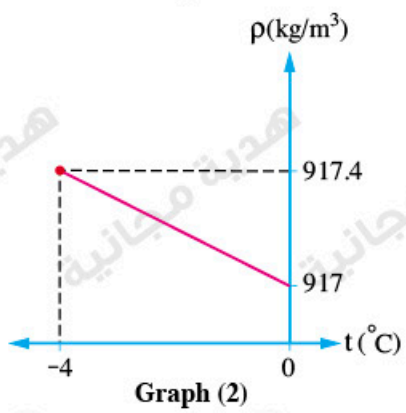


ⓐ Region A, because water expands in it.
ⓑ Region A, because water contracts in it.
ⓒ Region B, because water expands in it.
ⓓ Region B, because water contracts in it.

32 Graph (1) represents the relation between density (ρ) of pure water and its temperature (t) on the Celsius scale. Graph (2) represents the same relationship for ice.



Graph (1)



Graph (2)

By studying the two graphs, the density of ice at 0°C is ..... .

ⓐ equal to the density of liquid water at 0°C
ⓑ greater than the density of liquid water at 0°C
ⓒ less than the density of liquid water at 0°C
ⓓ indeterminable

33 What is the mass of a quantity of pure water that has a volume of 20 cm^3 at a temperature of 4°C ?

ⓐ 10 g ⓑ 20 g ⓒ 100 g ⓓ 200 g

---

34 If the volume of 1 kg of pure water at a temperature of 4°C is V_1 and the volume of 1 kg of pure water at a temperature of 2°C is V_2, so the ratio $\left(\frac{V_1}{V_2}\right)$ is ..... .

ⓐ greater than 1 ⓑ less than 1 ⓒ equal to 1 ⓓ indeterminable

---

35 A quantity of pure water has a mass of 100 g, so its volume at:

(i) 4°C is ..... .

ⓐ 100 cm^3 ⓑ greater than 100 cm^3

ⓒ less than 100 cm^3 ⓓ indeterminable

(ii) 20°C is ..... .

ⓐ 100 cm^3 ⓑ greater than 100 cm^3

ⓒ less than 100 cm^3 ⓓ indeterminable

---

36 At which temperature:

(i) does one cubic meter of pure water have the greatest mass?

ⓐ 4°C ⓑ 10°C ⓒ 25°C ⓓ 80°C

(ii) does one kilogram of pure water have a greater volume?

ⓐ 4°C ⓑ 10°C ⓒ 25°C ⓓ 80°C

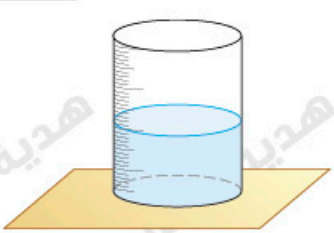
---

37 A quantity of pure water whose volume at a temperature of 4°C equals 1 m^3 is cooled until it freezes, so the increase in its volume when it turns into ice of density 917 kg/m^3 is approximately ..... .

ⓐ 0.03 m^3 ⓑ 0.045 m^3 ⓒ 0.06 m^3 ⓓ 0.09 m^3

---

38 The opposite figure shows a beaker containing pure water at a temperature of 4°C. What happens to the density of the water in the beaker when:



(i) adding an equal quantity of pure water at 4°C to the beaker?

ⓐ Increases. ⓑ Decreases.

ⓒ Doesn't change. ⓓ The answer cannot be determined.

(ii) adding an equal quantity of pure water at 10°C to the beaker?

ⓐ Increases. ⓑ Decreases.

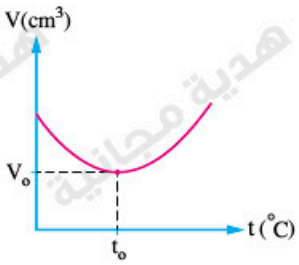
ⓒ Doesn't change. ⓓ The answer cannot be determined.

(iii) dissolving a quantity of salt in it?

ⓐ Increases. ⓑ Decreases.

ⓒ Doesn't change. ⓓ The answer cannot be determined.

39 The opposite graph represents the relation between the volume (V) of a quantity of pure water of mass 2 g and its temperature (t), so:



(i) The value of (t_o) on the graph equals ..... .

ⓐ 2°C ⓑ 4°C

ⓒ 8°C ⓓ 10°C

(ii) The value of (V_o) on the graph equals ..... .

ⓐ 0.99 cm^3 ⓑ 1 cm^3 ⓒ 1.9 cm^3 ⓓ 2 cm^3

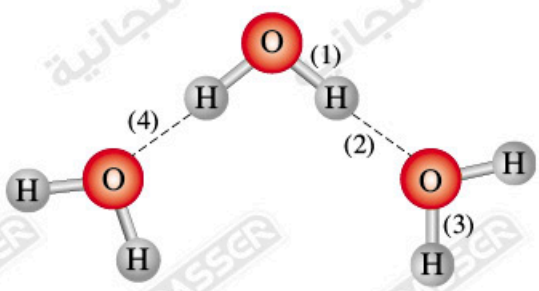
---

40 Two identical containers (1) and (2) contain equal quantities of pure water at temperatures t_1 and t_2, respectively. The temperatures of both containers increased by one degree, causing an increase in the density of water in container (1) and a decrease in the density of water in container (2). Which of the following could represent the temperatures t_1, t_2 respectively?

ⓐ 1°C, 3°C ⓑ 4°C, 6°C ⓒ 3°C, 6°C ⓓ 6°C, 3°C

---

41 The opposite figure shows some water molecules, so the bonds that are responsible for the unique behavior of water density compared to the other compounds of similar composition are ..... .



ⓐ (1), (2) ⓑ (1), (3)

ⓒ (3), (4) ⓓ (2), (4)

---

42 You can distinguish between a sample of pure water and another of water containing dissolved pollutants at the same temperature by measuring ..... .

ⓐ the mass of each of them ⓑ the volume of each of them

ⓒ the weight of each of them ⓓ the density of each of them

---

43 Two beakers, A and B, each contains a quantity of a saline solution at the same temperature. A colored ice cube of fresh water was placed in each beaker. The two beakers were observed through the short period during the melting of each ice cube. They were as shown in the opposite figure. What is your conclusion about the concentration of salt in the two solutions?

A B

ⓐ The concentration of the solution in beaker A is higher.

ⓑ The concentration of the solution in beaker B is higher.

ⓒ The concentrations of the two solutions are high and equal.

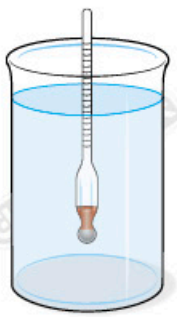
ⓓ The concentrations of the two solutions are low and equal.

44 Three beakers contain three saline solutions a, b and c at room temperature with concentrations of 5 g/L, 35g/L and 20 g/L, respectively. If three identical ice cubes of freshwater are placed one in each solution, the correct order of the solutions in terms of the time taken for the ice cube to melt in them is ..... .

ⓐ c < b < a ⓑ a < b < c ⓒ c > a > b ⓓ a < c < b

---

45 The opposite figure shows a hydrometer balanced in pure water. What happens to the hydrometer if salt is added and dissolved in the water?



ⓐ It sinks further into the water.
ⓑ A larger part of it floats up.
ⓒ The length of the floating part of it does not change.
ⓓ The answer cannot be determined.

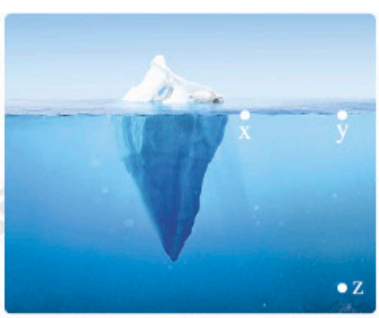
---

46 Which of the following factors **does not** directly affect ocean currents?

ⓐ Variation of the water salinity.
ⓑ Variation of the water temperature.
ⓒ Variation of the water pressure.
ⓓ Variation of the marine organism's species.

---

47 The opposite figure shows an iceberg in an ocean, At which of the positions x, y, z shown in the figure the water has the higher density?



ⓐ Position x
ⓑ Position y
ⓒ Position z
ⓓ The water density is the same at all three positions.

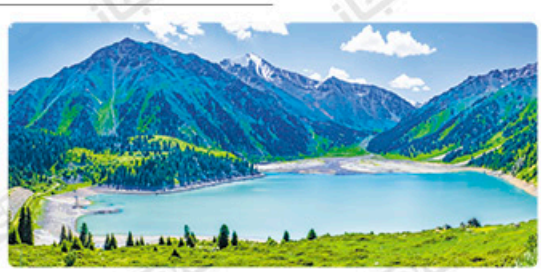
---

48 At which of the following positions in water the density of water is higher assuming all are at a temperature of 4°C ?

ⓐ Deep Ocean. ⓑ Sea surface.
ⓒ The surface of a lake of freshwater. ⓓ The bottom of a frozen river.

---

49 The opposite figure shows a closed saltwater lake, so when the water level decreases in the lake over time due to evaporation of water from it, the density of the lake water ..... .



ⓐ increases
ⓑ decreases
ⓒ remains unchanged
ⓓ the answer cannot be determined

Second Miscellaneous Questions

1 Write the scientific term for each of the following:

(a) Any substance that can flow and does not have a fixed shape but takes the shape of its container.

(b) The mass of a unit volume of a substance.

(c) The ratio of the density of a certain substance to the density of pure water at the same temperature.

2 Give reason for:

(a) The density of a pure substance does not change when the mass or volume of the sample taken from it changes.

(b) Density has a unit of measurement, while relative density does not have a unit of measurement.

(c) The presence of mercury in the hydrometer bulb.

(d) The freezing of lake water in polar regions begins at the surface rather than the bottom.

(e) Fish live without freezing in frozen lakes or rivers.

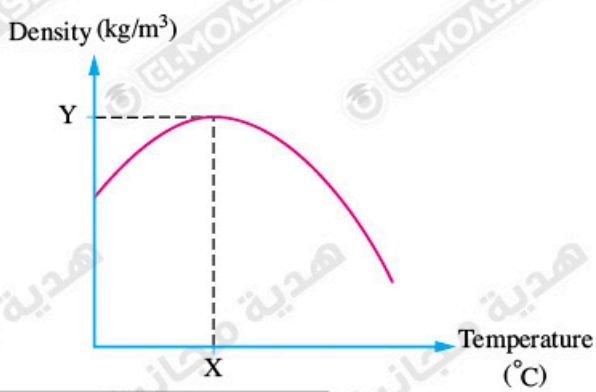
3 What happens in each of the following cases:

(a) Increasing the temperature of a body concerning its density?

(b) Increasing the temperature of pure water from 4°C to 10°C concerning its density?

4 Mention two factors on which the density of a substance depends.

5 The opposite figure represents the relation between the density of pure water in (kg/m^3) and temperature in (°C), **so what** is the value of each of X, Y in the figure?

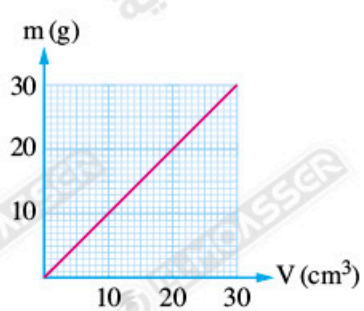


6 The opposite graph represents the relation between the mass (m) of different quantities of pure water and the volume (V) of each at a constant temperature.

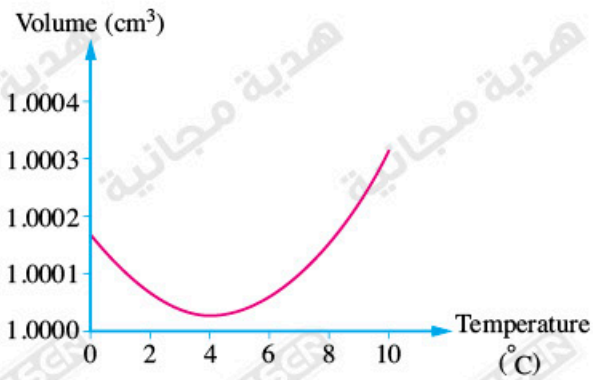
What do you expect to be:

(a) The temperature of water ? **Explain**.

(b) The mass of 500 cm^3 of water at the same temperature?



7 🕮 Analyze the opposite graph and **deduce what happens to** the water density with the change in temperature.



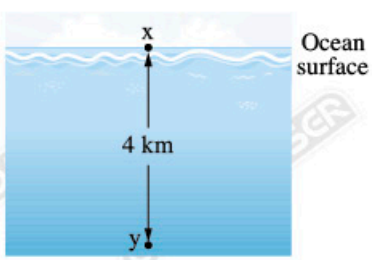
8 **Explain how** the behavior of water differs from other liquids when studying the effect of changing temperature on density.

9 🕮 **Give an example** of how the changes in temperature and water density can affect living organisms in an aquatic environment.

10 **How** can you increase the density of pure water at room temperature in two methods?

11 **Mention** the factors that affect the density of water in the oceans **and explain** the effect of each.

12 In the opposite figure, **explain why** the density of water at point y is greater than at point **x**.



13 **Explain why** the temperature at the bottom of lakes in polar regions doesn't drop below 4°C.