Sudan University Of Science & Technology

College of Graduate Studies

Effect of Silver Nitrate Concentrations on pH of Water

أثر تراكيز نترات الفضة في الأس الهيدروجيني للماء

A thesis submitted In partial fulfillment of the requirements of the Degree of M.Sc in Physics

Submitted :

Fatima Hussein Alamir Ahmed

Supervisor:

Prof. Mubarak Dirar Abd Allah

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الآية

قال تعالى:

﴿أَوَلَمْ يَرَ الَّذِينَ كَفَرُوا أَنَّ السَّمَاوَاتِ وَالْأَرْضَ كَانَتَا رَتْقًا فَفَتَقْنَاهُمَا وَجَعَلْنَا مِنَ الْمَاءِ كُلَّ شَيْءٍ حَيٍّ أَفَلَا يُؤْمِنُونَ﴾

سورة الأنبياء الآية: (٣٠)

Dedication

To those who have been tracing me by bringing up from childhood ….

Those who are a lantern that lightens my thought through advice , and guidance when I grew up …

Those who encouraged me to love knowledge and being insisting on it .. My parents …

To those who have hugged me with kindness , commanding me via collaboration , rewarding me to advancement ..My brothers & My sister …

To whom he pushed and supported me on going forth on my science course : my lifemate ..My husband …

To my bossom rose my dear daughter (Malaz) …

To everyone who tought me ever taking my hands in order to obtain knowledge .

Fatima

Acknowledgment

After thanking the Almighty , who is the provider and the most rewardable , it is worthy to offer my gratitude and confession to everyone who guided , tougtht and took my hands to achieve this project .

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To everyone who helped me to fulfil this research.

Abstract in English

In this work the effect of changing silver Nitrate ($AgNO_3$) concentration on water pH was investigated . It was found that the pH of water increases as silver nitrate concentrations increase . This is since silver nitrate increases ionization degree of water , since it can be easily ionized .

Abstract in Arabic

في هذه الدراسة تم البحث في معرفة تأثير نترات الفضة (Ag) على الأس الهيدروجيني في الماء . لقد وُجد أن الأسّ الهيدروجيني في الماء تزداد قيمته بزيادة تركيز نترات الفضة طردياً وذلك لأن نترات الفضة تزيد درجة تأيُّن الماء بسبب سهولة تأيُّنها .

Content

Index Tables

Index Figures

Index Images

Chapter One

(1.1) Introduction

Water is considered the most common material on the earth surface covering about 70 % of the whole ground layer . It is a natural material that exists in oceans , seas , rivers , underground and even in the air that we breathe . No life without water .

Many scientists viewed that water sweet filteration is just a slow slaughtering of water because this process relies on adding certain substances and in turn when using such deformed water , it has already been deprived from many of its qualities that make water vivid and unique . This causes several and different health problems .

It is known that water is the liquid of life . It is the most existent on the ground surface where it covers 4/5 of the earth . Water is found in its three shapes : liquid , solid , gas . For most livings water is considered the basic structure where it represents 2/3 of the human body . As well , water is one of those substance that is react in different cells and fibers it is the space where the biological molecules melt within the cell . Additionally , water is regarded as a good solvent for compounds ionizers and some copolymers compounds . It is what give the polarized nature for the water molecules [1] .

The important characteristic of water solvents is the intensification of positive ionized hydrogen (H^+) and the negative ionized hydroxyl (OH^-) . These ionizers come out from water ionization . Besides , water is regarded one good classical example of hydrogenic associations [2] .The relative acidic or basic level of a solution is measured by pH . The pH is a measure of hydrogen ion concentration in water , specifically the negative logarithm (log) of the hydrogen ion concentration . The measurement of pH lies on a scale of

0 to 14 , with a pH of 7.0 being neutral , and bearing equal numbers of hydroxyl (OH^-) and hydrogen (H^+) ions . A pH of less than 7.0 is acidic ; a pH of more than is basic . The pH level can be determined by various means such as color indicators , pH paper or pH meters . A pH meter is the most common and accurate means used to measure [3] .

Water is one of the four ancient ' elements ' . In fact , throughout the universe , no other substance has ever received so much attention , socially , scientifically , technologically , environmentally . For us widespread occurrence industries , and its inestimable influence on human activity , water occupies an irreplaceable position in man's history . water can be estimated that of the approximately 5.7 thousand million persons on earth there are 60 thousand million gallons of water available for each person , seemingly more than enough to go around . Living tissue is composed mainly of water . Cells , organs , and organisms are constantly bathed in an aqueous environment without water , many chemical reactions could not take place , biological systems would not function and life as we know it would not have originated . However , the detailed , molecular-level role that water plays in the function of a chemical or biological system is still a mystery and a matter of great scientific debate . One of the central problems in biochemistry is to understand the structure and function of proteins at a molecular level [4] .

(1.2) Problem of research

Water pH plays an important role for human life . For proper biological activities pH must have certain specific value unfortunately the human activities affect water natural pH . Thus one needs a mechanism that change water pH to have a proper value .

(1.3) Purpose of research

Due to the importance of water PH in human life , this research is concerned with studying the effect of changing the concentration of silver nitrate on water pH .

(1.4) Research content

This current research consists of three chapters . The first chapter deals with the research introduction : Water Importance and properties are in the second chapter . The experiment of the research is exhibited in chapter three .

Chapter Two

Properties of Water

(2.1) Introduction

Water is a common substance , but life cannot exist without it . Water is a major component of living things. Humans are about two-thirds water, and most other animals contain equal or even greater proportions . Woody plants are at least 50% water, and the water content of herbaceous plants usually is 80% to 90% . Bacteria and other micro-organisms normally contain 90 to 95% water . Water is important physiologically . It plays an essential role in temperature control of organisms . It is a solvent in which gases , minerals , organic nutrients , and metabolic wastes dissolve . Substances move between cells and within the bodies of organisms via fluids comprised mostly of water . Water is a reactant in biochemical reactions , the turgidity of cells depends upon water , and water is essential in excretory functions [5]. The purpose of this chapter is to exhibit the physical properties of water.

(2.2) Physical properties

Water is hydrogen oxide in which hydrogen exhibits an oxidation state of +1 and oxygen of -2 . Pure water is a colourless , odourless , and tasteless transparent liquid . It can exist in one of three states of aggregation : a solid – ice , liquid water , and a gas-water vapor or steam . At 0^oC , the solid and liquid phases are in a state of dynamic equilibrium , therefore the melting point of ice is 0^oC . At $+4^oC$, it has the greatest density equal to $1 g/cm^3$. Above or below this temperature , the density of water is less than $1 g/cm^3$. This feature distinguishes water from all other substances , whose density diminishes with lowering of the temperature . When water solidifies , its volume grows and its density lowers : 92 volumes of liquid water yield 100 volumes of ice . The water molecule is polar and has a triangular structure . The electronegative oxygen atom is at the apex of the triangle , and the hydrogen atoms are at the corners of the base . The bond angle is 104.5^{o} [6] .

(2.2.1) Structure of water

A water molecule consists of two hydrogen atoms covalently bonded to one oxygen atom (Fig 2.1.1) . The angle formed by lines through the centers of the hydrogen nuclei and the oxygen nucleus is 105^{o} . The distance between hydrogen and oxygen nuclei is 0.96×10^{-8} cm . An oxygen nucleus is heavier than a hydrogen nucleus , so electrons are pulled relatively closer to the oxygen nucleus . This gives the oxygen atom a small negative charge and each of the hydrogen atoms a slight positive charge resulting in polarity of the water molecule .

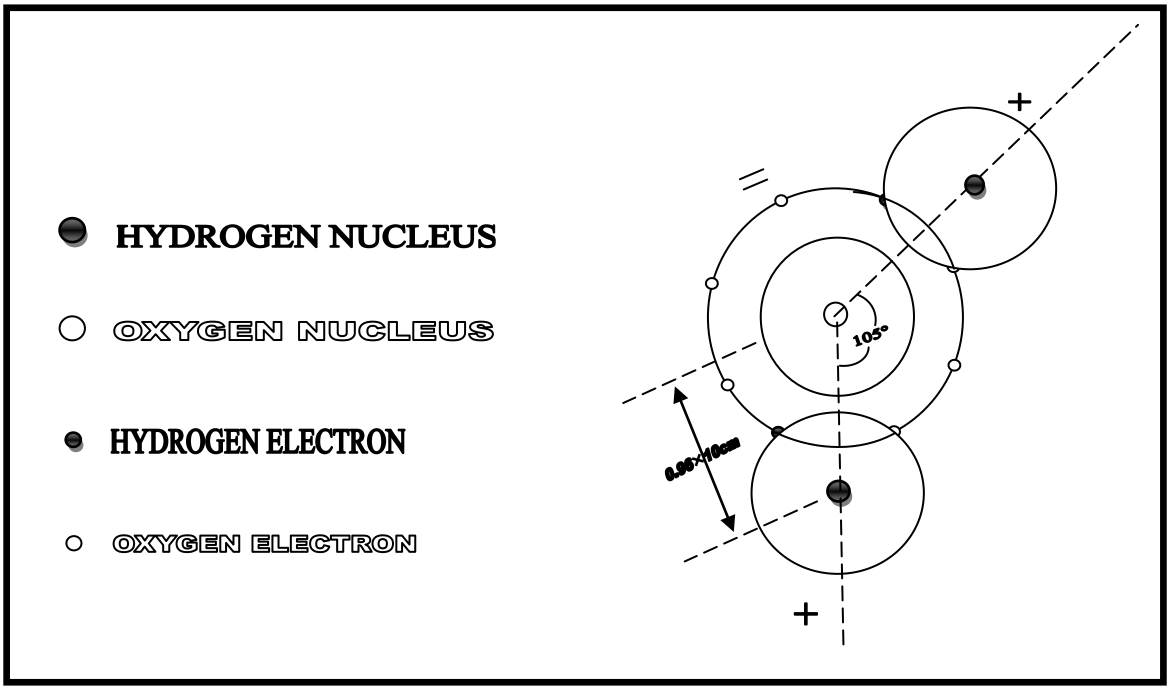


Fig (2.1.1) The water molecule

(2.2.2) Thermal characteristics

Water is a liquid between 0 and 100^{o}C at standard atmospheric pressure (760 mm of mercury) . Freezing and boiling points of water , 0 and 100^{o}C , respectively , are much higher than those of other hydrogen compounds of low molecular weight .

The aberrant behavior of water results from hydrogen bonding . Molecules of other common hydrogen compounds do not form hydrogen bonds and are joined only by van der waals attractions . Considerable thermal energy is required to break hydrogen bonds and convert ice to liquid water or to change liquid water to vapor .

Depending on its internal energy content water exist in solid , liquid , or gaseous phase . In ice , all hydrogen atoms are bonded ; in liquid phase , a proton of the hydrogen atoms is bonded ; in vapor , there are no hydrogen atoms bonds . An increase in the internal energy content of water a gitates its molecules , causes hydrogen bonds to stretch and break , and temperature to rise . The opposite effect occurs when the energy content of water declines [5] .

Heat Transfer

Heat transfer is all about the transfer of heat from one point to another. If we consider any system which will be at higher temperature compared to surroundings, there will be transfer of heat from system to the surroundings.

Heat transfer is given by

$$Q = m \times c \times \Delta T \qquad (2.2.1)$$

Where :

m ≅ the mass

C ≅ the specific heat

Δ T ≅ the temperature difference in K.

There are three types of Heat transfer :

1. Conduction
2. Convection
3. Radiation.

Heat transfer (Q) by Conduction formula is given by

$$Q = \frac{K A (T_{Hot} - T_{cold})}{d} \qquad (2.2.2)$$

Where:

k ≅ the thermal conductivity of the material

A ≅ the cross sectional area

T_{Hot} ≅ the higher temperature

T_{Cold} ≅ the cooler temperature

t ≅ the time taken

d ≅ the thickness of the material.

Heat transfer by Convection is given by

$$Q = H_c A(T_{Hot} - T_{Cold}) \qquad (2.2.3)$$

Where :

H_c ≅ the heat transfer coefficient.

The Heat transfer by radiation is given by

$$Q = \sigma (T^4_{Hot} - T^4_{Cold}) A \qquad (2.2.4)$$

Here

σ ≅ The Stefan Boltzmann Constant.

Heat transfer is usually expressed in Joules. Heat transfer formula is used in problems to find the heat transfer taking place for any given material[7] .

The amount of energy (or heat) in calories (cal) required to raise the temperature of a substance by $1^{o}C$ is the specific heat . The specific heat of ice is 0.47(cal/g)/^{o}C , and the specific heat of water is 1.0 (cal/g)/^{o}C . Water has a high specific heat compared with most other substances . Specific heat values in calories per gram for other common substances on watersheds are as follows : dry mineral soil , 0.18 – 0.22 ; moist sandy soil , 0.21 – 0.36 ; moist loam soil , 0.25 – 0.50 ; wet organic soil , 0.70 – 0.80 ; air , 0.24 ; peat and humus , 0.45 ; fresh leaves , 0.80 – 0.95 ; twigs , bark , and wood , 0.61 – 0.77 . The materials with greater specific heat values contain a high percentage of water .

Water freezes when its energy content declines and molecular motion slows so that hydrogen bonds form to produce ice . Ice melts when its energy content rises and molecular motion increases and too few hydrogen bonds are present to maintain the crystalline structure of ice . The freezing point of water is $0^{o}C$. If the temperature of water falls to $0^{o}C$, 80cal of heat must be removed from each gram of water to cause it to freeze with no change in temperature . To melt 1g of ice at $0^{o}C$ with no change in temperature requires 80cal . The energy necessary to cause the phase change between liquid water and ice (80cal/g) is the latent heat of fusion .

Water changes from liquid to vapor when it attains enough internal energy and molecular motion to break all hydrogen bonds . Water vapor condenses to form liquid water when it loses energy and molecular motion decreases to permit formation of hydrogen bonds . The amount of energy necessary to cause the liquid to vapor phase change is 540cal/g . This quantity of energy is the latent heat of vaporization .

(2.2.3) Density

Ice molecules form a tetrahedral lattice through hydrogen bonding . Spacing of molecules in the lattice creates avoid , so a volume of ice weighs less than the same volume of liquid water . Thus , ice is lighter than water and floats . The density of water increases as temperature rises until maximum density is attained at about 4°C . Further warming decreases its density . Two processes influence density as water warms above 0°C . Remnants of the crystalline lattice of ice break up and increase density , and bonds stretch to decrease density . From 0 to 4°C , destruction of the remnants of the lattice has the greatest influence on density , but further warming causes density to decrease through bond stretching . Densities of water at different temperatures are given in (Table 2.3.1) .A cubic meter of water at 10°C will weigh 999.10 kg , but at 30°C , a cubic meter of water only weighs 995.65 kg .

Table (2.3.1) Density of fresh water (g/cm^3) at different temperatures between 0 and 40°C.

°C	g/cm^3	°C	g/cm^3	°C	g/cm^3
0	0.99984	14	0.99925	28	0.99624
1	0.99990	15	0.99910	29	0.99595
2	0.99994	16	0.99895	30	0.99565
3	0.99997	17	0.99878	31	0.99534
4	0.99998	18	0.99860	32	0.99503
5	0.99997	19	0.99841	33	0.99471
6	0.99994	20	0.99821	34	0.99437
7	0.99990	21	0.99800	35	0.99403
8	0.99985	22	0.99777	36	0.99309
9	0.99978	23	0.99754	37	0.99333
10	0.99970	24	0.99730	38	0.99296
11	0.99961	25	0.99705	39	0.99260
12	0.99950	26	0.99678	40	0.99222
13	0.99938	27	0.99652		

The dissolved mineral content or salinity influences the density of water (Table 2.3.2) . Water at 20^{o}C with 30 parts per thousand (ppt) salinity has a density of 1.0210g/cm^{3} as compared to 0.99821g/cm^{3} for fresh water at the same temperature . thus , water at 20^{o}C with 30 ppt salinity weighs 22.19kg more per cubic meter than fresh water at 20^{o}C.

Table (2.3.2) The density of water (g/cm^{3}) of different salinities at selected temperatures between 0 and 40^{o}C.

Salinity (parts per thousand)					
^{o}C	0	10	20	30	40
0	0.99984	1.0080	1.0160	1.0241	1.0321
5	0.99997	1.0079	1.0158	1.0237	1.0316
10	0.99970	1.0075	1.0153	1.0231	1.0309
15	0.99910	1.0068	1.0144	1.0221	1.0298
20	0.99821	1.0058	1.0134	1.0210	1.0286
25	0.99705	1.0046	1.0121	1.0196	1.0271
30	0.99565	1.0031	1.0105	1.0180	1.0255
35	0.99403	1.0014	1.0088	1.0162	1.0237
40	0.99222	0.9996	1.0069	1.0143	1.0217

(2.2.4) Surface Phenomena

The rise of water in small-bore tubes or soil pores is called capillary action . To explain Capillary action , one must consider cohesion , adhesion , and surface tension . Cohesive forces result from attraction between like molecules . Water molecules are cohesive because they form hydrogen bonds with each other . Adhesive forces result from attraction between unlike molecules . Water adheres to a solid surface if molecules of the solid surface form hydrogen bonds with water . Such a surface is called hydrophilic because it wets easily . Adhesive forces between water and the solid surface are greater than cohesive forces among water molecules . Water will bead on a hydrophobic surface and run off , for cohesion is stronger than adhesion .

For example , raw wood wets readily , but a coat of paint causes wood to shed water .

The net cohesive force on molecules within a mass of water is zero , but cohesive forces cannot act above the surface . Molecules of the surface layer are subjected to an inward cohesive force from molecules below the surface . Surface molecules act as a skin and cause the phenomenon known as surface tension . Surface Tension is strong enough to permit certain insects and spiders to walk over the surface of water , and to allow needles and razor blades to float . The strength of the surface film decreases with increasing temperature , and increases when electrolytes are added to water . Soap and most dissolved organic substances decrease surface tension . Water rises a few centimeters to more than a meter in thin glass tubes or in fine-gained soils . Capillary action is the combined effects of surface tension , adhesion , and cohesion . In a thin tube , water adheres to the walls and spreads up ward as much as possible . Water moving up the wall is attached to the surface film , and molecules in the surface film are joined by cohesion to molecules below . As adhesion drags the surface film upward , it pulls water up the tube against the force of gravity . the column of water is under tension because water pressure is less than atmospheric pressure . Capillary rise is inversely proportional to tube diameter . Space exists among soil particles because they do not fit together perfectly . This space functions in the same manner as a thin glass tube , and it permits water to rise above the water table in a dry soil . Capillarity in soil increases as the average particle size of the soil decreases . If Capillary tube walls or soil pores are hydrophobic , capillary action will be downward .

(2.2.5) Viscosity

Fluids have an internal resistance to flow . Resistance to shear or angular deformation is viscosity , and it represents the capacity of a fluid to convert kinetic energy to heat energy . Viscosity results from cohesion between fluid particles , interchange of particles between layers of different velocities , and friction between the fluid and the walls of the conduit . In laminar flow , water moves in layers with little exchange of molecules among layers . During laminar flow in a pipe , the water molecules in the layer in contact with the pipe often adhere to the wall and do not flow . There is friction between the pipe wall and those molecules that do flow . The influence of the pipe wall on the flow of molecules declines with distance from the wall . Nevertheless , there is still friction between the layers of the flowing water . When flow becomes turbulent , the molecules no longer flow in layer and the movement of water becomes more complex . Viscosity often is reported in centipoises(cp) . In terms of force , 100 cp is equivalent to 1g/cm.ser or 0.1 Newton . sec/m^2 . Viscosity decreases as temperature rises , and the absolute viscosity of water at 0 , 20 , and 50^{o}C is 1.78 , 1.00 , and 0.547 cp , respectively . Water flow in pipes and channels and seepage through soil are favored slightly by warmth , because viscous shear losses decrease with decreasing viscosity [5] .

The viscosity of a fluid is a measure of its resistance to gradual deformation by shear stress or tensile stress [8] .

$$F = -\frac{1}{3} n\, m\, \ell \frac{\partial u_x}{\partial z} \qquad (2.5.1)$$

Where

F ≅ The force

n ≅ number of molecule per unit volume

m ≅ The mass

$$F = -\eta \frac{\partial \mathcal{U}_x}{\partial z} \quad (2.5.2)$$

Thus :

η ≅ viscosity

$$\eta = {}^{m}/_{3}\, n\langle \mathcal{U} \rangle \ell \quad (2.5.3)$$

$$\rho = mn \quad (2.5.4)$$

$$\therefore \eta = {}^{1}/_{3}\ \rho \langle \mathcal{U} \rangle \quad (2.5.5)$$

$$\mathcal{U} = \sqrt{\frac{8\,\kappa\,T}{m}} \quad (2.5.6)$$

Where

$\mathcal{U}$ ≅ Thermal speed

ℓ ≅ mean free path

ρ ≅ density

$$\ell = \frac{1}{\sqrt{2}\, n\, \sigma} \quad (2.5.7)$$

$$\sigma = \pi\, d^2 \quad (2.5.8)$$

Where :

σ ≅ The cross section

d ≅ Radius

$$\eta = \frac{1}{3}\frac{(8\,\kappa\,\mathrm{T})^{1/2}}{\sqrt{\pi}}\frac{1}{\sqrt{2}\,\pi\,d^2} \qquad (2.5.9)$$

$$\therefore \eta = \frac{(8\,\kappa\,\mathrm{T}\,m)^{1/2}}{3\,\sqrt{2}\,\pi^{3/2}\;d^2} \qquad (2.5.10)$$

(2.2.6) Pressure

A fluid has little or no elasticity of shape and conforms to the shape of its container . Fluids are liquids , and the ideal liquid offers no resistance to shearing forces . Unless completely confined , a liquid has a free surface that is always horizontal expect at the edges . Liquid are considered to be essentially incompressible . Water can be treated as a fluid .

Consider the pressure of water on a small area (Fig 2.6.1) . The water column of height (h) pressing down on a small area (ΔA) has volume of (hΔA) . The weight of water or force (F) is

$$\mathrm{F} = \gamma\, h\, \Delta\, \mathrm{A} \qquad (2.6.1)$$

Where :

γ = weight of water per unit volume .

Pressure (P) is a force acting over a unit area :

$$\mathrm{P} = \frac{F}{\Delta\,\mathrm{A}} \qquad (2.6.2)$$

Thus , the pressure on the point described above may be expressed as

$$\mathrm{P} = \frac{\gamma\, h\, \Delta\, \mathrm{A}}{\Delta\, \mathrm{A}} = \gamma\, h \qquad (2.6.3)$$

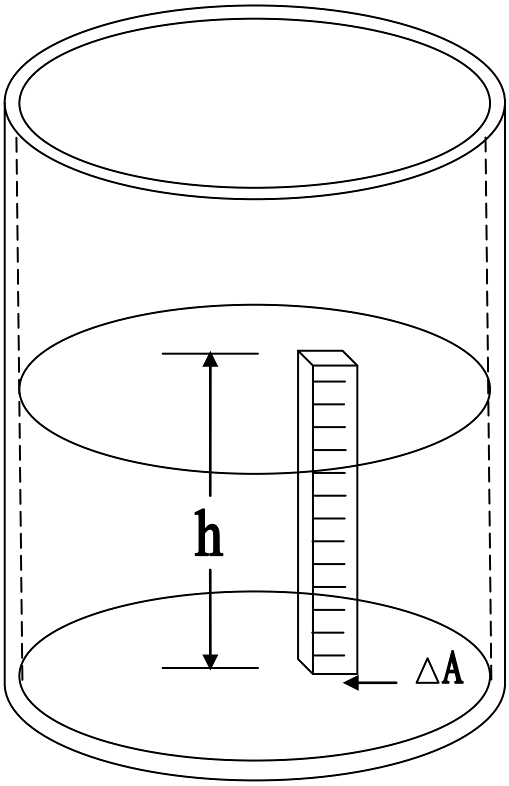


Fig (2.6.1) pressure of water on a surface (ΔA) beneath of depth (h) .

This pressure is for the fluid only , and it is the product of the height of the water column and the unit weight of water . To obtain the absolute pressure , we must include atmospheric pressure . Pressure can be converted to force by multiplying by the area over which the pressure is acting . This force is always normal to the surface .

Because pressure at a point depends mainly upon depth of water above the point , pressure often is given as water depth . The actual pressure could vary slightly among different waters of the same depth because the specific weight of water varies with temperature and salinity .

(2.2.7) Solvent action

In an electric field of a condenser , water molecules orient themselves , pointing their positive ends towards the negative plate and their negative ends towards the positive plate (Fig 2.7.1) . The orientation of molecules neutralizes part of the charge applied to the condenser plates . The voltage required to produce a given voltage on condenser plates is a measure of the dielectric constant of the substance surrounding the condenser plates . In a vaccum , 1 volt applied from a battery to the plates produces a voltage of 1 volt on the condenser plates . In constants , the dielectric constants of air and water are 1.0006 volt and 81 volt , respectively .

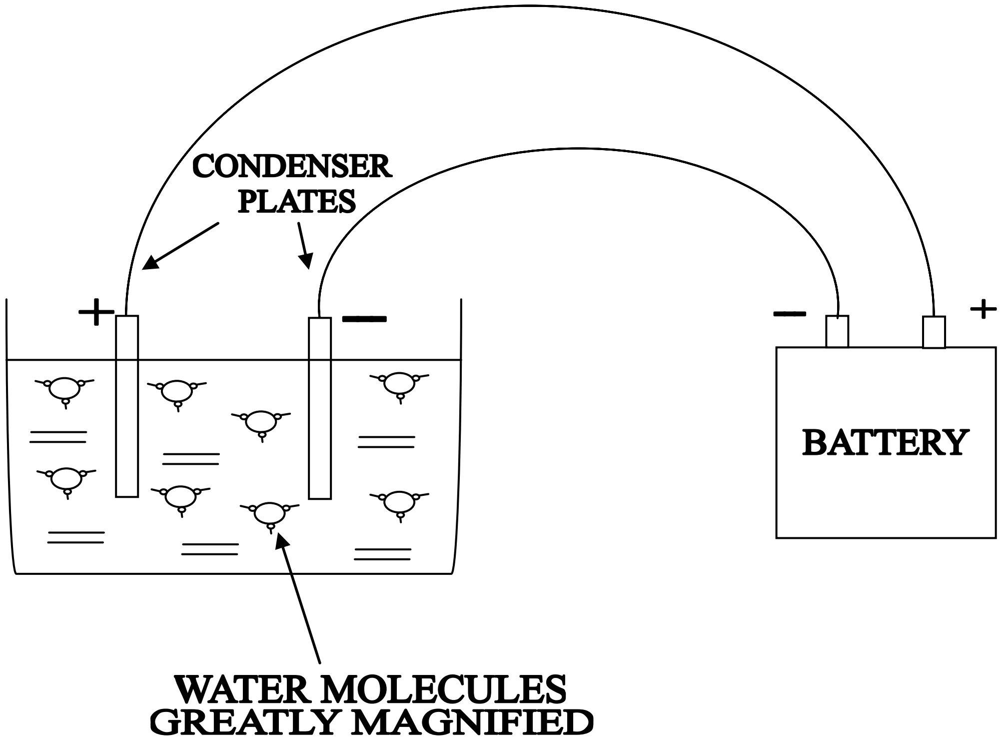


Fig (2.7.1) Orientation of water molecules in an electric field .

A crystal of salt maintains its structure in air because of electrical attraction between anions and cations , e.g. , $Na^+ + Cl^- = NaCl$. Salt dissolves readily in water because the attractive forces between anions and cations are 81 times less in water than in air . Water insulates ions from each other because water molecules are attracted to dissolved ions . Each anion attracts the positive ends of several water molecules , and each cation attracts the negative ends of other water molecules (Fig 2.7.2) . Ions can each attract several water molecules because ionic charges are much stronger than the charges on opposite sides of a water molecule . Water is said to hydrate ions , and hydration neutralizes charges on ions just as the water molecules neutralizes the charge on a condenser plate . Because of its high dielectric constant and polar properties , water is an excellent solvent for most inorganic and many organic substances .

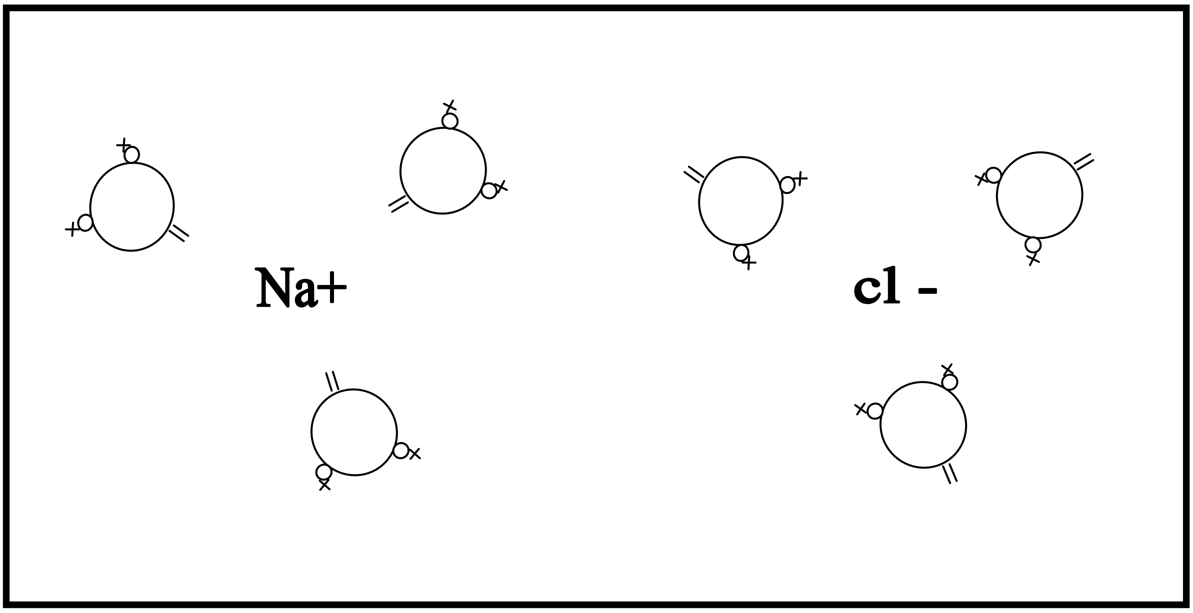


Fig (2.7.2) Hydration of dissolved ions by water molecules .

(2.2.8) Conductivity

Conductivity is the ability of a substance to convey an electrical current . In water , electrical current is conveyed by the dissolved ions . Thus , pure water is a very poor conductor . Natural waters contain dissolved ions and can conduct an electrical current . Conductivity increases in direct proportion to dissolved ion concentrations .

(2.2.9) Temperature

The temperature of water is a measure of its internal , thermal energy content . It is a property that can be sensed and measured directly with a thermometer . Heat content is a capacity property that must be calculated . Heat content usually is considered as the amount of energy above that held by liquid water at 0^oC . It is a function of temperature and volume .Water temperature is related to solar radiation and air temperature [5] .

(2.3) Chemical properties of water

Water is usually the solvent for these chemical reactions although it does react under many conditions . One such condition is the passing of an electric current through water , which decomposes H_2O into hydrogen and oxygen gases . This process is called the electrolysis of water . From the balanced chemical equation , we notice that two volumes of hydrogen ar produced for every volume of oxygen .

$$2H_2O\,(l) \xrightarrow{\text{electricity}} 2H_2\,(g) + O_2\,(g) \qquad (2.3.1)$$

One of the five basic types of reactions is a replacement reaction . In this reaction an active metal (Li , Na , K , Ca , Sr , or Ba) reacts directly with water to give a metal hydroxide and hydrogen gas . These reactions occur rapidly at room temperature[9] . For example , potassium metal reacts violently with water as follows :

$$2K\,(s) + 2H_2O\,(l) \rightarrow 2KOH\,(aq) + H_2\,(g) \quad (2.3.2)$$

(l) ≅ Liquid

(s) ≅ solid

(g) ≅ gas

(aq) ≅ aqueous .

(2.3.1) Hydration

The polarity and small size of water molecule determine its strong hydrating properties . Hydration is defined as the attachment of water to a substance . Water molecules can attach themselves to various ions and form hydrates . Examples are the crystal hydrates $CuSo_4$, $5H_2O$, Na_2So_4 , $10H_2O$ and $FeSo_4 . 7H_2O$.

Hydration occurs when water reacts with oxides , which results in the formation of a base or acid[6] .

$$CaO + H_2O \rightarrow Ca(OH)_2 \quad (2.3.3)$$

$$P_2O_5 + 3H_2O \rightarrow 2H_3PO_4 \quad (2.3.4)$$

Percent water in a hydrate :

The percent water in a hydrate is the ratio of the mass of water in the hydrate to the mass of the hydrate , all multiplied by 100% [9] .

$$\frac{\text{Mass of water}}{\text{Mass of hydrater}} \times 100\,\% = \%\,H_2O \quad (2.3.5)$$

(2.3.2) Unlike hydration , hydrolysis

Which also occurs with the participation of water , leads to the decomposition of a substance .

P_4O_{10} (s) + $6H_2O$ (l) → $4H_3PO_4$ (aq) (2.3.6)

$AlCl_3$ (s) + $6H_2O$ (l) → $[Al(H_2O)_6]^{+3}$ + $3Cl^-$ (aq) (2.3.7)

Ca_3N_2 (s) + $6H_2O$ (l) → $3Ca(OH)_2$ (aq) + $2NH_3$(g) (2.3.8)

(2.3.3) Water both in the cold and with heating reacts

Actively with many metals proceeding hydrogen in the electro-chemical series . In these reactions . the relevant oxides or hydroxides form , and hydrogen is displaced :

$2Fe + 3H_2O \rightarrow Fe_2O_3 + 3H_2\uparrow$ (2.3.9)

$2Na + 2H_2O \rightarrow 2NaOH + H_2\uparrow$ (2.3.10)

$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2\uparrow$ (2.3.11)

(2-3-4) Water has the ability to act as an acid or a base according to Bronsted-Lowry theory

Water is an a mphoteric substance .

H_2O (l) + NH_3 (aq) → OH^- (aq) + NH_4^+(aq) (2.3.12)

Acid

H_2O (l) + H_2S (aq) → H_3O^+ (aq) + HS^- (aq) (2.3.13)

Base

(2.3.5) In aqueous chemistry

Water can act as an oxidizing agent as well as reducing agent . Water is reduced to H_2 by metals with E^o value less than – 0.41 v.

$$2H_2O\ (l)\ +\ 2e^- \quad \rightarrow \quad 2HO^-\ (aq)\ +\ H_2\ (g)$$

$$E_\circ\ =\ -0.41\ v\ \text{ for } [OH^-]\ =\ 10^{-7}M \qquad (2.3.14)$$

Water can also be oxidized by the equation[6] :

$$O_2\ (g)\ +\ 4H^+(aq)\ +4e^- \quad \rightarrow \quad 2H_2O\ (l)$$

$$E_\circ\ =\ +0.82\ v\ \text{ for } [H^+]\ =\ 10^{-7}M \qquad (2.3.15)$$

(2.3.6) Reactions that produce water

Water is a produced by several types of reactions . The simplest reaction is the formation of water directly from hydrogen and oxygen . In this reaction , hydrogen and oxygen gases react to give H_2O . The reaction takes place very slowly at room temperature but explosively if exposed to a flame . From the balanced chemical equation , we note that two volumes of hydrogen react with one volume of oxygen .

$$2H_2(g)\ +\ O_2\ (g) \xrightarrow{\text{spark}} 2H_2O\ (l) \qquad (2.3.16)$$

Another reaction that produces water is the combustion of hydrocarbons . Hydrocarbons are organic compounds containing hydrogen and carbon . They bum in oxygen to give carbon dioxide and water . For example , propane C_3H_8 , under-goes combustion as follows :

$$C_3H_8\ (g)\ +5O_2 \xrightarrow{\text{spark}} 3CO_2\ (g)\ +\ 4H_2O\ (g) \qquad (2.3.17)$$

Organic compounds containing hydrogen and oxygen also undergo combustion to give carbon dioxide and water . Ethanol C_2H_5OH , For example , is currently blended with gasoline to produce gasohol . It undergoes combustion to give carbon dioxide and water as follows :

$$C_2H_5OH\ (g)\ +\ 3O_2\ (g)\ \xrightarrow{\text{spark}}\ 2CO_2\ (g)\ +\ 3H_2O\ (g) \qquad (2.3.18)$$

Recall that neutralization reactions also produce water . An acid neutralizes a base to produce an aqueous and water .For example , battery acid , H_2SO_4 , reacts with aqueous lye , NaOH , to produce sodium sulfate and water .

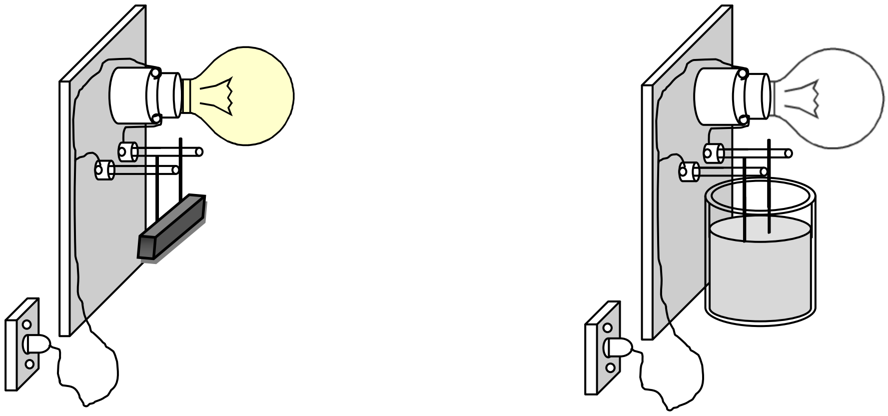
$$H_2SO_4\ (aq)\ +\ 2NaOH\ \rightarrow\ NaSO_4\ (aq)\ +\ 2H_2O\ (l) \qquad (2.3.19)$$

The decomposition of a hydrate compound also produces water . A hydrate is a crystalline compound that contain a specific number of water molecules attached to an ionic formula unit . Gypsum is a hydrate of calcium sulfate , $CaSO_4$. The formula $CaSO_4$. $2H_2O$ indicates that two water molecules are attached to each formula unit . Heating a hydrate releases water from the compound . For example , heat decomposes gypsum to give $CaSO_4$ and two molecules of water . thus :

$$CaSO_4 . 2H_2O\ (s)\ \overset{\Delta}{\rightarrow}\ CaSO_4\ (s)\ +\ 2H_2O\ (g) \qquad (2.3.20)$$

(2.4) Ionization of water

In Figure (2.4.1) we see that pure water is a very poor conductor of electricity comparing with the metals are good conductors of electricity . Electricity is defined as the flow of electrons . The valence electrons in metals are free to flow . Evidence suggests that it is difficult to push electrons from one water molecule to another . We explain this observation by suggesting that there are ions present in pure water .



(a) Strong conductor **(b) weak conductor**

Figure (2.4.1) Conductivity Apparatus

(a)Metals are good conductor of electricity . A metal completes the electrical circuit and the apparatus lights.

(b)Pure water is a very poor conductor . It does , however , very weakly conduct an electric current.

Arrhenius found that salt solutions are good conductors of electricity . He correctly concluded that ions in the solution are responsible for electrical conductivity . Since water is a very poor conductor , we can conclude that only a few ions are present in pure water (Figure 2.4.2) .

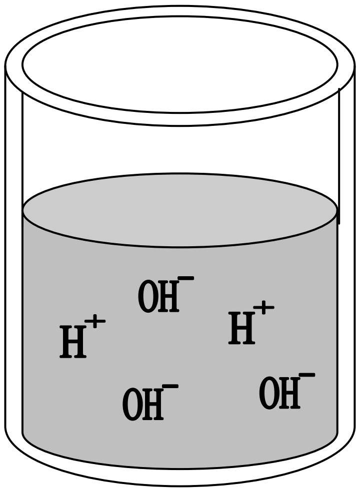


Figure (2.4.2) Ionization of water

(Pure water ionizes to give a few hydrogen ions and hydroxide ions . Water is a very weak conductor of electricity because only 1 molecule in about 500,000,000 forms ions)

It is well known that water molecules in the liquid state are free to move about and collide with one another . Although it happens only rarely , on occasion two water molecules collide with sufficient energy for their bonds to break apart . This bond breaking produces a hydronium ion , H_3O^+ , and a hydroxide ion , OH^- . Moreover , this occurrence is a dynamic process . While some molecules are breaking apart , other ions are combining to form water molecules . At any given moment , only 1 water molecule in 500 million molecules is ionized . Apparently , however , these few ions in water are sufficient to conduct a very weak electric current . The chemical equation for the collision reaction is

$$H_2O\ (l) + H_2O\ (l) \rightarrow H_3O^+\ (aq) + OH^-\ (aq) \quad (2.4.1)$$

Hydronium ion hydroxide ion

Alternatively , we can simplify the reaction by writing the ionization of water as :

$$H_2O\ (l) \rightarrow H^+\ (aq) + OH^-\ (aq) \qquad (2.4.2)$$

Hydrogen ion hydroxide ion

The concentration of hydrogen ions in pure water is 1.0 X 10^{-7} mol/L at 25°C . If we know the concentration of hydrogen ions , is known also know the concentration of hydroxide ions . Since the ionization of water gives one H^+ and one OH^- for each molecule of water that ionizes , the two concentration are equal . Therefore , the concentration of OH^- must also be 1.0 X 10^{-7} mol/L at 25°C . Moreover , the molar concentration of H^+ multiplied by the molar concentration of OH^- equals a constant . This product is called the ionization constant of water (symbol K_w) .

Let's calculate the value of K_w at 25° C . For converience , we use brackets to symbolize molar concentration . Hence :

$[H^+]$ ≅ is the symbol for the molar concentration of hydrogen ions .

We calculate a value for K_w as follows :

If $$[H^+] = 1.0 \times 10^{-7} \qquad (2.4.3)$$

Then $$[OH^-] = 1.0 \times 10^{-7} \qquad (2.4.4)$$

And $$[H^+][OH^-] = (1.0 \times 10^{-7})(1.0 \times 10^{-7}) \qquad (2.4.5)$$

$$[H^+][OH^-] = 1.0 \times 10^{-14} \qquad (2.4.6)$$

$$\therefore k_w = 1.0 \times 10^{-14} \ (at 25°C) \qquad (2.4.7)$$

Notice that $[H^+]$ and $[OH^-]$ are inversely proportional . That is , if $[H^+]$ increases , $[OH^-]$ decreases , so that the constant K_w remains the same . We should emphasize the water is neutral even though it contains small amounts of both H^+ and OH^- . Moreover , every aqueous solution has hydrogen ions and hydroxide ions . Even a hydrochloric acid solution contains H^+ and OH^- . Although an aqueous HCl solution has a high concentration of H^+ , it has a few OH^- as well . In every aqueous solution . the product of $[H^+]$ and $[OH^-]$ is equal to the ionization constant of water

$$[H^+][OH^-] = 1.0 \times 10^{-14} \qquad (2.4.8)$$

If an aqueous HCl solution is 0.1 M , we can calculate its hydroxide ion concentration :

$$[0.1][OH^-] = 1.0 \times 10^{-14} \qquad (2.4.9)$$

$$\therefore [OH^-] = 1.0 \times 10^{-13} \qquad (2.4.10)$$

Although $[OH^-]$ is only 0.000 000 000 000 1 M , the hydrochloric acid solution contain a trace of hydroxide ion .

So , in an acidic aqueous solution the $[H^+]$ is greater than $[OH^-]$. In a basic aqueous solution , $[H^+]$ is less than $[OH^-]$. In a neutral aqueous solution , $[H^+]$ is equal to $[OH^-]$.

(2.5) pH of water

A pH (potential of hydrogen) . Pure water is neutral and has a pH of 7 . We also know that an acid has a pH of less than 7 . As the pH value decreases , the solution becomes more acidic . Thus , a pH of 3 is more acidic than a pH of 4 . As the pH value increases , the solution becomes more basic . Thus , a pH of 11 is more basic than a pH of 10 .

In mathematical terms , the pH is the negative logarithm (log) of the molar hydrogen ion concentration[9].

$$pH = -\log [H^+] \qquad (2.5.1)$$

The pH of pure water is calculated from the relation :

$$pH = -{}^{1}/_{2} \log k_w . \qquad (2.5.2)$$

where :

K_w is the ionic product of water [10] .

(2.5.1) The pH scale

In all aqueous solutions , pH values may range between about 0 and 14 or more as shown in Figure (2.5.1) . Molar solutions of strong mineral acids , such as HCl , HNO_3 or H_2SO_4 have pH values less than 1 . Weak acids , such as ethanoic or citric acid in decimolar solution have a pH of around 3 .

A useful standard is 0.05 M potassium hydrogen phthalate which , at 15^{o}C has a pH of 4 . Although pure water is neutral and has a pH of 7 . Freshly distilled water rapidly absorbs carbon dioxide from the air to form a very dilute solution of carbonic acid , and therefore has a pH of around 6[11] .

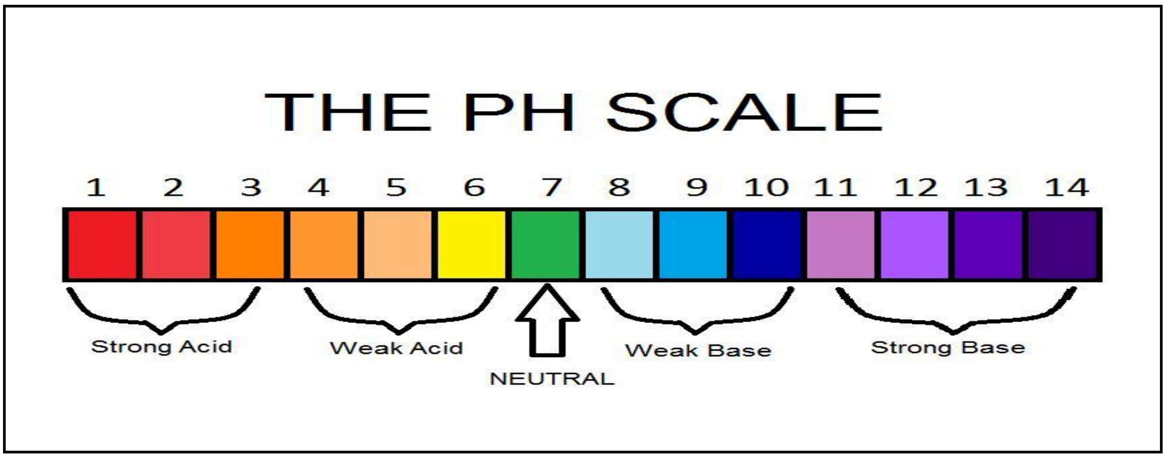


Figure (2.5.1) The pH scale

(2.5.2) pH meters

A pH meter measures the electric potential (milli volts) across in electrode when immersed in water . This electric potential is a function of the hydrogen ion activity in the sample . Therefore , pH meters can display results in either millivolts (mV) or pH units .

A pH meter consists of a potentiometer , which measures electric current ; a glass electrode , which senses the electric potential where it meets the water sample ; a reference electrode , which provides a constant electric potential ; and a temperature compensating device , which adjusts the readings according to the temperature of the sample . The reference and glass electrodes are frequently combined into a single probe called a combination electrode .

There is a wide variety of meters , but the most important part of the pH meter is the electrode . Buy a good , reliable electrode and follow the manufacturer's instructions for proper maintenance . Infrequently used or improperly maintained electrodes are subject to corrosion , which makes them highly inaccurate [12] .

Chapter Three

Effect of Silver Nitrate Concentrations on pH of Water

(3.1) Introduction

Water does not exist in nature as pure distilled water . It is usually mixed with salts of different element at different concentrations . Certainly the type and concentration of these salts affect their physical properties . One of these important properties is the pH of water which plays an important role in the biological activities inside the human body . Therefore this research is concerned with studying the effect of changing silver nitrate concentration on the water pH . The experiment was done at Sudan University of Science and Technology , Chemistry laboratory at the university .

(3.2) Apparatus & Materials

The following apparatus and materials were used .

(3.2.1) Apparatus

PH meter , Standard Flasks , Funnel , Beakers , Wash Bottle , Tissue paper , Forceps , Electrodes .

(3.2.2) Materials

Buffers solutions of pH 4.0 and 7.0 , Distilled water , Silver nitrate .

(3.3) Methodology

Prepare 10 water samples , with each sample mixed with specific amount of silver nitrate . Thus one have 10 different concentrations of silver nitrate ranging from 0.01 g/ml .. up to .. 0.1 g/ml in steps of 0.01 g/ml . Switch on the pH meter (At least 30 minutes before the test) . Then prepare the buffer solution 4.0 and 7.0 . Calibrate the pH meter to 4.0 and 7.0 using the buffers and by adjusting the calibration knob . In a clean dry (50ml) beaker take the solution sample and place the electrodes in the beaker containing the sample and check for the reading in the ph meter . Wait until you get a stable reading . Read the pH value and take the electrode from the sample , wash it with distilled water and then wipe gently with soft tissue .Repeat the same procedures to find the value of pH of the given sample . The reading obtained to are tabulated below .

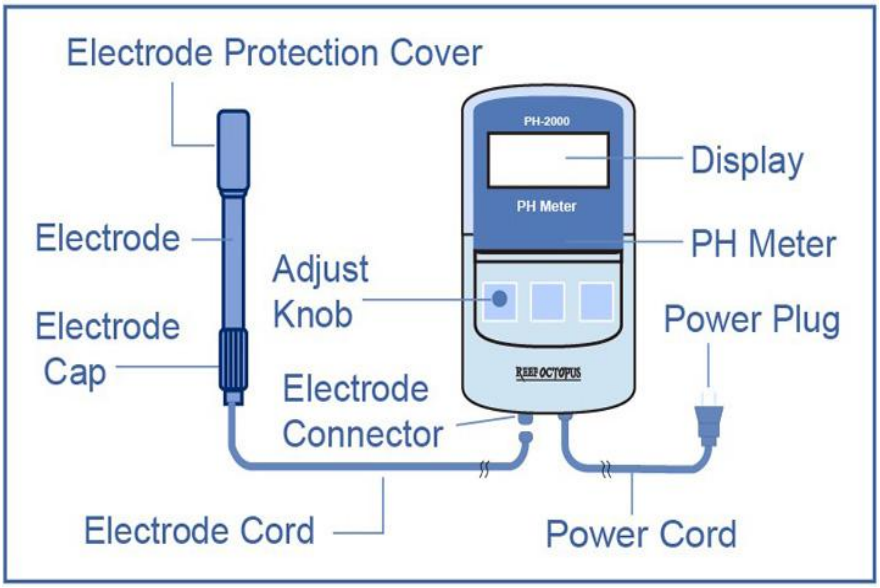


Figure (3.3.1) shows connecting the pH meter

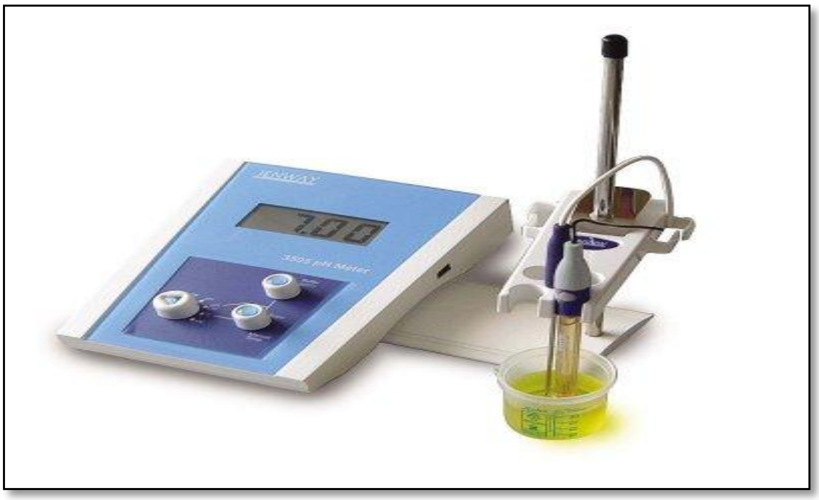


Image (3.3.1) shows the sample reading device by the pH meter

Image (3.3.2) pH meter

Image (3.3.3) Electrode glass

(3.4) Results

Table (3.4.1) : Relation between silver nitrate concentrations & water pH

Concentration g/ml	pH values
0.1	7.59
0.09	7.20
0.08	7.45
0.07	7.25
0.06	6.62
0.05	6.40
0.04	5.94
0.03	5.61
0.02	5.34
0.01	5.24

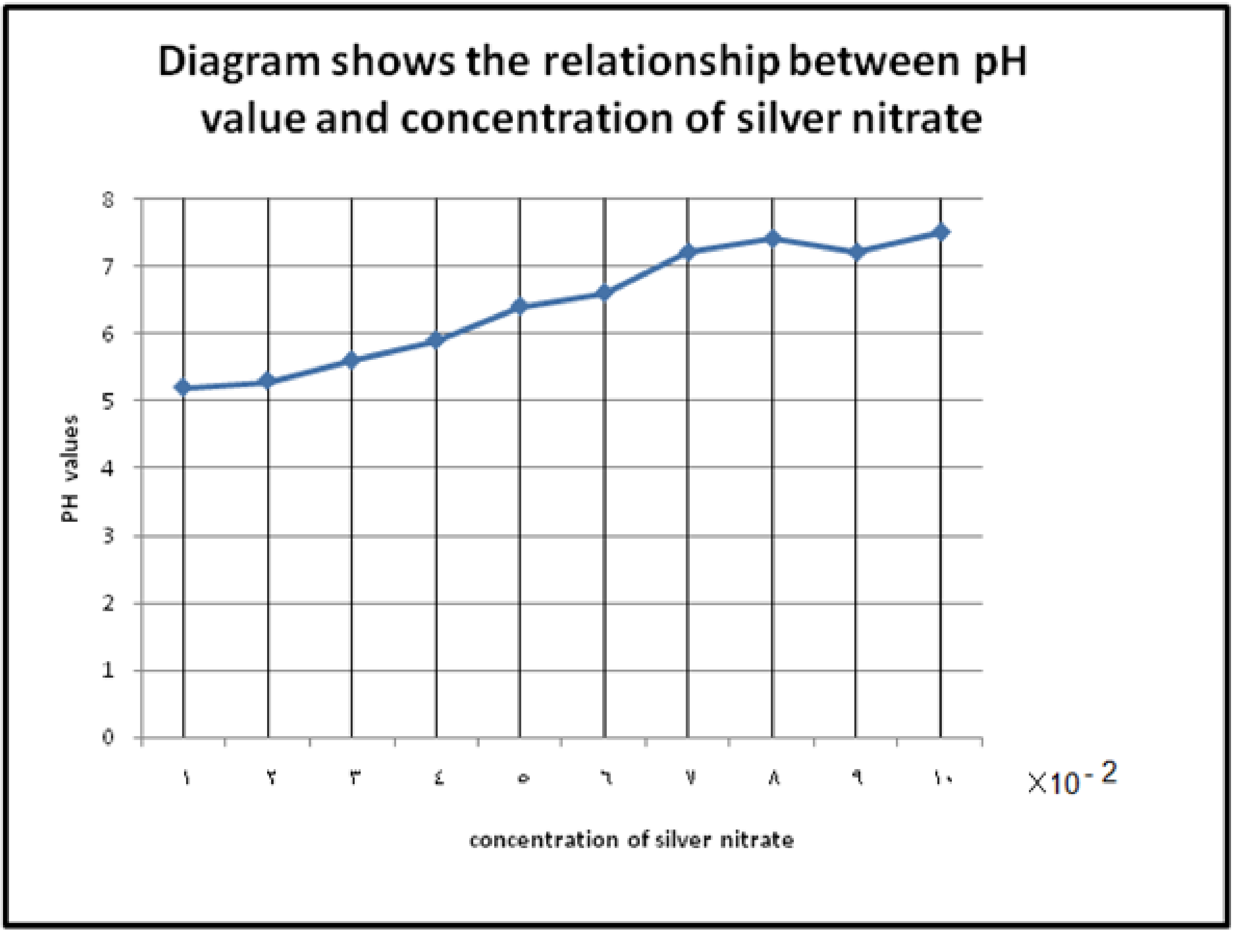


Figure (3.4.1) PH versus concentration of silver nitrate

(3.5) Discussion

It was found that when the concentration of the silver nitrate in water decrease pH decreases . Thus the pH of water is proportional to the concentration of the silver nitrate in water . In view of Fig (3.4.1) this relation is non linear .

(3.6) Recommendations

1. Increasing knowledge of water features and its pH which measures the acidification and saltation in liquids . As well , water minerals electrolyte flibany items should be focused on , and only that has to be done according to the regular instructions and tips so as not passively influence the living organisms in water environment.
2. Other non toxic compounds need to be studied to see how it affect water pH .

(3.7) Conclusion

The pH of water is affected by the type of salt exist as well as the concentration .

References

[1] د.صلاح احمد سليمان و د.فكري ابراهيم الشهاوي ، مقدمة في الكيمياء الطبيعية للغازات والسوائل ومحاليلها ،(مكتبة بستان المعرفة، مصر- الإسكندرية ، 2004) .

[2] د.خالد الكبيسي ، الكيمياء الحيوية ،(دار وائل للطباعة والنشر والتوزيع ،الأردن-عمان ، 2002).

[3] Osmonics Inc, pure water handbook , (Publisher osmonics , USA , 1997) .

[4] G .Wilse Robinson ,Water in Biology , Chemistry & Physics (Publisher World Scientific Publishing Company , USA , 1996).

[5] Claude E. Boyed ,Water Quality: An Introduction , (Publisher Springer , New York , 2015).

[6] Prem Dhawan **,** Inorganic Chemistry For IIT JEE And Other Engg Entrance Exams Paperback , **(**Publisher Tata Mcgraw Hill , Delhi , 2007).

[7] J.P. Holman , Heat Transfer , (Publisher McGraw-Hill Education , New York , 2009) .

[8] D. Mubarak Dirrar Abd Allah , handbook , (Khartoum , Sudan University of Science &Technology , 2010) .

[9] Charles H. Corwin , Introductory Chemistry , (Publisher Prentice Hall , New Jersy , 2012).

[10] Prof . Ing. Anatol Malijevsky **,** Physical Chemistry In Brief **,** (Publisher Create Space Independent Publishing Platform , 2014) .

[11] David Kealey & PJ Haines , Analytical Chemistry , (Publisher Taylor & Francis , New York , 2002) .

[12] Arnold E. Green bero , Standard methods for the Examination of water & waste water , (Publisher American Public Health Association , USA , 1999) .