Discovery consists in seeing what everyone else has seen and thinking what no one else has thought.

Albert Szent-Györgi

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1. INTRODUCTION

From the beginning I clearly knew that I wanted to do a project on Science because I wanted to learn and the most important thing enjoy doing it.

For the last reason I saw immediately that it had to be related to Chemistry, which, preferably, should include laboratory work and that I would not mind if there were some Biology contents.

That was how I started looking until I found a topic which caught my attention: vitamin C. Then I needed to specify what I'd like to concentrate when developing it, so I decided to ask me shocking questions like: 'Which is the relation between vitamin C and colds?', 'Why have I always been told to drink orange juice when flu started?' or 'Why was my mother so obsessed to make me drink the orange juice immediately after preparing it?'

And from these and considering the university degree I'm really fond of, Biochemistry, I saw that the most related aspect of vitamin C which connected best to all my requirements was its determination, as it implied the fact of reporting a lot about it and also includes laboratory work.

That was how I proposed this to my Physics and Chemistry teacher, Teresa, and she agreed to tutor the project.

Besides , I chose to do the project in English; this was an idea from my English teacher Ester. I discussed it with Teresa and I deeply analyzed it and finally accepted, just like a challenge.

Chemistry and English are the two subjects which attract me the most. Although I knew the amount of work this would mean, I decided to try the combination of both, thinking on my professional and academic future.

Once I decided on a particular topic, I focused myself to the aim according to the Chemistry and Biology acquired knowledge in recent years.

<u>AIMS</u>

The most important aim I devote my project to is vitamin C determination in different drinks. This has helped me to make a further study of its presence in packed fruit juices and in natural ones to observate its large oxidation capacity.

What is more, to answer the question mentioned above, I have gone deep into the vitamin C beneficial effects for health and its relation with the fruit juices.

Regarding the project organization, we can distinguish two different parts.
In the first one we can find a theoretical part where I have explained the things we must take into account when working in a laboratory (safety, risks, chemical residues, etc) and the different concentrations and solutions types (part necessary because of the experimental work that I have done). Then, there is a section exclusively on vitamin C, which is chemically known as ascorbic acid, where I tried to make a compilation of the most important aspects of it and get into two of my aims: its benefits and its sources (information extracted from a diet book and some questions to a dietician).

The second part covers the experiments, but before them, I have considered important to summarize the types of products and reagents used to better understand their performance in the practices. After all these, I have explained the preparation of some solutions, without which it wouldn't have been possible the vitamin C determination, and the following explanation of each practice made or from squeezed natural juice or from a packed fruit juice. All the samples done with natural juice fruits are 10% (10 ml of fruit juice in 100 ml of solution).
The method I have used is based on the comparisons of the juice solutions with a pattern solution, here is from where I have extracted some results and have made tables of each juice used, where I have gathered all the information obtained from the experimental part and from following calculations attached in the Annex.
All these have helped me to finally write the conclusions I have reached.

To finally end with the project, I have done a small valoration of it. There I have tried to objectively value what I have infered from the project.
I have also added an Annex where we can find some project parts more extended as: the RDA; tables of vitamin C food and the final results calculations.
Finally we also attach a CD where we can find the project in Catalan and in English, as well as the powerpoints used in the presentation.
Here it comes the project.

2. LABORATORY SAFETY

2.1 SECURITY RULES

- It is indispensable to use a laboratory coat to protect the clothes and a pair of approved safety glasses to protect the eyes.
- It is necessary to collect the long hair, to have short nails and not to wear rings on your hands. As regards to footwear, heeled shoes are not allowed. The shoes must totally cover the feet.
- It is not recommended to wear skirts, shorts and tights, because they are made of synthetic fibres and for the action of certain chemical products, they can stick to the skin.
- Contact lenses are not admitted in the laboratory.
- You must use masks for your respiratory protection when you work in polluted atmospheres.
- Avoid contact of chemical products with the skin, the eyes and the mucoses in any case. When you work with irritant or corrosive products, you must manipulate them with gloves (the material the gloves are made of, must be appropriate with the chemical products that you manipulate and with the type of task you must do).

  You must use them carefully and try not to breathe its vapours.

  You must introduce them into pipettes with the help of pipette pumps to avoid accidents or spread diseases.
- The reactions which give off gases must be done inside the showcases with the extractor on; because the laboratory atmosphere should be maintained as clean as possible. (If you don't have showcases, the reaction must be done in an open space or in a space which has possibilities to leave the reaction receptacle outside).
- To avoid possible fires, flammable products like alcohol or esters should be manipulated far from the fire.
- When you have to heat a test tube there is the danger that the content overflows violently. To avoid this, you should heat it intermittently or put it more inclined to the flame. You mustn't target the mouth tube to your face.
- To extinguish the flame from the cookers, you must close the keys correctly to prevent possible leakages.

- You mustn't return the reactive excess to the original container because the product can be unclean and specially for the possibility of introducing the excess in the wrong container and leading to virulent reactions.
- You mustn't throw away the waste for the drains or in the bins.
- It is forbidden to smoke, drink or eat inside the laboratory.
- You can not keep food or drinks in the refrigerators intented for the storage of chemical products.
- You should wash your hands thoroughly after doing an experiment and ever before leaving the laboratory.
- You must look/observe the pictograms that appear in products to manipulate them correctly.
- You must report where the security (laboratory) elements are, like fire extinguishers, fire blankets, alarms, eyewash and emergency exit.

2.2 SECURITY ELEMENTS

The main security elements in a chemical laboratory are:

1. Fire extinguishers.
2. Fire blankets.
3. Emergency showers.
4. Eyewash.
5. Emergency exits.

Illustration 1: Fire extinguisher

Illustration 2: Fire blanket

Illustration 3: Eyewash

Illustration 4: Emergency shower

Illustration 5: Emergency exit

2.3 PICTOGRAMS

Symbol	Definition
	**Explosive (E):** products that even in air absence can react quickly, release heat and explode. Examples: organic peroxides, nitro-glycerine, trinitrotoluene.
	**Flammable (F) or extremely flammable (F+):** fuel products that at room temperature produce sufficient vapour to originate a flame in presence of a heat source. Examples: ethyl alcohol, gasoline, turpentine, butane, etc.
	**Oxidizing (O):** products that in contact with others, particularly with flammable ones, originate a strongly exothermic reaction. Example: ammonium nitrate.
	**Toxic (T) or very toxic (T+):** Products that can cause immediate effects (sharp), like poisoning, rash, lacrimation, respiratory problems and vomiting. Also they can cause long term effects (chronic) for health (digestive, neurological, pulmonary, circulatory, etc). Examples: hydrogen cyanide, chlorine, some medicines, arsenic, etc.

	**Corrosive (C):** Products that in contact with tissues can generate a destructive action. Examples of corrosive acids: hydrochloric acid, sulphuric acid, nitric acid, etc… Examples of bases or corrosive alkalis: ammonia, caustic soda (sodium hydroxide/salt).
	**Harmful (Xn):** Products that for inhalation, ingestion or skin penetration can produce seriously limited risks. Example: copper sulphate (II).
	**Irritant (Xi):** Non corrosive products, that in prolonged contact with the skin or the mucous membrane can cause an inflammatory reaction. Example: sodium carbonate.
	**Radioactive (R):** Products which emit ionizing radiation and which bring serious risks to health. Examples: uranium, plutonium, etc.
	**Oxidant:** Products that when heated, can be quickly decomposed and produce oxygen, which can violently react with other chemical products. Examples: potassium permanganate, bleach, concentrated hydrogen peroxide, nitric acid, etc.

	**Environmental hazard/ Dangerous for the environment (N):** Products which present or could present in any aspect in short or long term risks for the environment: fauna, flora, watercourses, etc. Examples: carbon tetrachloride, pesticides, mercury, fertilizers with phosphates, detergents, etc.

2.4 R- AND S- PHRASES

Risk and security phrases, report information of the risks generated by the product (R-phrases) and of the basic safety rules which had to be followed (S-phrases)

R- phrases

Phrases that indicate the specified risks of a substance.
Risk phrases, denoted by a series of numbers preceded by the letter R, indicate the nature of special risks and they refer to:

- Physicochemical properties.
- Toxicological properties.
- Specific effects on health.
- Effects on the environment.

Below we can see the different R-phrases and their possible combinations that can be found:

R1 - Explosive when dry.
R2 - Risk of explosion by shock, friction, fire or other sources of ignition.
R3 - Extreme risk of explosion by shock, friction, fire or other sources of ignition.
R4 - Forms very sensitive explosive metallic compound.
R5 - Heating may cause an explosion.
R6 - Explosive with or without contact with air.
R7 - May cause fire.
R8 - Contact with combustible material may cause fire.
R9 - Explosive when mixed with combustible material.
R10 - Flammable.
R11- Highly flammable.
R12 - Extremely flammable.
R14 - Reacts violently with water.

R15 - Contact with water liberates extremely flammable gases.

R16 - Explosive when mixed with oxidising substances.

R17 - Spontaneously flammable in air.

R18 - In use, may form flammable/explosive vapour-air mixture.

R19 - May form explosive peroxides.

R20 - Harmful by inhalation.

R21 - Harmful in contact with skin.

R22 - Harmful if swallowed.

R23 - Toxic by inhalation.

R24 - Toxic in contact with skin.

T25 - Toxic if swallowed.

R26 - Very toxic by inhalation.

R27 - Very toxic in contact with skin.

R28 - Very toxic if swallowed.

R29 - Contact with water liberates toxic gas.

R30 - Can become highly flammable in use.

R31 - Contact with acids liberates toxic gas.

R32 - Contact with acids liberates very toxic gas.

R33 - Danger of cumulative effects.

R34 - Causes burns.

R35 - Causes severe burns.

R36 - Irritating to eyes.

R37 - Irritating to respiratory system.

R38 - Irritating to skin.

R39 - Danger of very serious irreversible effects.

R40 - Limited evidence of a carcinogenic effect.

R41 - Risk of serious damage to eyes.

R42 - May cause sensitisation by inhalation.

R43 - May cause sensitisation by skin contact.

R44 - Risk of explosion if heated under confinement.

R45 - May cause cancer.

R46 - May cause heritable genetic damage.

R48 - May cause cancer by inhalation.

R49 - May cause cancer by inhalation.

R50 - Very toxic to aquatic organisms.

R51 - Toxic to aquatic organisms.

R52 - Harmful to aquatic organisms.

R53 - May cause long-term adverse effects in the aquatic environment.

R54 - Toxic to flora.

R55 - Toxic to fauna.

R56 - Toxic to soil organisms.

R57 - Toxic to bees.

R58 - May cause long- term adverse effects in the environment.

R59 - Dangerous for the ozone layer.

R60 - May impair fertility.

R61 - May cause harm to the unborn child.

R62 - Possible risk of impaired fertility.

R63 - Possible risk of harm to the unborn child.

R64 - May cause harm to breast-fed babies.

R65 - Harmful: may cause lung damage if swallowed.

R66 - Repeated exposure may cause skin dryness or racking.

R67 - Vapours may cause drowsiness and dizziness.

R68 - Possible risk of irreversible effects.

Combinations of R-phrases

R14/15 - Reacts violently with water, liberating extremely flammable gases.

R15/29 - Contact with water liberates toxic, extremely flammable gases.

R20/21 - Harmful by inhalation and in contact with skin.

R20/22 - Harmful by inhalation and if swallowed.

R20/21/22 - Harmful by inhalation, in contact with skin and if swallowed.

R21/22 - Harmful in contact with skin and if swallowed.

R23/24 - Toxic by inhalation and in contact with skin.

R23/25 - Toxic by inhalation and if swallowed.

R23/24/25 - Toxic by inhalation, in contact with skin and if swallowed.

R24/25 - Toxic in contact with skin and if swallowed.

R26/27 - Very toxic by inhalation and in contact with skin.

R26/28 - Very toxic by inhalation and if swallowed.

R26/27/28 - Very toxic by inhalation, in contact with skin and if swallowed.

R27/28 - Very toxic in contact with skin and if swallowed.

R36/37 - Irritating to eyes and respiratory system.

R36/38 - Irritating to eyes and skin.

R36/37/38 - Irritating to eyes, respiratory system and skin.

R37/38 - Irritating to respiratory system and skin.

R39/23 - Toxic: danger of very serious irreversible effects through inhalation.

R39/24 - Toxic: danger of very serious irreversible effects in contact with skin.

R39/25 - Toxic: danger of very serious irreversible effects if swallowed.

R39/23/24 - Toxic: danger of very serious irreversible effects through inhalation and in contact with skin.

R39/23/25 - Toxic: danger of very serious irreversible effects through inhalation and if swallowed.

R39/24/25 - Toxic: danger of very serious irreversible effects in contact with skin and if swallowed.

R39/23/24/25 - Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.

R39/26 - Very toxic: danger of very serious irreversible effects through inhalation.

R39/27 - Very toxic: danger of very serious irreversible effects in contact with skin.

R39/28 - Very toxic: danger of very serious irreversible effects if swallowed.

R39/26/27 - Very toxic: danger of very serious irreversible effects through inhalation and in contact with skin.

R39/26/28 - Very toxic: danger of very serious irreversible effects through inhalations and if swallowed.

R39/27/28 - Very toxic: danger of very serious irreversible effects in contact with skin and if swallowed.

R39/26/27/28 - Very toxic: danger of very serious irreversible effects in contact with skin and if swallowed.

R42/43 - May cause sensitization by inhalation and skin contact.

R48/20 - Harmful: danger of serious damage to health by prolonged exposure through inhalation.

R48/21 - Harmful: danger of serious damage to health by prolonged exposure in contact with skin.

R48/22 - Harmful: danger of serious damage to health by prolonged exposure if swallowed.

R48/20/21 - Harmful: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.

R48/20/22 - Harmful: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.

R48/21/22 - Harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.

R48/20/21/22 - Harmful: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.

R48/23 - Toxic: danger of serious damage to health by prolonged exposure through inhalation.

R48/24 - Toxic: danger of serious damage to health by prolonged exposure in contact with skin.

R48/25 - Toxic: danger of serious damage to health by prolonged exposure if swallowed.

R48/23/24 - Toxic: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.

R48/23/25 - Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.

R48/24/25 - Toxic: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.

R48/23/24/25 - Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.

R50/53 - Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

R51/53 - Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

R52/53 - Harmful to aquatic organisms may cause long-term adverse effects in the aquatic environment.
R68/20 - Harmful: possible risk of irreversible effects through inhalation.
R68/21 - Harmful: possible risk of irreversible effects in contact with skin.
R68/22 - Harmful: possible risk of irreversible effects if swallowed.
R68/20/21 - Harmful: possible risk of irreversible effects through inhalation and in contact with skin.
R68/20/22 - Harmful: possible risk of irreversible effects through inhalation and if swallowed.
R68/21/22 - Harmful: possible risk of irreversible effects in contact with skin and if swallowed.
R68/20/21/22 - Harmful: possible risk of irreversible effects through inhalation, in contact with skin and if swallowed.

There are two R-phrases that nowadays are no longer used:
R13 - Extremely flammable liquefied gas.
R47 - May cause birth defects.

S- phrases

Phrases that indicate the type of advice that's related to the kind of substance.
Advice phrases denoted by a series of numbers preceded by the letter S, indicate the recommended safety precautions and they refer to:

- Storage and handling.
- Personal hygiene.
- Spills and waste.
- Personal protective equipment.
- Incident / accident.
- Reactivity / incompatibility.

Below we can see the different S-phrases and their possible combinations that we can find:

S1 - Keep locked up.

S2 - Keep out of the reach of children.

S3 - Keep in a cool place.

S4 - Keep away from living quarters.

S5 - Keep contents under … (appropriate liquid to be specified by the manufacturer).

S6 - Keep under … (inert gas to be specified by the manufacturer).

S7 - Keep container tightly closed.

S8 - Keep container dry.

S9 - Keep container in a well-ventilated place.

S10 - Keep contents wet.

S11 - Avoid contact with air.

S12 - Do not keep the container sealed.

S13 - Keep away from food, drink and animal foodstuffs.

S14 - Keep away from … (incompatible materials to be indicated by the manufacturer).

S15 - Keep away from heat.

S16 - Keep away fro sources of ignition – No smoking.

S17 - Keep away from combustible material.

S18 - Handle and open container with care.

S20 - When using do not eat or drink.

S21 - When using do not smoke.

S22 - Do not breathe dust.

S23 - Do not breathe gas/fumes/vapour/spray (appropriate wording to be specified by the manufacturer).

S24 - Avoid contact with skin.

S25 - Avoid contact with eyes.

S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

S27 - Take off immediately all contaminated clothing.

S28 - After contact with skin, wash immediately with plenty of .. (to be specified by the manufacturer).

S29 - Do not empty into drains.

S30 - Never add water to this product.

S33 - Take precautionary measure against static discharges.

S35 - This material and its container must be disposed of in a sage way.

S36 - Wear suitable protective clothing.

S37 - Wear suitable gloves.

S38 - In case of insufficient ventilation wear suitable respiratory equipment.

S39 - Wear eye/face protection.

S4. - To clean the floor and all objects contaminated by this material use … (to be specified by the manufacturer).

S41 - In case of fire and/or explosion do not breathe fumes.

S42 - During fumigation/spraying wear suitable respiratory equipment (appropriate wording to be specified by the manufacturer).

S43 - In case of fire use … (indicate in the space the precise type of fire-fighting equipment. If water increases the risk add → Never use water).

S45 - In case of accident or if you feel unwell seek medical advice immediately (show the label where possible).

S46 - If swallowed, seek medical advice immediately and show this container or label.

S47 - Keep at temperature not exceeding …ºC (to be specified by the manufacturer).

S48 - Keep wet with … (appropriate material to be specified by the manufacturer).

S49 - Keep only in the original container.

S50 - Do not mix with … (to be specified by the manufacturer).

S51 - Use only in well-ventilated areas.

S52 - Not recommended for interior use on large surface areas.

S53 - Avoid exposure - obtain special instructions before use.

S56 - Dispose of this material and its container at hazardous or special waste collection point.

S57 - Use appropriate containment to avoid environmental contamination.

S59 - Refer to manufacturer/supplier for information on recovery/recycling.

S60 - This material and its container must be disposes of as hazardous waste.

S61 - Avoid release to the environment. Refer to special instructions/safety data sheet.

S62 - If swallowed, do not induce vomiting: seek medical advice immediately and show this container or label.

S63 - In case of accident by inhalation: remove casualty to fresh air and keep at rest.

S64 - If swallowed, rinse mouth with water (only if the person is conscious).

Combinations of S-phrases

S1/2 - Keep locked up and out of the reach of children.
S3/7 - Keep container tightly close in a cool place.
S3/7/9 - Keep container tightly closed in a cool, well-ventilated place.
S3/9/14 - Keep in a cool, well-ventilated place away from … (incompatible materials to be indicated by the manufacturer).
S3/8/14/49 - Keep only in the original container in a cool, well-ventilated place away from … (incompatible materials to be indicated by the manufacturer).
S3/9/49 -Keep only in the original container in a cool, well-ventilated place.
S3/14 - Keep in a cool place away from … (incompatible materials to be indicated by the manufacturer).
S7/8 - Keep container tightly closed and dry.
S7/9 - Keep container tightly close and in a well-ventilated place.
S7/47 - Keep container tightly closed and at temperature not exceeding … ºC (to be specified by the manufacturer).
S8/10 - Keep container wet, but keep the contents dry.
S20/21 - When using do not eat, drink or smoke.
S24/25 - Avoid any inhalation, contact with skin and eyes. Wear suitable protective clothing and gloves.
S27/28 - After contact with skin, take off immediately all contaminated clothing, and wash immediately with plenty of … (to be specified by the manufacturer).
S29/35 - Do not empty into drains; dispose of this material and its container in a safe way.
S29/56 - Do not empty into drains, dispose of this material and its container at hazardous or special waste collection point.
S36/37 - Wear suitable protective clothing and gloves.
S36/37/39 - Wear suitable protective clothing, gloves, and eye/face protection.
S36/39 - Wear suitable protective clothing and eye/face protection.
S37/39 - Wear suitable gloves and eye/face protection.

S47/49 - Keep only in the original container at temperature not exceeding …ºC (to be specified by the manufacturer).

2.5 TYPES OF CHEMICAL RESIDUES

The residue's classification in different groups is based on their composition and it tries to facilitate the subsequent management for the residuum solicitor companies.
We can divide the residues generated in the laboratory in two different groups:

Illustration 6: Chemical residues

Fungible materials residues, where we include for example fragments of broken glass, plastic bottles remnants or empty ones.
The types of container that we find in this group are:

- **Clean glass container** (not contaminated with chemicals).
- **Chemical contaminated glass container** (less the stabbing one).
- **Stabbing chemical contaminated material container** (as Pasteur Pipettes, glass capillaries…)

Chemical Residues (such as liquid and solid). Here we would include reagent remnants or expired products and leftovers from the experiments (which cannot be returned to its original containers). These kind of chemical residues can not be deleted down the drain because there are certain substances which can violently react with water, such as the corrosive, alkali metals, non-biodegradable and hazardous to the environment.
This is why we tend to divide the chemical residues in five groups:

- **Halogenated organic solvents:** they include highly flammable and toxic organic liquids which contain more than 2% of halogen. Like: chloroform, bromoform, carbon tetrachloride or perchlorethylene.
- **Non-halogenated organic solvents:** they include highly flammable and toxic liquids which contain less than 2% of halogen. Like alcohols**,** ketones, esters, aldehydes and amides.
- **Acids and acid solutions:** they include aqueous solutions and inorganic acids of more than 10% in volume. They are corrosive and very harmful. Like: hydrochloric, sulphuric and nitric acid solutions.
- **Inorganic salts and alkalis solutions:** composed by aqueous solutions. In general they include oxides, hydroxides and carbonates, all of them act as strong bases and are equal or more corrosive than most acids. Some examples could be: soda, potash, sodium, chloride, potassium iodide or calcium sulphate.
- **Salts, heavy metals and compound solutions.** They are basically composed by mercury oxides, chromic solutions, cadmium solutions, arsenic and lead. They are highly toxic and hazardous to the environment. Noteworthy that are directly related to acid rain.

2.6 THE SECURITY LABEL

Any recipient which contains a product or a chemical reagent must have a visible label where it gathers the next information:

1. Product's name.
2. Producer information.
3. Pictograms and danger signs.
4. R and S phrases.
5. Product coding.
6. Start date storage.

As we can see below in the illustration:

Illustration 7: Security label model

3. LABORATORY TOOLS

The majority of the gadgets used in a laboratory are made of glass as this material, presents some qualities that other materials don't, for example:

- It is transparent and so, it allows observing mixtures or reactions.
- It is also easy to clean and strongly resistant to high temperatures.

Below we can find the most used in a laboratory:

Illustration 8: Balance

Balance: measuring instrument which is used to assess the weight or the mass of an object.

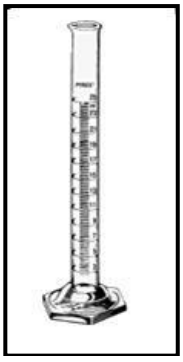


Illustration 9: Graduated cylinder

Graduated cylinder: is a cylindrical graduated gadget used for measuring volumes (especially in solvents like water and methanol). Normally it is graduated in millimetres, they can have different capacity and there can also be made of glass or plastic.

Pipette: is a tube shape gadget used to measure small volumes. There are two types of pipettes:

1. Volumetric: measure a single volume with high accuracy.
2. Graduated: measure several volumes, but less precise.

Illustration 10: Pipette

Graduated burette: is a graduated recipient which has a tube shape and which contains a key at the bottom to regulate the liquid passage. There can be of different capacities and its graduation can be in ml tenths. It is very useful especially in titrations.

Support is needed for the user, who needs to have free the hands.

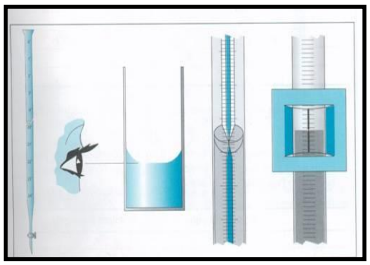


Illustration 11: Graduated burette

Illustration 12: Volumetric flask

Volumetric flask: recipient with flat bottom and long neck, which has a mark level that indicates its maximum capacity. It's a precise container used to prepare solutions of known concentration. This flask also contains a cork to facilitate the levelling and the subsequent homogenization of the solution.

Illustration 13: Beaker

Beaker: is a cylindrical vessel with a beak. It's a tool used throughout the laboratory: to dissolve, mix heat, react, etc. If the beaker is graduated allows measuring approximate volumes. It has great application in experimental chemistry tasks as it is resistant to sudden changes in temperature.

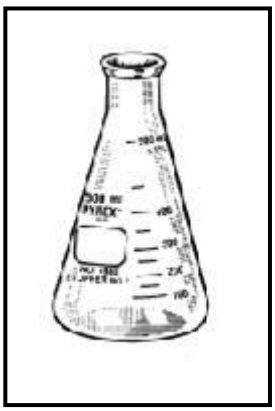


Illustration 14: Erlenmeyer flask

Erlenmeyer flask: transparent cone shaped container with a narrow opened tip, it usually has a long cylindrical neck and often include some marks.

Used by the laboratories because its practical shape for: agitation mixtures and for controlling liquids evaporation. It also accepts corks.

Illustration 15: Spatula

Spatula: metal tool used to catch small amounts of solid products. (Warning: to avoid the contamination of other products, spatulas should be kept clean and dry).

Pipette pump: gadget used to suck the liquid we want to enter into a pipette or a dropper. To use it, you only have to press and oppress the pipette pump (clicking the valve) when we suck the liquid and open the valve to eject it.

Illustration 16: Pipette pump

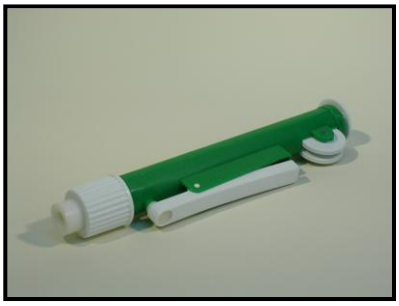


Illustration 17: Pipettor pump

Pipettor pump: like the pipette pump, it's a device who allows sucking liquid safely to fill a pipette. The suction is done only with one hand. To pour liquid just press the lever located on the lateral surface of the device.

Funnel: inverted cone shaped instrument ended with a tube at its apex. It is used to transfer liquid within a narrow container, such as for example, a bottle. It's also good to separate solids non dissolved in liquids (with the filter paper help).

Illustration 18: Funnel

4. SOLUTIONS

Matter can be presented in to different ways: homogeneous and heterogeneous.
Homogeneous matter is the one we can't distinguish its components (nor a naked eye or with the microscope's help), i.e. the one which presents a uniform distribution of its particles so that at any point it has got the same composition and properties.
Homogeneous matter comprises:

1. Homogeneous mixtures, which are formed by different components as seawater.
2. Pure substances, composed by one component. They can be:
    - ✓ Elements or substances which contain one type of atoms and which they can't be discomposed into other more simples by chemical processes.
    - ✓ Compound or substances formed by more than one type of atoms.

Heterogeneous matter is the one we can distinguish its components (nor a naked eye or with the microscope's help). We can say this matter is composed by two or more types of homogeneous matter, each homogeneous part is named phase so the set is called heterogeneous mixture.
The different heterogeneous phases present different properties as they are different substances.

Solutions are a particular type of homogeneous mixtures and they are formed by solute and solvent.
Solutions = solute + solvent
Solute is the dissolved substance. It is usually found in a lower proportion and associated with a solid.
Solvent is the substance which dissolves and includes the solute, normally it is in major proportion and it is associated with a liquid (in many solutions, the solvent is water).

Solubility as a property

It's the amount of solute dissolved in a determined volume of solvent in a saturated solution. The solutions can be:

1. Diluted, if they contain a small proportion of solute.
2. Concentrated, if they contain a lot of solute proportion.
3. Saturated, if the solvent doesn't support/accept a greater amount of solute in a determined temperature.
4. Not saturated, if the solvent still support/accept more amount of solute.
5. Oversaturated, if they contain more solute dissolved of the corresponding.

As the solubility depends on the temperature, if we heat the saturated solution, we would be able to add more solute. To interpret this, we use solubility curves.
Solubility curves are graphics which reflect the amount of solute that can be dissolved in a determined amount of solvent depending on the temperature.
Below we can find an example:

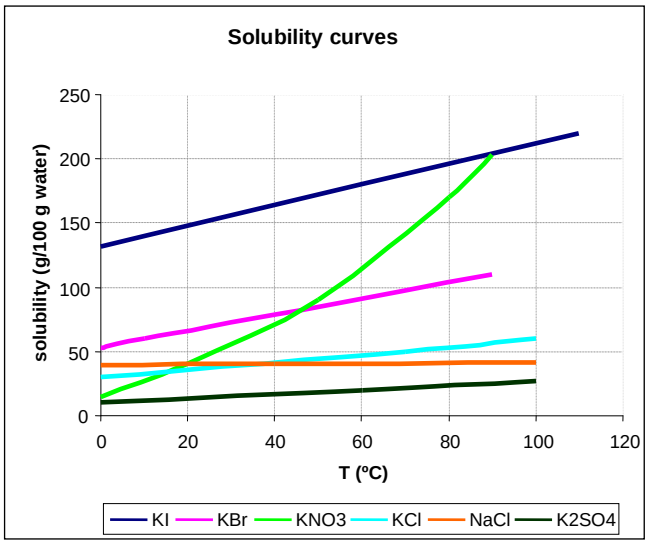


Illustration 19: Model of solubility curves

We have talked about the solutions composition (as regards to types: saturated, diluted, concentrated… solutions) and about them solubility, now we are going to talk about their composition, but for this we must introduce a new term: concentration.

The concentration is the relation existing between the solute and the solvent amount in a solution.

The solution concentration can be expressed in different ways, but almost always it's based on the relation between the mass and the volume of its components. Here we find some examples:

- Mass percentage (%).

$$\% = \frac{\text{mass of solute}}{\text{mass of solution}} \text{x} 100$$

- Volume-volume percentage (% VOL).

$$\% \text{ v} = \frac{\text{liters of solute}}{\text{liters of solution}} \text{x} 100$$

- Molarity or molar concentration (M).

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

- Molality (m).

$$\textbf{Molality} = \frac{\textbf{moles of solute}}{\textbf{kg of solvent}}$$

- Normality (N).

$$\text{Normality} = \frac{\text{gram equivalents (solute)}}{\text{liters of solution}}$$

- Mole fraction (X) or molar fraction, which can be both (from the solute or from the solvent).

$$\text{Xs} = \frac{\text{moles of solute}}{\text{moles of solute} + \text{moles of solvent}}$$

- ppm (parts per million).

$$\text{ppm} = \frac{\text{mg of solute}}{\text{kg of solution}}$$

But we are going to focus on the molar concentration or molarity (M).

The molarity is the number we find of solute moles per litre of solution.

It's the most common method of expressing concentration, especially if we work with chemical reactions and their stoichiometric relations. The only disadvantage when using molarity is that the volume varies depending on temperature.

M= n/v where "n" is the moles of solute and "v" is the volume of the solution in liters.

4.1 PREPARE A SOLUTION FROM A SOLID

Firstly, using a balance, we measure the amount of solute we need (using a watch glass to hold it). Then we add it inside a beaker, cleaning the solute remains that may have been left in the watch glass with some of the solvent we are going to use.

Secondly we use a stirring rod to dissolve the solute; later helped by the same rod, we transfer the solution to the volumetric flask and we add solvent until there is no solute in the beaker.

Finally we continue adding solvent to our volumetric flask until making level (when we are in a centimetre to reach the mark level the solvent is added with a dropping pipette) and we just homogenize.

The levelling is considered correct when the meniscus formed by the liquid is situated tangent above the level mark (as is shown in the drawing below):

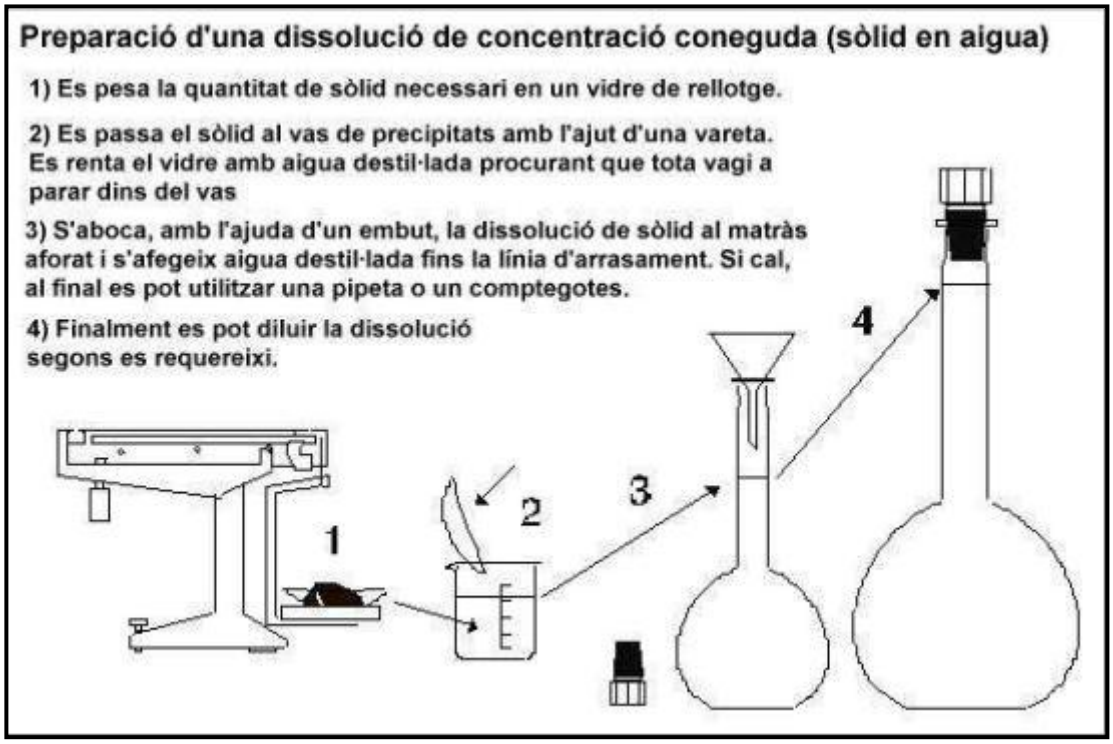


Illustration 20: Solution preparation from a solid

4.2 PREPARE A SOLUTION FROM A LIQUID

Using a pipette (previously well cleaned) and with the pipette pump help, we suck up the volume necessary of a concentrated solution to prepare ours and we introduce it into the volumetric flask. So that no liquid is left inside the pipette we hold its neck on the flask.
To complete our solution we add the solvent we want to use inside the flask until making level (when we are in a centimetre to reach the mark level the solvent is added with a dropping pipette) and we just homogenize.
The diluted solution is properly prepared when the meniscus formed by the liquid is situated tangent above the level mark (as is shown in the drawing below).

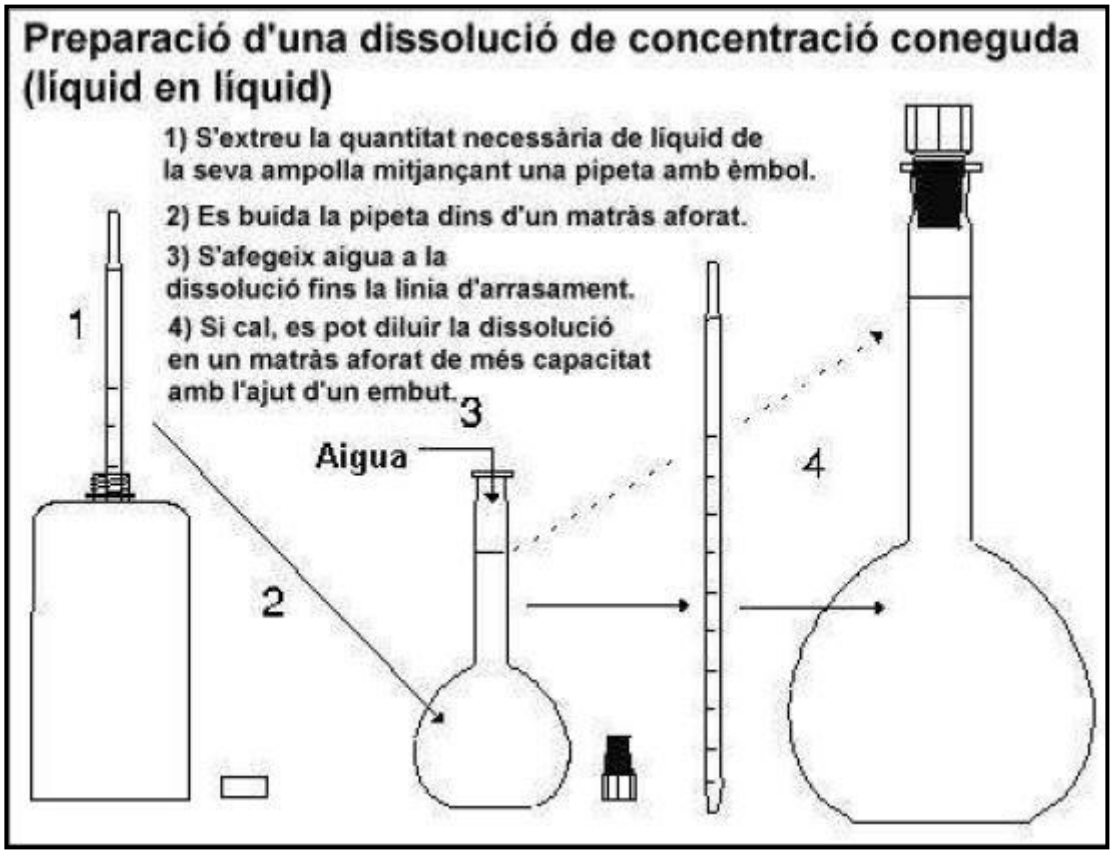


Illustration 21: Solution preparation from a liquid

4.3 QUANTITATIVE CHEMICAL ANALYSIS

A titration is a quantitative chemical analysis method to determine a substance concentration (reagent rated) adding a specific volume of a second substance (valuating agent) of known concentration which reacts with the first.

This type of analysis follows the steps below:

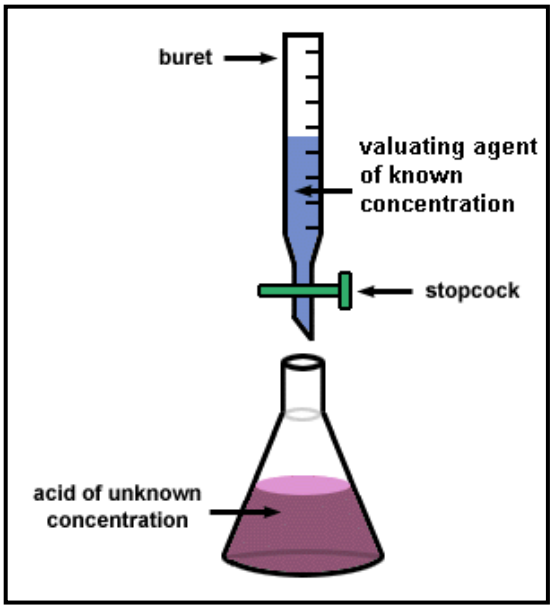


Illustration 22: Titration example

On one hand we dissolve the substance we want to analyse and we transfer the solution into a volumetric flask until levelled. Using a pipette, we take the volume we have to value and put it in an Erlenmeyer flask. On the other hand, we placed in a burette (which we also level) the valuating agent. Here it starts the titration.

We open the burette stopcock and let the valuating agent out intermittently while we shake the flask. We follow the same process until we reach the equivalence point (the point where the valuating agent added is equivalent to the reagent).

This point is known by a suitable indicator which changes colour when passes to have over-reagent to have an excess of valuating agent.

From the volume agent consumed and taking into account the stoichiometry reaction we can calculate the problem solution concentration.

Illustration 23: Reaching the equivalence point

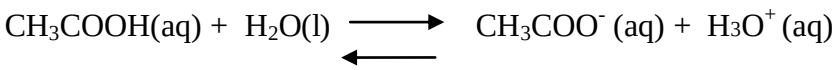
→

Illustration 24: Equivalence point reached

4.4 ACIDS AND PH

The acid-base reactions are proton transfer reactions. Acids are substances, many of them have sour taste, which have solvent power and its aqueous solutions produce hydrogen ions. While bases or alkali substances have a bitter taste, a degreaser power and its aqueous solutions produce hydroxide ions.
Both acids and bases are corrosive and lose their own properties when they react with each other.

According to the Brönsted and Lowry theory (1923) an acid can be defined as any substance capable to transfer protons and a base is any substance that can accept protons.
An acid which has a great capacity to transfer protons is a strong acid (e.g. hydrochloric acid); whereas an acid with little tendency to transfer protons is called a weak acid (e.g. acetic acid). So that, when a base has much capacity to accept protons is called a strong base (e.g. sodium hydroxide) and called a weak base when it has a little ability to accept protons (e.g. ammonia).
Strong acids and bases are the ones which we find completely dissociated in water, unlike the weak acids (which would be mainly the organic ones such as ascorbic) where a significant acid molecules portion doesn't react with water and therefore this is not completely dissociated.
To quantitatively determine an acid or a base strength we use the equilibrium dissociation constants of the acid or the base i.e. their reaction with water molecules.
In the following example we can see the acetic acid reaction with water:



Acidity and basicity are very important properties. Their measurement in a solution or in a substance is made by pH and it is determined by the number of free hydrogen ions (H+) as it's explained below.

The pH is the abbreviation of 'pondus Hydrogenium' which literally means 'the hydrogen weight'. It is defined as a negative decimal logarithm of the hydrogen ion activity in a solution:

$$pH = -\log [H^+]$$

The pH measurement result is determined by the number of protons (ions H) and the number of hydroxyl ions (OH^-) relation.
pH has no measurement units, it's only expressed by numbers. So we say that a solution is neutral if the number of protons are equal to the number of the hydroxyl ions, when this is greater than the number of the protons we say that the solution is basic; however, if the number of protons exceeds the number of hydroxyl ions, we say that the solution is acidic.

When we have to determine the pH we can follow different methods, like:

- Using a pH-meter: an electronic instrument which is related to the difference between two electrodes.
- Or using indicators, classified in:
    - Paper indicators: those have different colours for each exact pH value.
    - Indicators such as methyl orange.

To interpret pH values, we use a pH scale, a number line which goes from 0 to 14.
This scale indicates the different acidity, basicity and neutrality (when the pH = 7) degrees as we can see in the illustration.

When acids contact in water, their ions are separated, that's why we say that water acts as a great ions or ionic solutions solvent.

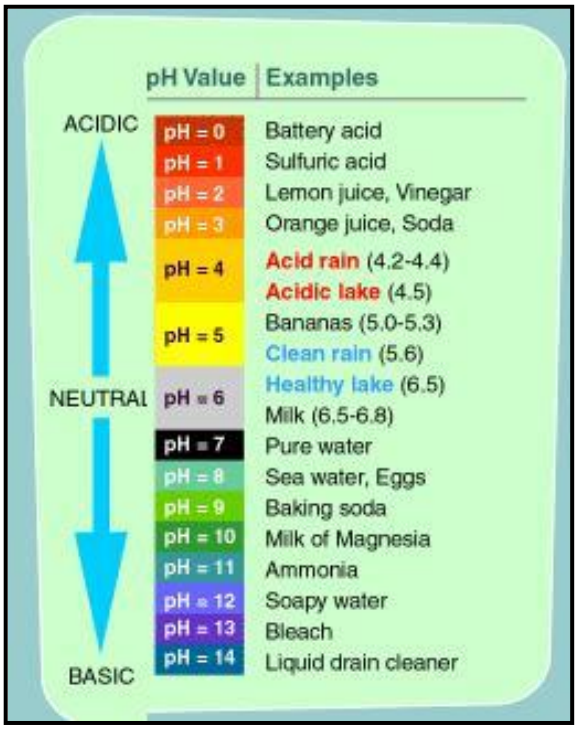


Illustration 25: pH scale

pH determination is one of the most important analytical procedures, especially in chemistry and biochemistry, since it determines many features about the structure and activity of bio macromolecules (that is to say, the cells and the organism behaviour).

To finish we can also add that pH is a logarithmic factor, i.e., when a solution becomes ten times more acidic, the pH decreases one point, as a result, it only decreases two points when the solution becomes one hundred times more acidic.

5. VITAMINS

The diet needs aren't only covered with the intake of proteins, carbohydrates, fats and minerals, since we need a few quantities of organic compounds known as vitamins. A compound is called vitamin when it can't be synthesized in sufficient amount by the organism. However vitamins are essential for growing and for a correct body function because they are indispensable for the metabolism. The problem is that only few foods contain them all and that's why we can only provide the appropriate provision of them with a varied diet, considering that the only vitamin synthesized by the body is vitamin D, formed by the skin exposure to the sun.

This kind of substances is easily altered by temperature changes, pH and long storages. Furthermore, tobacco, alcohol or drugs produce a greater expense of some of them.
Although a supplementary contribution is good, the ones which come from (fresh) food are more effective than those produced in the laboratory.

We might note that when they act as a catalysis' part, they are linked/connected to enzymes and form/ make up prosthetic groups.

Because of its solubility, vitamins are divided into two groups:

- **Fat-soluble vitamins**, i.e., that are dissolved in fats and oils. These are stored in the liver and in fatty tissues especially in the adipose. If they are consumed with excess, they can be toxic. The fat-soluble vitamins are: vitamin A (or retinol), vitamin D (or calciferol), vitamin E (or tocopherol) and vitamin K.
- **Water-soluble vitamins**, i.e., that are dissolved in water. These are coenzymes precursors and so, necessary for many chemical reactions in our metabolism. Generally they aren't toxic when they are taken in higher doses than the required because these are secreted in the urine. Opposite to the fat-soluble ones, they aren't stored in the body and this implies that must be provided regularly from outside. The water-soluble vitamins are: all the B vitamins (B1, B2, B3, B5, B6, B8 and B12) and vitamin C also called ascorbic acid.

5.1 VITAMIN C

The vitamin C discovery and its relation with the disease appeared in its absence (scurvy) occurred in the twentieth century by the Hungarian chemist and physician Alber Szent-Györgyi Nagyrápolt.
Vitamin C was isolated in 1928 by Albert, organic chemistry professor at Szedged University and 1937 Medicine Nobel Prize. Its synthesis is mainly of the English chemist Walter Norman Haworth work, professor at the Birmingham University and Chemistry Nobel Prize in 1927 for all his effort done in determining the ascorbic acid structure; award shared with Paul Karrer, Russian professor at Zurich University for his work on vitamins.

As we mentioned above, vitamin C is part of the water-soluble vitamins, so the excess is removed from the urine. Its highest concentration in the body organs is in the adrenal glands, in some parts of the eye, in the muscles and in the body fat.

This is the most vulnerable of all the vitamins, since it is influenced by factors such as oxygen contact (oxidation), light contact or cooking (which destroys 40% of it, so we can say eating raw food is best), a long storage period or even tobacco smoke.
We can find the same example in packed or natural juices, when the first ones are exposed to light; they lose a large vitamin content.

It's not a synthesizable vitamin (either by humans or animals) i.e., it has to be ingested.
The vitamin C sources are basically two:

- **Plant origin sources**. It's contained by the majority of the fruits and vegetables. This is mainly present in green peppers, citrus, orange juice, strawberries, kiwis, tangerines, cauliflower, spinaches, potatoes... (Annex).
- **Supplements:** as tablets, capsules or even mixed with honey. The most common combinations are: vitamin C effervescent (highly tolerated by the body), chewing tablets (used especially for children), non-acidic vitamin C (particularly suitable for people with acidity problems) or vitamin C with bioflavonoids (to deal with the capillaries fragility).

5.1.1 VITAMIN C PROPERTIES AND FUNCTIONS

Ocular properties

1. It improves the vision and has preventive function against glaucoma or cataracts.

Circulatory system

2. It decreases blood pressure and prevent vascular diseases onset, it also intercepts the cholesterol and fat adhesion to blood vessels and strengthens their walls to avoid rupture and internal bleedings.

Dermis

3. It helps preventing or improving skin problems like eczema or psoriasis.
4. It supports collagen creation, ideal for healing wounds caused by trauma, cuts, burns and surgery. It's also suitable for new tissue formation in broken bones problems, muscle strains, ligament rupture, arthritis or even regular nose bleeding, and for delay aging.

Diseases and bacterial infections

5. It reduces complications of the diabetes type II (poor vision, infections, healing problems…).
6. It is antibacterial so inhibits the growth of certain bacteria that are harmful to the body, such *Helicobacter pylori* which its administration is useful for the prevention or the healing of gastric ulcers.

Hormonal properties

7. Together with flavonoids, it helps to produce more estrogens decreasing the symptoms produced by the menopause.

8. It is also very useful in regulating the production of the thyroid hormone (an endocrine gland very important for our metabolism).

Antioxidant property

9. It's antioxidant*, i.e., it facilitates the elimination of free radicals generated by the own body or from outside (as for example pollutants like lead, its ingestion or inhalation produces serious health problems; or nitrates and nitrites from prepared meats, responsible of the stomach cancer appearance).
   This property seems to have positive influence on Alzheimer treatments or illnesses such as fibromyalgia or multiple sclerosis.
   Its virtue as an antioxidant improves our immune system, that's why it's used in patients subjected to radiotherapy or chemotherapy as it increases the defences that these treatments decrease.
10. Their antioxidant effects are appropriate to prevent the free radicals action which can facilitate hearing sclerosis and precipitate the deafness onset.

Laxative property

11. Vitamin C has laxative properties.

Depression and alcoholism

12. It is involved in the neurotransmitters formation so that's why it's appropriate for most depressions.
13. Their supplements are adequate to treat its deficit in alcoholism. Vitamin C also protects from pollution and from the cigarette smoke effects.

* An antioxidant is a type of molecule capable to prevent or delay the oxidation of other molecules. The oxidation is a chemical reaction of electron transfer from a substance to an oxidizing agent. This kind of reaction can produce free radicals (unbalanced cells that are responsible of destroying the healthy ones) that cause a chain reaction which harm cells.

Immune System

14. It contains histamine antagonist properties, so it's used to prevent allergies, asthma and other respiratory inflammations like sinusitis.
15. Recent studies have shown that its ingestion doesn't prevent colds and flues onset, but it decreases their duration (between 20 and 30%) and improves their symptoms.

5.1.2 THERAPEUTIC USES

- It serves as a support of the immune system. Vitamin C strengthens the immune cells (macrophages and lymphocytes) and also the immunoglobulins concentration in blood serum.
- It improves the immune functions related to the treatment and prevention of diseases associated with age.
- It has been shown that deydroascorbate acid (the main oxidized form of vitamin C in the body) reduces mortality and neurological deficit to people who has suffered strokes.
- Vitamin C could play an important role in the cholesterol synthesis regulation according to a study made in 1986.
- A high dose of vitamin C is related to the AIDS virus replication.
- A preliminary study published in the Annual of Surgery (USA) found that the administration and antioxidant supplementation using α-tocoferol and ascorbic acid decrease the stay in the ICU (Intensive Care Unit).
- In January 2007, the FDA (Food and Drug Administration) approved a toxicity testing Phase I to determine safe doses of intravenous vitamin C that can be used as a cancer potential treatment in people who have exhausted other conventional treatment options.
- A recent article published in "Proceeding of the National Academy of Sciences" by Mark Levine and collaborators from the National Institute of Diabetes and Kidney Diseases talks about an injection of high doses of vitamin C as a method to reduce

tumour weight and growth in 50% according to studies carried out in rats with ovarian, brain and pancreatic cancer.

- A study done on animals has demonstrated that vitamin C is a nerve functions and muscle protection of lead poisoning (as it reduces its concentration). For example; when smokers are supplemented 1000 mg of vitamin C, its blood lead levels decrease 81%.
- According to a study executed in 18 autistic children in 1993 a vitamin C supplement reduces the severity symptoms in autistic children.
- What is more it has been shown that vitamin C improves sperm quality in infertile men.
- Vitamin C injected intravenously is a part of the treatment who receives people intoxicated by amanita ingestion.
- Apart from all the therapeutic uses mentioned above, it has also been proved that its administration can slow down the Parkinson progress and be useful in treating herpes.

5.1.3 RDA

It is difficult that a vitamin C excess (or vitamin C hypervitaminosis) have toxic or harmful effects on the body because as we have said before, it's a water-soluble vitamin so expelled in urine.

Its daily recommended amount is ranging between 15-115 mg/day, however, this depends on the age, the sex and the state of the person in an specific moment.

For 2000 mg intakes per day it has been diagnosed gastrointestinal disorders, diarrhea and kidney stones.

Below we can see a vitamin C RDA table in mg/day and its analysis; we can find this table more extended in Annex:

State	Age	Men	Women
	1-3 years	15	15
	4-8 years	25	25
	9-13 years	45	45
	14-18 years	75	65
	+18 years	90	75
Smokers	+18 years	125	110
Pregnancy			80-85
Lactation			115-120

Table 1: Vitamin C RDA.
Source: Food and Nutrition Board of the U.S Institute of Medicine

Note that men have a slightly higher necessity to take this vitamin, followed by women during lactation. We can also stress, as we have said before, the fact that smokers (both men and women) need a little more amounts than non-smokers of the same age; as a cigarette destroys between 25 and 40 mg of vitamin C.

However, the daily vitamin C dose is completely covered eating a varied and balanced diet rich in fruits and vegetables.

To finalize we should mention that there are always situations where it is essential to increase its administration. These circumstances are basically:

- Pregnancy and lactation.
- Alcoholic or smoker people.
- Diabetics.
- Asthmatic and allergic people.
- People who take daily medications (such as oral contraceptives, cortisones, antibiotics, etc.).

5.1.4 LACK OF VITAMIN C AND SCURVY

As it produces beneficial effects on health when we ingest adequate doses, non or low ingestion of it can cause several problems that may degenerate into more serious illnesses.
Its deficiency can be manifested in a general body weakness state or other particular symptoms such as difficulty on healing.
Below we can find some of its lack signs:

1. Inflamed or bleeding gums.
2. Nose bleeds.
3. Bleedings (which lead to anemia).
4. Wound healing deficiency.
5. Bruises and broken capillaries those appear due to a small hit.
6. Weak dental enamel/gingivitis.
7. Rough, dry and aged skin, more propitious to have wrinkles.
8. Weight loss.
9. Fatigue (the muscles are like tired, weak) and sadness feeling.
10. Rheumatoid arthritis or swollen joints.
11. Bones fragility.
12. Hypoglycemia (glucose concentration in blood abnormally low).
13. Highest possibility of contracting diseases.
14. Scurvy.

The scurvy is the disease caused by vitamin C deficiency or lack in our diet. It is manifested as a result of poor intake of fresh fruit and vegetables (which as we have seen before, are its principal sources), this explains the fact that in the antiquity this disease was very common, especially in regions where it wasn't easy to have food which contain this type of vitamin.

For a long time, scurvy origin was unknown and during two and a half centuries it was treated as a kind of contagious infirmity. It became one of the most epidemics for sailors and fishermen who were travelling for months in a boat during the Middle Age.

Scurvy was attributed to various factors such as the cold seas and even the ships wood. The Spanish sailors called it "the ships plague", the Portuguese "the Loanda harm" and the English "the sea disease".

The scurvy cure wasn't discovered until James Lindt experiments (doctor in the British navy in 1747). James took twelve sailors affected by the disease and made six groups of two. Each group received a different treatment to observe its evolution. After this, the only couple who had been supplied with orange and lemon juice on its diets, evolved favourably.

Illustration 26: James Lindt

So then, we were at a time that although the agent which caused the disease wasn't known, they already knew its cure. Since then, the British navy sailors were called "limely" or lemon drinkers.

The discovery of vitamin C and its relation to scurvy occurred in the twentieth century by the Hungarian Scientific, Albert Szent-Györgyi Nagyrápolt.

Symptoms

The scurvy is characterized by a general body weakness and for:

1. Poor healing and opening up of the already healed wounds.
2. Hemorrhages/bleedings (which lead to anemia).
3. Phlebothrombosis/venous thrombosis.
4. Ecchymosis/bruises due to high blood vessels fragility.
5. Swollen joints.
6. Swollen and bleeding gums.
7. Hair fall.

In terminal states, fever, edema (inflammation due to a liquid accumulation in tissues), jaundice (yellowish skin and mucous membranes due to a bilirubin augment) are frequent. What is more, convulsions, sudden shocks (inadequated blood flow) or even death are also possible.

The symptoms in children are a bit different: anorexia, suppuration, gastroenteritis, multiple hemorrhages, aggressiveness, nape rigidity (as in meningitis cases) and sudden death.
The people more predisposed to contract/develop scurvy are the undernourished.

5.1.5 CURIOSITIES

- The humans together with guinea pigs, monkeys, the Chinese nightingale, the fruit bats and a type of trout are the only species which can't synthesize vitamin C.
- It's best to take vitamin C out of meals so it doesn't interfere with the digestive process.
- To protect vitamin C from the rest of the food, it's advisable to avoid eating raw food and canned one. If you cook food which contains vitamin C it's convenient to drink the broth as we remember that's a type of water-soluble vitamin.

- This vitamin is easily destroyed in contact with oxygen, light and warmth as it oxidizes and loses its activity.
- The vitamin C content in fruit and vegetables varies depending on the maturity degree. When they are green is when there is less vitamin C content, this increases the quantity just when they are ripen and finally it decreases again. In summary: overripen fruit have already lost part of its vitamin C content.

5.2 ASCORBIC ACID

5.2.1 ASCORBIC ACID BIOSYNTHESIS

Vitamin C or ascorbic acid is also known as anti-scurvy vitamin. Here we can see its structure:

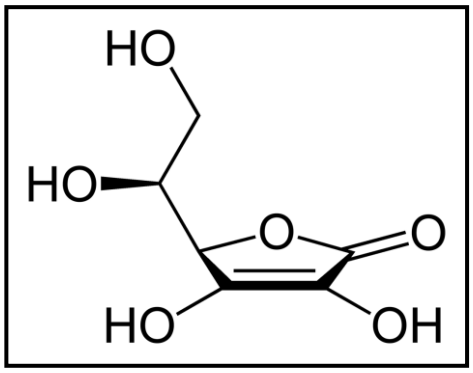


Illustration 27: Ascorbic acid structure

It corresponds to a *L*-dienol gulonic acid 2-3 lactone. It is designated as *L*-ascorbic acid for its relation with L-gulosa, but in fact it's dextrorotatory (substance which deviates the polarized light plane to the right). *D*-gulose and *L*-gulosa by the reaction of the same alcohol cause sorbitol, and for the oxidation of the same dibasic acid originate the saccharic acid. The two vitamin C enol groups determine its acidity and form the ascorbic acid as we can observate in the following illustration:

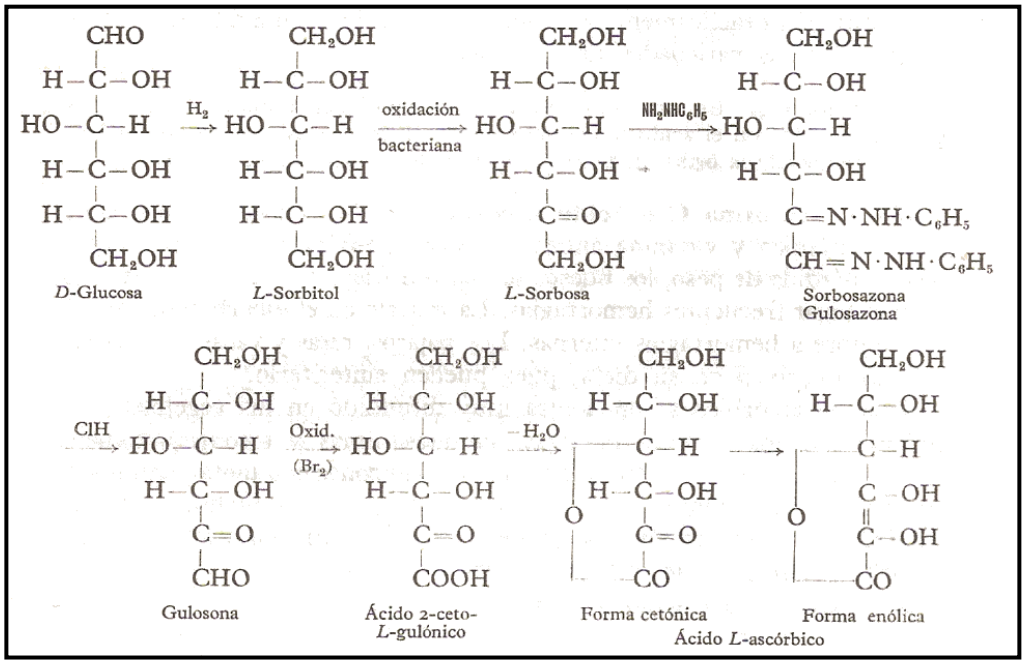


Illustration 28: Transformation from *D*-glucose to *L*-ascorbic acid schema

The ascorbic acid can also be obtained industrially from *D*-glucose and *L*-xylose or *L*-lyxose according to the steps below:

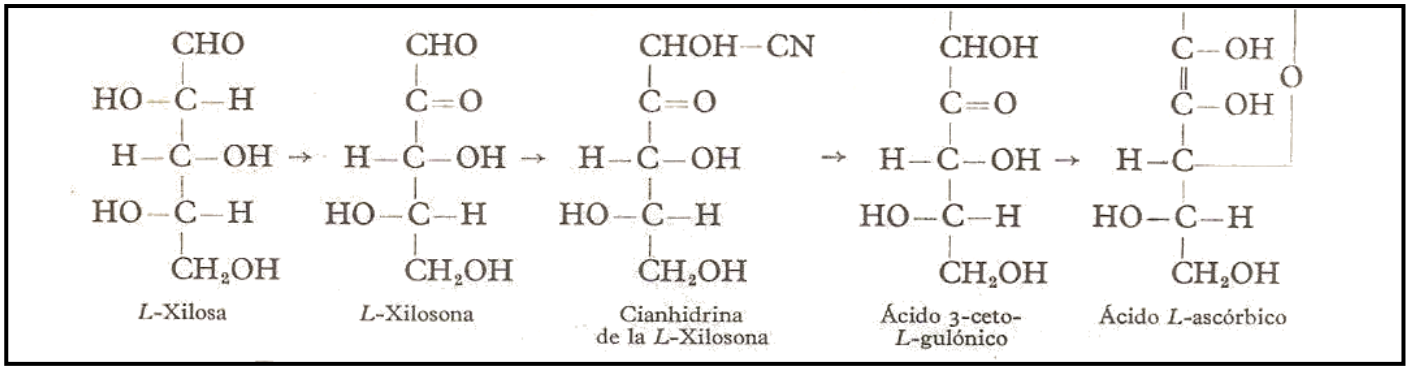


Illustration 29: Transformations from *L*-xylose to *L*-ascorbic acid schema

Humans together with the other species before mentioned haven't got the enzymatic capacity to produce vitamin C; and this is because *L*-gulonolactone oxidase (the last enzyme in the synthesis process) is absent because the gene for this enzyme (Pseudo ΨGULO gene) is faulty/defective.

This refers to a genetic mutation, occurred approximately 63 million years ago, which isn't lethal for the organism, because vitamin C is abundant in food sources.

It has been detected that the species which are affected by this mutation, have adapted a mechanism to compensate it.

5.2.2 ASCORBIC ACID CHEMISTRY

The ascorbic acid has different structural elements which contribute to their chemical behaviour, like: the lactone and the two enol hydroxyl groups and its primary and secondary alcohol group.

Oxidation and antioxidation ascorbic acid mechanism

As we mentioned previously, vitamin C is the most unstable vitamin being easily destroyed by heat and easily oxidised from the two hydrogens loss to a diketon from (dehydroascorbic acid) as we appreciate beneath:

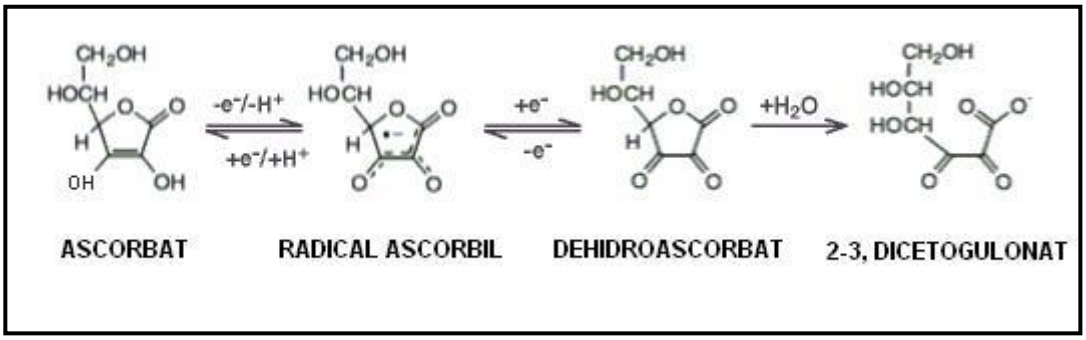


Illustration 24: Ascorbic acid oxidation scheme

The endiol structure is responsible of its antioxidant qualities, considering that endiols can be easily oxidized to diketone as it's shown below:

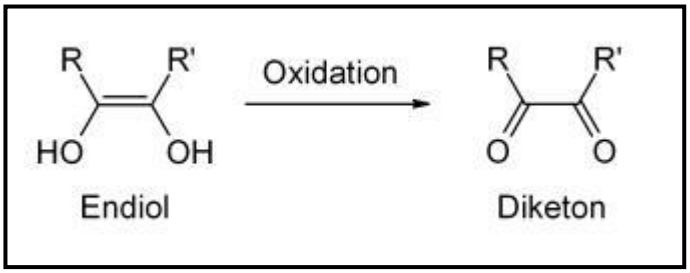


Illustration 31: Simplified endiol structure

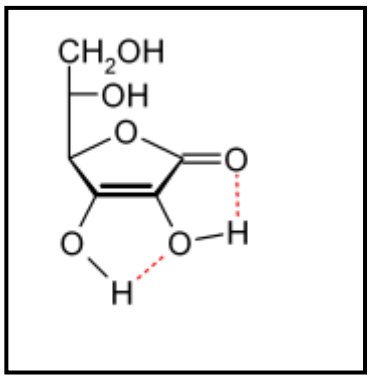


Illustration 32: Completed endiol structure

The ascorbic acid forms two hydrogen bonds link which decisively contribute to the endiol stability and chemical qualities structure.

5.2.3 STEREOCHEMISTRY

Ascorbic acid exists in four different stereoisomerism ways which show its optical activity:

1. *L*-ascorbic acid.
2. *D*-ascorbic acid.
3. Acid *L*-isoascorbic.
4. Acid *D*-isoascorbic.

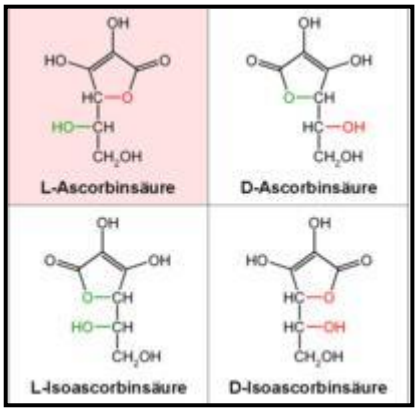


Illustration 33: Acid ascorbic stereoisomers

The *D*-and *L*-ascorbic acid molecules are enantiomers to each other, the same way that *L*- and *D*- are for the isoascorbic.

5.2.4 ASCORBIC ACID USES

The ascorbic acid and its sodium, potassium and calcium salts are often used as antioxidants in food. These compound are water soluble so they can't protect their fats from oxidation. For the same purpose ascorbic acid esters soluble in fat with long-fatty acids (ascorbyl palmitate or ascorbyl stereate) can also be used as antioxidants.
80% of the world's ascorbic acid supply is produced in China.
Currently most of the vitamin C is produced by the genetically modified organisms (GMO vitamin C) help as it's cheaper.

The additive E numbers more used in Europe are:

1. E300: ascorbic acid.
2. E301: sodium ascorbate.
3. E302: calcium ascorbate.
4. E303: potassium ascorbate.
5. E304: ascorbic acid fatty acid esters: ascorbyl palmitate and ascorbyl stereate.

It is also added to water previously treated with iodine to make it drinkable, neutralizing the unpleasant iodine taste; and it can also be used in plastic production.

5.2.5 ASCORBIC ACID DETERMINATION

The concentration of an ascorbic acid solution can be found out in different ways, some of them explained below. However, we must emphasize that the method used was the one with N-bromosuccinimide.

DCPIP. It is a widely used agent (dye 2,6 diclorofenol-indofenol or DCPIP). We just add this dye to the ascorbic acid solution until a faint pink colour persists for about 15 seconds.

IODINE. This method requires the iodine and an indicator (the starch) use. The iodine reacts with all the ascorbic acid, when the last one has reacted, the iodine excess form a dark blue complex thanks to the starch indicator help.

IODATE AND IODINE. This vitamin C determination method implies the fact of compose and standardize the iodine solution (for example: generate iodine by the reaction of iodate and iodide ion in ascorbic acid presence).

N-BROMOSUCCINIMIDE (NBS). The NBS is an oxidation agent, which oxidizes the ascorbic acid (following the same method as in the one with iodine; the excess of NBS indicates the quantitative chemical analysis end forming a blue/black complex with starch) in the titration.

6. PRODUCT DESCRIPTION

6.1 NBS

The NBS or Bromosuccinimide is a chemical reagent used in radical substitution and electrophilic addition reactions in organic chemistry.

Bromosuccinimide can be considered as a bromine source.

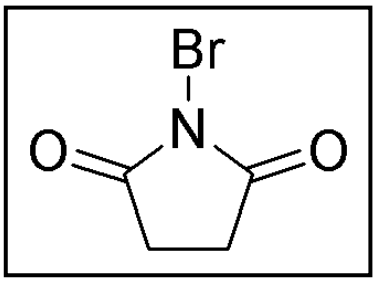


Illustration 254: NBS structure

Properties

Molecular formula: $(CH_2CO)_2NBr$

Molecular mass: 177.99g/moles.

Appearance: Pure NBS is white, although it can often be found white or slightly brown due to bromine.

Melting point: 174-179 ºC

Density: 2.098 g/cm^3

In our case, we are using a 98% purity NBS.

Precautions we should consider when using it

1. In general, NBS reactions are exothermic.
2. Over time, NBS is decomposed realising bromine.
3. Although N-bromosuccinimide is easier and safer to use than bromine, we must avoid its inhalation.
4. We must take special care when it is abundantly used.
5. It should be kept in a refrigerator.

Risks

It's harmful if swallowed; it also irritates the eyes, the skin and the respiratory tract.

Advises and tips

In eye contact case, we should wash them immediately with plenty of water and go to see a doctor. We should also wear suitable protective clothes.

6.2 GLACIAL ACETIC ACID

Acetic acid (also called etanoic acid according to IUPAC) can be found in acetate ion form.

This acid is present in vinegar (between 3-6%) being primarily responsible of its flavour and its odour. In its anhydrous form is named glacial acetic acid.

The acetic acid is used as a reagent and solvent in the acetates preparations and favours the dye fixation in fibbers.

Properties

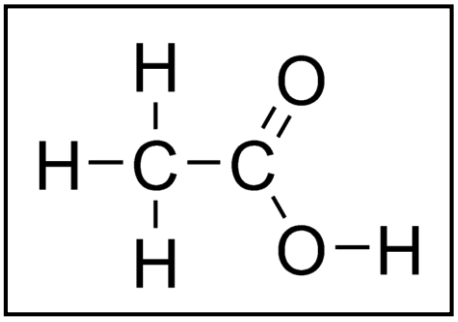


Illustration 35: Glacial acetic acid formula

Molecular formula: CH_3COOH

Molecular mass: 60.05g/moles.

Appearance: white or light yellow solid.

Density: 1.05 g/cm³

Melting point: 17 ºC

Boiling point: 118 ºC

Freezing point: higher than 16 ºC

Acidity (pKa): 4.76

In our case, we are using a 99,5 % purity glacial acetic acid.

Precautions we should consider when using it

Latex gloves don't offer protection to glacial acetic acid.

Risks

It is corrosive so it must be handled carefully.
R10 - Flammable.
R35 - Causes severe burns.

Advises and tips

S2 - Keep out of the reach of children
S23 - Do not breathe gas/fumes/vapour/spray (appropriate wording to be specified by the manufacturer).
S26 - In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.

In addition, it's recommended to handle it in a smoke extractor.

6.3 POTASSIUM IODIDE (KI)

The potassium iodide is a crystal salt widely used especially in photography and radiation treatment as an analytical reagent. In addition is also used as a food additive.
It is obtained by a iodine in aqueous KOH solution.

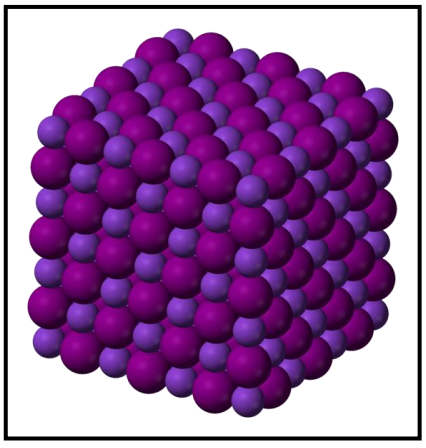


Illustration 36: KI

Properties

Molecular form: KI
Molecular mass: 166.01 g/moles.

Appearance: white salt-tasted crystals or powder.

Density: 3.13g/cm³

Melting point: 680 ºC

Boiling point: 1330º C

Soluble in water, ethanol, acetone and glycerine.

Precautions we should consider when using it:

It requires personal protective elements like: safety glasses, gloves and a gown.

Risks

1. It's a mild irritant.
2. A chronic overexposure can be harmful for the thyroid gland.

6.4 STARCH

It's widely distributed among plants which synthesize it using carbon dioxide from the atmosphere and water in chlorophyll presence.

It's used for the sugar reduces in wine determination according to Rebelein method.

It's used as an indicator and together with iodine form a blue compound, stable at low temperatures.

Properties

Molecular formula: $(C_6H_{10}O_5)_n$

Molecular mass: $(162.14)_n$ g/moles.

In our case, we are using a 2% solution.

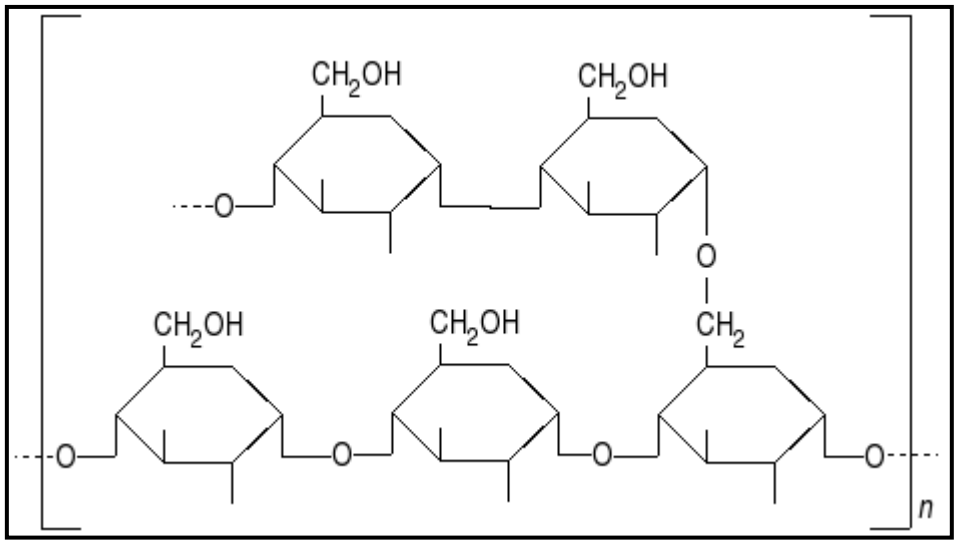


Illustration 37: Starch structure

6.5 *L*-ASCORBIC ACID

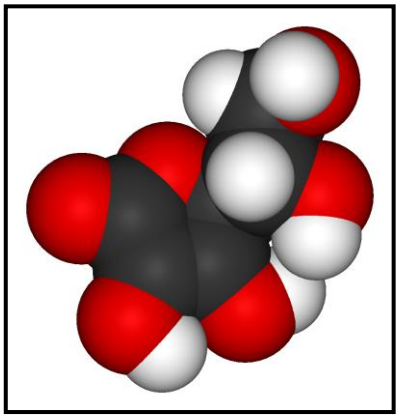


Illustration 38: Ascorbic acid

Ascorbic acid or vitamin C is a water-soluble vitamin, chemically related with glucose.
This organic acid is a powerful reducing agent capable of reacting with oxygen so often used as an antioxidant.

Properties

Molecular formula: $C_6H_8O_6$
Molecular mass: 176.13 g/mol
Appearance: white or light yellow solid.
Density: 1.65 g/cm³
Melting point: 190 - 192 °C
Water-soluble
Acidity (pKa): 4.17 (first), 11.6 (second).

In our case, we are using a 99% purity ascorbic acid.

Precautions we should consider when using it

It's light sensitive, therefore, exposure to air favours its decomposition.

Risks

Irritation by eye contact.

Advises and tips

We should avoid it from high temperatures.

7. PRACTICE INTRODUCTION

The chemical methods for ascorbic acid determination are primarily based on reducing its character. As we said before we dot the acid valoration through a NBS solution which acts as the oxidant, so that converts secondary alcohols into ketones (which lead to dehydroascorbic acid) to be irreversibly reduced to succinimida and hydrogen bromide form.

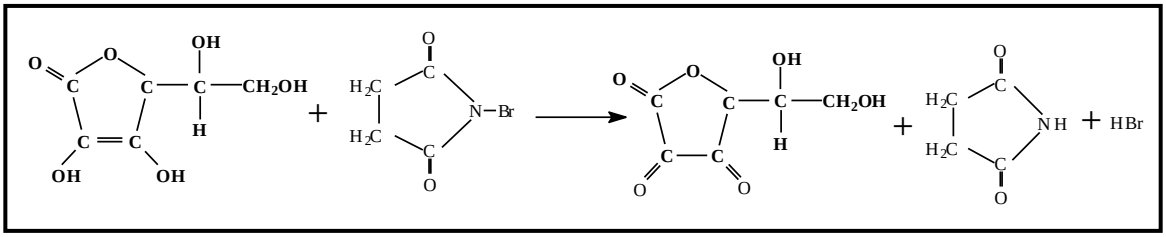


Illustration 39: Reduction reaction between succinimida acid and hydrogen bromide

The NBS has the ability to liberate iodine when it reacts with potassium iodide in acid medium (in our case, acetic) but in ascorbic acid presence the last one is oxidized first. If the two substances are in the same solution, until ascorbic hasn't been completely oxidized iodine is not going to be released by iodide oxidation.

A slight NBS excess when all the ascorbic acid has been oxidized will give the iodine appearance in the solution (we can detect this if we add a few drops of starch 2% which, together with the iodine, will dye blue/purple the solution).

The entailed reaction in our practices is mainly:

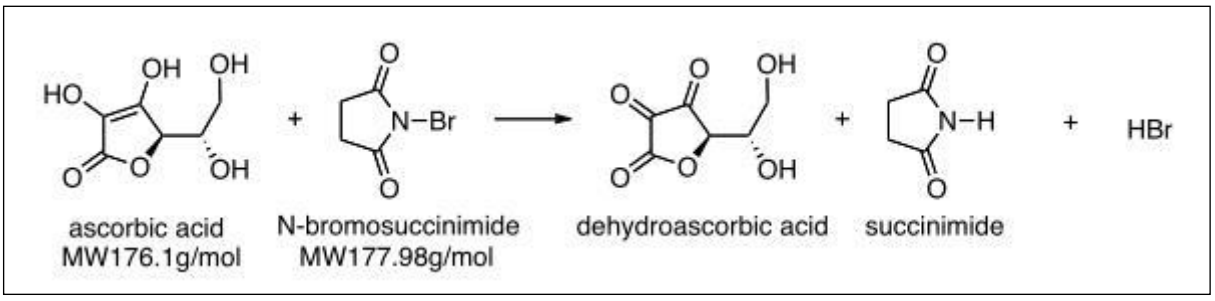


Illustration 40: Entailed reaction.

In summary, to determine the vitamin C amount that is contained in the sample problem (natural or bottled fruit juice) we must first know the NBS solution volume needed to react with all the ascorbic acid content in five different beakers.

For each experiment we require five beakers (that we will number from 1 to 5 with labels) and in which we will add different juice amounts (among other products); immediately we will observe them behaviour and their coloration once the agent has been added.
The results will be obtained from calculations made after the five beakers containing juice with the five beakers containing a pattern solution (made, among other products, with 99% purity ascorbic acid in place of different sample juices) comparisons.
Before practice though, we must prepare the ascorbic acid (used exclusively in the pattern solution), potassium iodide, acetic acid and NBS solutions, which are indispensable to carry out the experiment.

7.1 SOLUTIONS NEEDED TO PRACTICE PREPARATION

7.1.1 ASCORBIC ACID $2x10^{-3}$ M PREPARATION

Materials needed for preparation

1. Balance
2. A beaker.
3. A stirring rod.
4. A 500 ml volumetrik flask.
5. A plastic bottle.

Products needed for preparation

1. Ascorbic acid (solid).
2. Distilled water.

We want to prepare a 500 ml solution of ascorbic acid $2x10^{-3}$ M. But for do this, first we have to calculate the ascorbic acid grams (solute) that we need by the following conversion factor:

$$500\,\text{ml} \times \frac{2\text{x}10^{-3}\ \text{moles}\ C_6H_8O_6}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^3\ \text{ml}} \times \frac{176{,}13\,\text{g}\ C_6H_8O_6}{1\,\text{mole}} \times \frac{100\,\text{g pures}}{99\,\text{g impures}} = \mathbf{0{,}178}$$

grams $C_6H_8O_6$

Once we have made the calculations, we are able to begin to prepare the solution. Using a balance we weigh 0,178 g of $C_6H_8O_6$ (contained in a beaker). When we have the exact grams, we add a little of distilled water in the beaker and with a stirring rod help we dilute the solute. After it's diluted, and with the stirring rod help, we pass the beaker solution on a 500 ml volumetric flask.

Later we add water in the beaker until it doesn't remain solute. Finally we add distilled water to the flask to the level.

The solution is completed and transferred to a plastic bottle which contains an: ascorbic acid $2\text{x}10^{-3}$ M label.

7.1.2 KI 10% PREPARATION

Materials needed for preparation

1. Balance
2. A beaker.
3. A stirring rod.
4. A 100 ml volumetrik flask.
5. A plastic bottle.

Products needed for preparation

1. Potassium iodide (solid).
2. Distilled water.

We want to prepare 100 ml of KI 10% solution w/v = $\mathbf{\frac{10\,g\,KI}{100\,ml}}$

Using a balance we weigh 10 g of KI (contained in a beaker). When we have the exact grams, we add a little of distilled water in the beaker and with a stirring rod help we dilute the solute. After it's diluted, and with the stirring rod help, we pass the beaker solution on a 100 ml volumetric flask.

Later we add water in the beaker until it doesn't remain solute. Finally we add distilled water to the flask to the level.

The solution is completed and transferred to a plastic bottle which contains a: potassium iodide 10% label.

7.1.3 ACETIC ACID 10% PREPARATION

Materials needed for preparation

1. Balance
2. A beaker.
3. A stirring rod.
4. A 100 ml volumetrik flask.
5. A plastic bottle.

Products needed for preparation

1. Acetic acid 99,5% purity (solid).
2. Distilled water.

We want to prepare a 100 ml solution of acetic acid. But for do this, first we have to calculate the acetic acid grams (solute) that we need due to the 99,5% purity of the acetic acid by the following conversion factor:

$$100\,\text{ml (solution)} \times \frac{10\,\text{g (solute)}}{100\,\text{g (solution)}} \times \frac{100\,\text{g (solution)}}{99{,}5\,\text{g (solute)}} = \mathbf{10{,}05\ ml\ CH_3COOH}$$

Using a balance we weigh 10 g of CH_3COOH (contained in a beaker). When we have the exact grams, we add a little of distilled water in the beaker and with a stirring rod help we dilute the solute. After it's diluted, and with the stirring rod help, we pass the beaker solution on a 100 ml volumetric flask.

Later we add water in the beaker until it doesn't remain solute. Finally we add distilled water to the flask to the level.

The solution is completed and transferred to a plastic bottle which contains an: acetic acid 10% label.

7.1.4 STARCH 2% PREPARATION

This product comes ready from factory so we only need to clean a dropper bottle (like the one we see in the illustration) which contains the 2% starch tag and fill it with this solution.

Illustration 41: Dropper bottles

7.1.5 N-BROMOSUCCINIMIDE 10^{-3} M PREPARATION

Materials needed for preparation

1. Balance
2. A beaker.
3. A stirring rod.
4. A 500 ml volumetrik flask.
5. A plastic bottle.

Products needed for preparation

1. NBS (solid).
2. Distilled water.

We want to prepare a 500 ml solution of NBS 10^{-3} M. But for do this, first we have to calculate the NBS grams (solute) that we need due to the 98% purity of the NBS by the following conversion factor:

$$500\,\text{ml} \times \frac{2\times10^{-3}\ \text{moles}\,(CH_2CO)_2NBr}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^3\ \text{ml}} \times \frac{177{,}99\,\text{g}}{1\,\text{mole}} \times \frac{100\,\text{g impures}}{98\,\text{g pures}} = \mathbf{0{,}18}$$

g$(CH_2CO)_2NBr$

Using a balance we weigh 0,18 g of NBS (contained in a beaker). When we have the exact grams, we add a little of distilled water in the beaker and with a stirring rod help we dilute the solute. After it's diluted, and with the stirring rod help, we pass the beaker solution on a 500 ml volumetric flask.

Later we add water in the beaker until it doesn't remain solute. Finally we add distilled water to the flask to the level.

The solution is completed and transferred to a plastic bottle which contains a NBS 10^{-3} M label.

8. PRACTICE

8.1 PATTERN SOLUTION

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Ascorbic acid $2x10^{-3}$ M solution.
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the $C_6H_8O_6$ $2x10^{-3}$ M solution previously prepared and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of Ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	0,3558 mg	0,7 ml	$4,11x10^{-4}$ M
2	2 ml	0,71163 mg	0,5 ml	$3,3x10^{-4}$ M
3	4 ml	1,42327 mg	0,3 ml	$2,30x10^{-4}$ M
4	6 ml	2,1349 mg	0,2 ml	$1,6x10^{-4}$ M
5	8 ml	2,8465 mg	0,2 ml	$1,6x10^{-4}$ M

Table 2: Pattern solution results

8.2 SAMPLE 1: ZUMOSOL PASCUAL ORANGE JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Zumosol Pascual orange juice.
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the Zumosol Pascual orange juice and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pumb help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pumb help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add again two or three more 2% starch solution drops, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations for know the ascorbic acid amount contained in them (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Illustration 42: Result of the Zumosol Pascual orange juice practice

Number of beaker	Volume of ascorbic acid solution	Grams of ascorbic acid contained	Volume of NBS spent on the valoration	Concentration of NBS solution
1	1 ml	215,75 mg	7 ml	$8,75x10^{-4}$ M
2	2 ml	207,07 mg	13,5 ml	$8,7096x10^{-4}$ M
3	4 ml	118,64 mg	16,7 ml	$8,067x10^{-4}$ M
4	6 ml	59,60 mg	14,4 ml	$7,0588x10^{-4}$ M
5	8 ml	93,80 mg	27,5 ml	$7,7464x10^{-4}$ M

Table 3: Sample 1 Zumosol Pascual orange juice results

8.3 SAMPLE 2: ZUMOSOL PASCUAL ORANGE JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Zumosol Pascual orange juice.
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the Zumosol Pascual orange juice and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	226,16 mg	7,3 ml	$8{,}795 \times 10^{-4}$ M
2	2 ml	153,62 mg	10,4 ml	$8{,}387 \times 10^{-4}$ M
3	4 ml	112,77 mg	16 ml	8×10^{-4} M
4	6 ml	47,45 mg	12,1 ml	$6{,}68 \times 10^{-4}$ M
5	8 ml	130,90 mg	36,3 ml	$8{,}19 \times 10^{-4}$ M

Table 4: Sample 2 Zumosol Pascual Orange juice results

8.4 SAMPLE JUVER ORANGE JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Juver orange juice.
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).

4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of Juver orange juice and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	50,08 mg	2,1 ml	$6,77x10^{-4}$ M
2	2 ml	34,67 mg	3,2 ml	$6,1538x10^{-4}$ M
3	4 ml	31,70 mg	6 ml	$6x10^{-4}$ M
4	6 ml	23,05 mg	7,2 ml	$5,45x10^{-4}$ M
5	8 ml	20,63 mg	8,9 ml	$5,266x10^{-4}$ M

Table 5: Sample Juver orange juice results

8.5 SAMPLE FRESH SQUEEZED ORANGE JUICE

Material needed for preparation

1. 5 beakers
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Orange juice (just finished squeezing).
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).

4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the organge juice (just finished squeezing) and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	7,5087 mg	0,9 ml	$4{,}7368 \times 10^{-4}$ M
2	2 ml	5,6613 mg	1,5 ml	$4{,}2857 \times 10^{-4}$ M
3	4 ml	2,4597 mg	1,8 ml	3,1034x10-^{4} M
4	6 ml	2,0129 mg	2,4 ml	$2{,}8571 \times 10^{-4}$ M
5	8 ml	1,4040 mg	2,6 ml	$2{,}4528 \times 10^{-4}$ M

Table 6: Sample fresh squeezed orange juice results

8.6 SAMPLE 1: ECOLOGICAL MANDARINE JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Organic mandarine juice.
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).

4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the organic mandarine juice and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

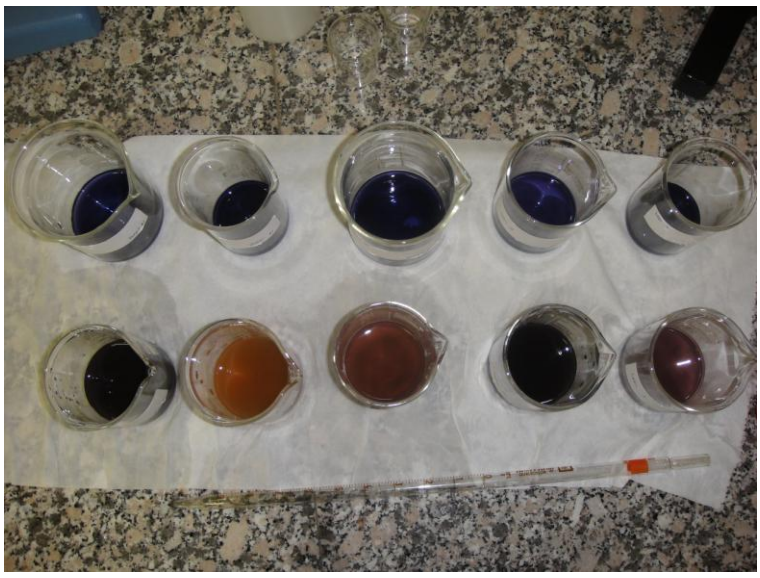


Illustration 43: Result of the ecological mandarin juice practice.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color

persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid containet**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	160,48 mg	5,4 ml	$8,4375x10^{-4}$ M
2	2 ml	100,91 mg	7,3 ml	$7,8494x10^{-4}$ M
3	4 ml	106,80 mg	15,3 ml	$7,927x10^{-4}$ M
4	6 ml	84,86 mg	19,2 ml	$7,5294x10^{-4}$ M
5	8 ml	68,58 mg	21,4 ml	$7,2789x10^{-4}$ M

Table 7: Sample 1 ecological mandarine juice results

8.7 SAMPLE 2: ECOLOGICAL MANDARINE JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Organic mandarine juice.
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the organic mandarine juice and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).

- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	152,58 mg	5 ml	$8,3x10^{-4}$ M
2	2 ml	95,88 mg	7 ml	$7,7x10^{-4}$ M
3	4 ml	97,56 mg	14,2 ml	$7,802x10^{-4}$ M
4	6 ml	72,67 mg	16,8 ml	$7,368x10^{-4}$ M
5	8 ml	91,71 mg	27 ml	$7,714x10^{-4}$ M

Table 8: Sample 2 ecological mandarine juice results

8.8 SAMPLE FRESH SQUEEZED MANDARINE JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Mandarine juice (just finished squeezing).
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the mandarine juice (just finished squeezing) and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).

- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

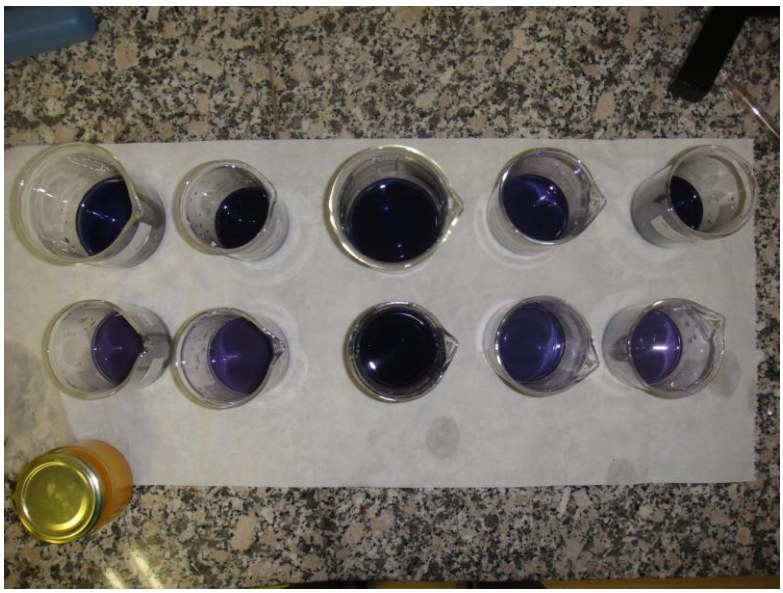


Illustration 44: Result of the fresh squeezed mandarin juice.

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid**	**Grams of ascorbic acid**	**Volume of NBS spent on**	**Concentration of NBS**

	solution	contained	the valoration	solution
1	1 ml	7,5087 mg	0,9 ml	$4{,}7368 \times 10^{-4}$ M
2	2 ml	3,4373 mg	1,1 ml	$3{,}5483 \times 10^{-4}$ M
3	4 ml	2,935 mg	1,7 ml	$2{,}982 \times 10^{-4}$ M
4	6 ml	2,45 mg	2,7 ml	$3{,}1034 \times 10^{-4}$ M
5	8 ml	2,848 mg	3,3 ml	$3{,}9203 \times 10^{-4}$ M

Table 9: Sample fresh squeeze mandarine juice results

8.9 SAMPLE TWO-HOUR SQUEEZED MANDARINE JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

7. Mandarine juice (squeezed two hours ago).
8. KI 10% solution (previously prepared).
9. Acetic acid 10% solution (previously prepared).
10. Starch 2% solution.
11. Distilled water.
12. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the mandarine juice (squeezed two hours ago) and we introduce it in the beaker containing the number 1 tag.

We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	3,96 mg	0,6 ml	$3,75x10^{-4}$ M
2	2 ml	2,0129 mg	0,8 ml	$2,857x10^{-4}$ M
3	4 ml	1,044 mg	1,1 ml	$2,1568x10^{-4}$ M
4	6 ml	1,1017 mg	1,7 ml	$2,2077x10^{-4}$ M
5	8 ml	0,9613 mg	2,1 ml	$2,0792x10^{-4}$ M

Table 10: Sample two-hour squeezed mandarine juice results

8.10 SAMPLE FRESH SQUEEZED LEMON JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Lemon juice (just finished squeezing).
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.

6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the lemon juice (just finished squeezing) and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	Volume of ascorbic acid solution	Grams of ascorbic acid contained	Volume of NBS spent on the valoration	Concentration of NBS solution
1	1 ml	5,0766 mg	0,7 ml	$4,1176x10^{-4}$ M
2	2 ml	3,962 mg	1,2 ml	$3,75x10^{-4}$ M
3	4 ml	2,9355 mg	2 ml	$3,3x10^{-4}$ M
4	6 ml	1,8709 mg	2,3 ml	$2,7710x10^{-4}$ M
5	8 ml	1,404 mg	2,6 ml	$2,4528x10^{-4}$ M

Table 11: Sample fresh squeezed lemon juice results

8.11 SAMPLE FRESH SQUEEZED UNRIPED KIWI JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Unriped kiwi juice (just finished squeezing).
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the unriped kiwi juice (just finished squeezing) and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	5,0766 mg	0,7 ml	$4{,}1176 \times 10^{-4}$ M
2	2 ml	5,466 mg	0,9 ml	$3{,}1034 \times 10^{-4}$ M
3	4 ml	1,219 mg	1,2 ml	$2{,}3076 \times 10^{-4}$ M
4	6 ml	1,1017 mg	1,7 ml	$2{,}2077 \times 10^{-4}$ M
5	8 ml	0,9613 mg	2,1 ml	$2{,}0792 \times 10^{-4}$ M

Table 12: Sample fresh squeezed unriped kiwi juice results

8.12 SAMPLE FRESH SQUEEZED RIPE KIWI JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Ripe kiwi juice (just finished squeezing).
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.

6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the ripe kiwi juice (just finished squeezing) and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Illustration 45: Result of the fresh squeezed ripe kiwi juice practice

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	14,38 mg	1,4 ml	$5,83x10^{-4}$ M
2	2 ml	11,528 mg	2,4 ml	$5,45x10^{-4}$ M
3	4 ml	5,661 mg	3 ml	$4,285x10^{-4}$ M
4	6 ml	6,87 mg	5,1 ml	$4,594x10^{-4}$ M
5	8 ml	4,93 mg	5,5 ml	$4,074x10^{-4}$ M

Table 13: Sample fresh squeezed ripe kiwi juice results

8.13 SAMPLE FRESH SQUEEZED OVERIPED KIWI JUICE

Material needed for preparation

1. 5 beakers.
2. 4 pipettes of 1 ml.
3. 4 pipettes of 2 ml.
4. 4 pipettes of 10 ml.
5. A graduated cylinder.
6. A pipette pump.
7. A burette.
8. A magnetic stirrer.
9. 5 stir bars for magnetic stirrer.

Products needed for preparation

1. Overriped kiwi juice (just finished squeezing).
2. KI 10% solution (previously prepared).
3. Acetic acid 10% solution (previously prepared).
4. Starch 2% solution.
5. Distilled water.
6. NBS 10^{-3} M.

With a 1 ml pipette and the aid of a pipette pump, we suck 1 ml of the overriped kiwi juice (just finished squeezing) and we introduce it in the beaker containing the number 1 tag. We follow the same process for the second beaker but this time instead of 1 ml we take 2 ml with a 2 ml pipette and a pipette pump help.

We respectively introduce 4, 6 and 8 ml of the solution with a 10 ml pipette and a pipette pump help in the third, fourth and fifth beakers.

After this, we add in each beaker:

- 1 ml of KI 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).

- 0,4 ml of acetic acid 10% solution (with the respective 1 ml, 2 ml and 10 ml pipettes).
- 3 drops of starch 2% (from the dropper bottle).
- 6 ml of distilled water (with the respective 1 ml, 2 ml and 10 ml pipettes).

After entering all these products in their respective beakers, we already have the samples problem prepared and we just need to titrate them.

We fill the burette with the NBS 10^{-3} M to the level. Then we introduce a stir barr in the beaker 1; subsequently, we place it on a magnetic stirrer and begin a slight agitation. We drop the NBS solution slowly in the beaker until we appreciate a dark color trace. We add two or three more 2% starch solution drops again, meantime we continue dropping NBS drips until the blue/violet color persists (when the solution has reached the equivalence point). To end the practice, we have to follow the same evaluation process for all the beakers.

From the notes of the NBS spent in each vessel to reach the equivalence point, we can make some calculations to know the ascorbic acid amount they contain (Annex).

Below there is a table, which contains the results attained from the practice and the following calculations:

Number of beaker	**Volume of ascorbic acid solution**	**Grams of ascorbic acid contained**	**Volume of NBS spent on the valoration**	**Concentration of NBS solution**
1	1 ml	8,80 mg	1 ml	$5x10^{-4}$ M
2	2 ml	3,4373 mg	1,1 ml	$3,548x10^{-4}$ M
3	4 ml	2,0129 mg	1,6 ml	$2,857x10^{-4}$ M
4	6 ml	1,46775 mg	2 ml	$2,5x10^{-4}$ M
5	8 ml	1,13073 mg	2,3 ml	$2,233x10^{-4}$ M

Table 14: Sampre fresh squeezed overriped kiwi juice results

9. CONCLUSIONS

Finally, we present the conclusions reached by doing deeply research on this topic:

1. After its realization, it has been confirmed the vitamin C inestability due to its large capacity to oxidation by contact with air, water or even to its photosensitivity. That is to say any juice which is exposed in one of these contexts is more sensitive to its oxidation.

   I must also emphasize that nowadays there is not any product on the market (even though it comes from a brand name) which contains 100% of vitamin C. So, the only guarantee we have to have it, is from pure natural juices, the fresh squeezed ones, which also dismiss additive or preservative vitamin C.
2. The practices done with kiwis, have allowed us to verify that the different ripe fruit states determine the amount of vitamin C. Thus the unripe kiwi is the one which presents less quantity, the ripe it's the one which presents more quantity by far.
3. Thanks to the mandarin practice I have been able to observe the variation of the vitamin C content depending on the time spent between it's squeezed and it's valorated, i.e., the just squeezed juice presents a considerably higher amount of ascorbic acid than the one left resting for a couple of hours. Due to the oxidation by oxygen and light mentioned above.
4. The vitamin C determination in brick packed juices or ecological in transparent glass bottles didn't give the expected results. The main cause was the different chemical components presence used by manufacturers for juices' conservation, such as antioxidants. These have been the responsible for stopping the action which the NBS had to produce in the practice, therefore they have prevented, slowed or masked the ascorbic acid oxidation.

   In short, we were using an oxidative method in antioxidants presence, so this means that the NBS amount spent was higher than in the natural juices practices, consequently the value which determines the vitamin C amount exponentially increased giving completely illogical results as we can see in the attached package juice tables obtained from calculations which can be found in the Annex and some photographs taken during the experiment realizations.

5. To determine the vitamin C content in fruits and fruit juices it's recommended its isolation or on the other hand it's possible that ascorbic acid and antioxidants appear mixed in the final results.
6. According to the practices made, the fruit which have more vitamin C would be the kiwi, followed by the orange, the mandarin and finally the lemon.
7. Finally I have been aware of the large errors amount which can be committed in the laboratory, not only because of its small and precise products uses (we can find this topic more extended in the Annex).

   In my case for example, I have done two types of errors: the visual and the one related with the handling.

   Firstly the handling error, which includes incorrect readings and weightings that I have made.

   And secondly, the visual one, which with it, I refer to the difficult precision the eye has when it has to distinguish colours in the same range.

   The human eye has a great capacity to differentiate colours like blue from yellow, red from green or white from black but when it's facing some colours situated in the same range, it's common to commit errors taking into account the big similarity between them.

   By this I mean that when I was trying to find the titrations end based on comparing my juice solution colour with a pattern solution previously done, I locked the burette NBS stopcock when I have thought the colours were the same; therefore the error it may have been originated is evident. However, it doesn't mean that the results aren't reliable, they are situated in the same parameters but they can slightly vary their accuracy.

10. PROJECT VALORATION

Working on this project has allowed me to immerse myself a little bit more in the research world. World that every day arouses more interest and curiosity in me.

I think it has been very helpful because I've made my way when working in a laboratory. What is more I have finally been able to distinguish all the laboratory gadgets, part of in my opinion, is very thick and often ambiguous due to the large amount of uses that a single instrument can have. The same case can be applied to the chemical residues and the pictograms from each product, due to the whole quantity of reagents that we can find.

As regards to the English project I can say that it has helped me to acquire a lot of vocabulary related to Chemistry (especially associated with the laboratory work) and Biology areas.
Honestly I have really enjoyed writing it in this language.

So the general valoration I do is positive, I should also add that nowadays I think it was a great idea to choose this topic.

Finally, I would like to thank Teresa and Ester, the persons whom I have received an unconditional support and which had helped me in whatever I have needed; without them this work couldn't have been possible.

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http://politube.upv.es/play.php?vid=2949

http://www.acidoascorbico.com

ANNEX

Vitamin C TABLE

Vitamin C or ascorbic acid rich foods (IR: Men 90 mg/day // Women 75 mg/day)[1] (IR: Men 60-80 mg/day // Women 60-70 mg/day)[2]				
FOOD	mg/100 g food	COMMON MEASURE (g)		mg/common measure
Guava in syrup canned	180,0	Individual portion	100-120	198,0
Blackcurrant	159,6	Handful closed hand	15-25	31,9
Pepper	129,2	Average unit	150-200	226,0
Brussels sprouts	110,0	Individual portion	200-250	247,5
Broccoli	110,0	Individual portion	200-250	247,5
Pepper Boiled	100,0	Average unit	150-200	175,0
Kiwi	68,1	Average unit	80-100	61,2
Papaya	64,0	Individual portion	100-120	70,4
Lychee	60,0	Individual portion	100-120	66,0
Watercress	60,0	Salad portion	15-30	13,5
Broccoli boiled	60,0	Individual portion	200-250	135,0
Roast beef	58,0	Individual portion	75-115	55,1
Strawberry	57,5	Individual portion	120-150	77,6

Garrison cabbage	57,0	Garnish	100-150	71,3
Breakfast cereals high in fiber	53,0	Individual portion	30-40	18,6
Lemon	52,0	Average unit	120-180	78,0
Orange	51,8	Average unit	150-180	85,5
Cauliflower	50,0	Individual portion	250-300	137,5
Fresh orange juice	50,0	Glass	150-200	87,5
White cabbage boiled	45,2	Individual portion	200-250	101,7
Beef liver cooked	44,3	Steak	75-115	42,1
Mango	44,0	Individual portion	120-180	66,0
Boiled Brussels sprouts	41,3	Individual portion	200-250	92,9
Mandarin	41,0	3 medium units	120-180	36,9
Spinach	40,0	Individual portion	60-80	28,0
Melon	32,1	2 medium cuts	200-300	80,3
Tomato	19,2	Average units	120-150	25,9

1. Dietary Referente Intakes. Washington, DC: The Nacional Academies Press; 2000.
2. Ortega RM, López AM, Requejo AM, et al. *La composición de los alimentos: Herramienta básica para la valoración nutricional.* Madrid: Complutense; 2004.

RDA

Below we find a vitamin C RDA extension found in the page 43-44 of the project.

Recommended Dietary Allowances (RDA)[1]: indicates the sufficient intake level to reach nearly all (97-98%) healthy individuals in a particular physiological condition and age group requirements.

Adequate Intake (AI)[1]: shows the approached, estimates, observed or experimentally determined nutrients intake by a healthy people group or groups which are suitable considered.

For infants (AIs)
0 - 6 months - 40 mg
7 - 12 months - 50 mg

For children (RDAs)
1-3 years - 15 mg
4-8 years - 25 mg
9-13 years - 45 mg

For men (RDAs)
14 - 18 years - 75 mg
19 - 30 years - 90 mg
31 - 50 years - 90 mg
51 - 70 years - 90 mg
+ 70 years - 90 mg

For women (RDAs)
14 - 18 years - 65 mg
19 - 30 years - 75 mg
31 - 50 years - 75 mg

51 - 70 years - 75 mg

+ 70 years - 75 mg

Pregnancy (RDAs)

- 18 years - 80 mg

19 a 50 years - 85 mg

Breastfeeding (RDAs)

- 18 years - 115 mg

19 a 50 years - 120 mg

[1]*These details were extracted from: "Dietary Reference Intakes for vitamin C, vitamin E, Selenium and Carotenoids.", Food and Nutrition Board, Institute of Medicine, NATIONAL ACADEMY PRESS, Advance Copy, 3;6-7, 2000.*

ERRORS CLASSIFICATION

The different types of errors which can be made in a chemical laboratory are:

1. The specific, systematic or constant. These are divided into:
    - Methodical. Due to the analysis method used.
    - Operating; which include for example the fact of performing weighing in an incorrect way.
    - Instrumental: errors associated to the instrument, often caused by incorrect readings or equipment calibration.
2. The undetermined, accidental or causal, which are linked to the statistics probability theory and which include:
    - Additives. They don't depend on the magnitude quantity of the sample, the relative error decreases with them.
    - Proportionate. It depends on the sample amount used. The larger sample, the greater the absolute error but the same relative error.
3. Due to indicators.

    Indicators are substances which show the end point of a valoration or a neutralization, that coincides with the equivalence point. It is based on a colour change, a fluorescence change or on a precipitate formation or disappearance.

    The interval in which it's produced is called the turn indicator.

    The human eye requires then larger concentration to differentiate a colour than the rest of them to see it.

PRACTICE CALCULATIONS

CONCENTRATION OF NBS SOLUTION

- **PATTERN SOLUTION**

$$\frac{0{,}7\text{ ml x }\dfrac{10^{-3}\text{ moles}}{1\text{liter}} x \dfrac{1\text{liter}}{10^{3}\text{ ml}}}{1{,}7\text{ ml x }\dfrac{1\text{liter}}{10^{3}\text{ ml}}} = \mathbf{4{,}1176x10^{-4}}$$

$$\frac{0{,}5\text{ ml x }\dfrac{10^{-3}\text{ moles}}{1\text{liter}} x \dfrac{1\text{liter}}{10^{3}\text{ ml}}}{1{,}5\text{ ml x }\dfrac{1\text{liter}}{10^{3}\text{ ml}}} = \mathbf{3{,}33x10^{-4}\ M}$$

$$\frac{0{,}3\text{ ml x }\dfrac{10^{-3}\text{ moles}}{1\text{liter}} x \dfrac{1\text{liter}}{10^{3}\text{ ml}}}{1{,}3\text{ ml x }\dfrac{1\text{liter}}{10^{3}\text{ ml}}} = \mathbf{2{,}30x10^{-4}\ M}$$

$$\frac{0{,}2\text{ ml x }\dfrac{10^{-3}\text{ moles}}{1\text{liter}} x \dfrac{1\text{liter}}{10^{3}\text{ ml}}}{1{,}2\text{ ml x }\dfrac{1\text{liter}}{10^{3}\text{ ml}}} = \mathbf{1{,}66x10^{-4}\ M}$$

$$\frac{0{,}2\text{ ml x }\dfrac{10^{-3}\text{ moles}}{1\text{liter}} x \dfrac{1\text{liter}}{10^{3}\text{ ml}}}{1{,}2\text{ ml x }\dfrac{1\text{liter}}{10^{3}\text{ ml}}} = \mathbf{1{,}66x10^{-4}\ M}$$

❖ **SAMPLE 1: ZUMOSOL PASCUAL ORANGE JUICE**

$$\frac{7\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{8\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}75x10^{-4}\ M}$$

$$\frac{13{,}5\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{15{,}5\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}7096x10^{-4}\ M}$$

$$\frac{16{,}7\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{20{,}7\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}067x10^{-4}\ M}$$

$$\frac{14{,}4\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{20{,}4\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}0588x10^{-4}\ M}$$

$$\frac{27{,}5\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{35{,}5\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}7464x10^{-4}\ M}$$

❖ **SAMPLE 2: ZUMOSOL PASCUAL ORANGE JUICE**

$$\frac{7{,}3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{8{,}3\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}795 \times 10^{-4}\ M}$$

$$\frac{10{,}4\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{12{,}4\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}38 \times 10^{-4}\ M}$$

$$\frac{16\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{20\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8 \times 10^{-4}\ M}$$

$$\frac{12{,}1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{18{,}1\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{6{,}68 \times 10^{-4}\ M}$$

$$\frac{36{,}3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{44{,}3\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}19 \times 10^{-4}\ M}$$

❖ **SAMPLE JUVER ORANGE JUICE**

$$\frac{2{,}1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{3{,}1\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{6{,}77 \times 10^{-4}\ M}$$

$$\frac{3{,}2\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{5{,}2\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{6{,}1538 \times 10^{-4}\ M}$$

$$\frac{6\,\text{ml} \times \frac{10^{-3}\,\text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}}{10\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}} = \mathbf{6x10^{-4}\ M}$$

$$\frac{7{,}2\,\text{ml} \times \frac{10^{-3}\,\text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}}{13{,}2\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}} = \mathbf{5{,}4545x10^{-4}\ M}$$

$$\frac{8{,}9\,\text{ml} \times \frac{10^{-3}\,\text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}}{16{,}9\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}} = \mathbf{5{,}2662x10^{-4}\ M}$$

- **SAMPLE FRESH SQUEEZED ORANGE JUICE**

$$\frac{0{,}9\,\text{ml} \times \frac{10^{-3}\,\text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}}{1{,}9\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}} = \mathbf{4{,}7369x10^{-4}\ M}$$

$$\frac{1{,}5\,\text{ml} \times \frac{10^{-3}\,\text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}}{3{,}5\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}} = \mathbf{4{,}28571x10^{-4}\ M}$$

$$\frac{1{,}8\,\text{ml} \times \frac{10^{-3}\,\text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}}{5{,}8\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}} = \mathbf{3{,}1034x10^{-4}\ M}$$

$$\frac{2{,}4\,\text{ml} \times \frac{10^{-3}\,\text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}}{8{,}4\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\,\text{ml}}} = \mathbf{2{,}8571x10^{-4}\ M}$$

$$\frac{2{,}6\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{10{,}6\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}4528 \times 10^{-4}\ M}$$

- **SAMPLE 1: ECOLOGICAL MANDARINE JUICE**

$$\frac{5{,}4\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{6{,}4\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}4375 \times 10^{-4}\ M}$$

$$\frac{7{,}3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{9{,}3\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}8494 \times 10^{-4}\ M}$$

$$\frac{15{,}3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{19{,}3\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}9274 \times 10^{-4}\ M}$$

$$\frac{19{,}2\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{25{,}2\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}5294 \times 10^{-4}\ M}$$

$$\frac{21{,}4\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{29{,}4\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}2789 \times 10\text{-}4\ M}$$

❖ **SAMPLE 2: ECOLOGICAL MANDARINE JUICE**

$$\frac{5\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{6\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{8{,}33x10^{-4}\ M}$$

$$\frac{7\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{9\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}77x10^{-4}\ M}$$

$$\frac{14{,}2\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{18{,}2\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}8021x10^{-4}\ M}$$

$$\frac{16{,}8\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{22{,}8\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}3684x10^{-4}\ M}$$

$$\frac{27\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{35\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{7{,}71428x10^{-4}\ M}$$

❖ **SAMPLE FRESH SQUEEZED MANDARINE JUICE**

$$\frac{0{,}9\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{1{,}9\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{4{,}7368x10^{-4}\ M}$$

$$\frac{1,1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{3,1\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{3,5483x10^{-4}\ M}$$

$$\frac{1,7\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{5,7\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2,9824x10^{-4}\ M}$$

$$\frac{2,7\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{8,7\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{3,10344x10^{-4}\ M}$$

$$\frac{3,3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{11,3\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2,92035x10^{-4}\ M}$$

❖ SAMPLE TWO-HOUR SQUEEZED MANDARINE JUICE

$$\frac{0,6\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{1,6\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{3,75x10^{-4}\ M}$$

$$\frac{0,8\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{2,8\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2,857x10^{-4}\ M}$$

$$\frac{1,1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{5,1\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2,1568x10^{-4}\ M}$$

$$\frac{1{,}7\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{7{,}7\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}20779 \times 10^{-4}\ M}$$

$$\frac{2{,}1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{10{,}1\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}0792 \times 10^{-4}\ M}$$

- **SAMPLE FRESH SQUEEZED LEMON JUICE**

$$\frac{0{,}7\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{1{,}7\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{4{,}11764 \times 10^{-4}\ M}$$

$$\frac{1{,}2\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{3{,}2\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{3{,}75 \times 10^{-4}\ M}$$

$$\frac{2\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{6\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{3{,}33 \times 10^{-4}\ M}$$

$$\frac{2{,}3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{8\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}77 \times 10^{-4}\ M}$$

$$\frac{2{,}6\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{10{,}6\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}45283 \times 10^{-4}\ M}$$

- **SAMPLE FRESH SQUEEZED UNRIPED KIWI JUICE**

$$\frac{0{,}7\ \text{ml} \times \frac{10^{-3}\ \text{moles}}{1\ \text{liter}} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}}{1{,}7\ \text{ml} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}} = \mathbf{4{,}1176 \times 10^{-4}\ M}$$

$$\frac{0{,}9\ \text{ml} \times \frac{10^{-3}\ \text{moles}}{1\ \text{liter}} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}}{2{,}9\ \text{ml} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}} = \mathbf{3{,}1034 \times 10^{-4}\ M}$$

$$\frac{1{,}2\ \text{ml} \times \frac{10^{-3}\ \text{moles}}{1\ \text{liter}} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}}{5{,}2\ \text{ml} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}3076 \times 10^{-4}\ M}$$

$$\frac{1{,}7\ \text{ml} \times \frac{10^{-3}\ \text{moles}}{1\ \text{liter}} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}}{7{,}7\ \text{ml} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}2077 \times 10^{-4}\ M}$$

$$\frac{2{,}1\ \text{ml} \times \frac{10^{-3}\ \text{moles}}{1\ \text{liter}} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}}{10{,}1\ \text{ml} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}0792 \times 10^{-4}\ M}$$

- **SAMPLE FRESH SQUEEZED RIPE KIWI JUICE**

$$\frac{1{,}4\ \text{ml} \times \frac{10^{-3}\ \text{moles}}{1\ \text{liter}} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}}{2{,}4\ \text{ml} \times \frac{1\ \text{liter}}{10^{3}\ \text{ml}}} = \mathbf{5{,}833 \times 10^{-4}\ M}$$

$$\frac{2{,}4\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{4{,}4\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{5{,}4545 \times 10^{-4}\ M}$$

$$\frac{3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{7\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{4{,}2857 \times 10^{-4}\ M}$$

$$\frac{5{,}1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{11{,}1\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{4{,}594594 \times 10^{-4}\ M}$$

$$\frac{5{,}5\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{13{,}5\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{4{,}074074 \times 10^{-4}\ M}$$

- **SAMPLE FRESH SQUEEZED OVERRIPED KIWI JUICE**

$$\frac{1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{2\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{5 \times 10^{-4}\ M}$$

$$\frac{1{,}1\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{3{,}1\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{3{,}548 \times 10^{-4}\ M}$$

$$\frac{1{,}6\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{5{,}6\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}857 \times 10^{-4}\ M}$$

$$\frac{2\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{8\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}5x10^{-4}\ M}$$

$$\frac{2{,}3\,\text{ml} \times \frac{10^{-3}\ \text{moles}}{1\,\text{liter}} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}}{10{,}3\,\text{ml} \times \frac{1\,\text{liter}}{10^{3}\ \text{ml}}} = \mathbf{2{,}233x10^{-4}\ M}$$

GRAMS OF ASCORBIC ACID CONTAINED

Eq of NBS = Eq of $C_6H_8O_6$

Molarity x volume x valence = molarity x volume x valence

❖ PATTERN SOLUTION

$$1\,ml \times \frac{2x10^{-3}\ moles\ C_6H_8O_6}{1\,liter} \times \frac{1\,liter}{10^3\ ml} \times \frac{176,13\,g\ C_6H_8O_6}{1\,mole} \times \frac{100\,g\ impure}{99\,g\ pure} \times \frac{10^3\,mg}{1g} = \mathbf{0,3558\ mg}$$

$$2\,ml \times \frac{2x10^{-3}\ moles\ C_6H_8O_6}{1\,liter} \times \frac{1\,liter}{10^3\ ml} \times \frac{176,13\,g\ C_6H_8O_6}{1\,mole} \times \frac{100\,g\ impure}{99\,g\ pure} \times \frac{10^3\,mg}{1g} = \mathbf{0,71163\ mg}$$

$$4\,ml \times \frac{2x10^{-3}\ moles\ C_6H_8O_6}{1\,liter} \times \frac{1\,liter}{10^3\ ml} \times \frac{176,13\,g\ C_6H_8O_6}{1\,mole} \times \frac{100\,g\ impure}{99\,g\ pure} \times \frac{10^3\,mg}{1g} = \mathbf{1,42327\ mg}$$

$$6\,ml \times \frac{2x10^{-3}\ moles\ C_6H_8O_6}{1\,liter} \times \frac{1\,liter}{10^3\ ml} \times \frac{176,13\,g\ C_6H_8O_6}{1\,mole} \times \frac{100\,g\ impure}{99\,g\ pure} \times \frac{10^3\,mg}{1g} = \mathbf{2,1349\ mg}$$

$$8\,ml \times \frac{2x10^{-3}\ moles\ C_6H_8O_6}{1\,liter} \times \frac{1\,liter}{10^3\ ml} \times \frac{176,13\,g\ C_6H_8O_6}{1\,mole} \times \frac{100\,g\ impure}{99\,g\ pure} \times \frac{10^3\,mg}{1g} = \mathbf{2,8465\ mg}$$

❖ SAMPLE 1: ZUMOSOL PASCUAL ORANGE JUICE

$$M = \frac{8,75x10^{-4}\ M \times 7\,ml \times 2}{2 \times 1\,ml} = 6,125x10^{-3}\ moles/l$$

$$6,125x10^{-3}\ moles/l \times 176,13\ g/mole \times 200\,ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 215,75\,mg$$

$$M = \frac{8,709x10^{-4}\ M \times 13,5\,ml \times 2}{2 \times 2\,ml} = 5,879x10^{-3}\ moles/l$$

$$5,879x10^{-3}\ moles/l \times 176,13\ g/mole \times 200\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 207,07\,mg$$

$$M = \frac{8,067x10^{-4}\ M \times 16,7\,ml \times 2}{2 \times 4\,ml} = 3,36x10^{-3}\ moles/l$$

$$3,36x10^{-3}\ moles/l \times 176,13\ g/mole \times 200\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 118,64\,mg$$

$$M = \frac{7{,}058\text{x}10^{-4}\ \text{M x } 14{,}4\ \text{ml x } 2}{2\ \text{x } 6\ \text{ml}} = 1{,}694\text{x}10^{-3}\ \text{moles}/\text{l}$$

$$1{,}694\text{x}10^{-3}\ \text{moles}/\text{l}\ \text{x } 176{,}13\ \text{g}/\text{mole}\ \text{x}200\ \text{ml x } \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x } \frac{1000\ \text{mg}}{1\text{g}} = 59{,}60\ \text{mg}$$

$$M = \frac{7{,}7464\text{x}10^{-4}\ \text{M x } 27{,}5\ \text{ml x } 2}{2\ \text{x } 8\ \text{ml}} = 2{,}6628\text{x}10^{-3}\ \text{moles}/\text{l}$$

$$2{,}6628\text{x}10^{-3}\ \text{moles}/\text{l}\ \text{x } 176{,}13\ \text{g}/\text{mole}\ \text{x } 200\ \text{ml x } \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x } \frac{1000\ \text{mg}}{1\text{g}} = 93{,}80\ \text{mg}$$

- **SAMPLE 2: ZUMOSOL PASCUAL ORANGE JUICE**

$$M = \frac{8{,}795\text{x}10^{-4}\ \text{M x } 7{,}3\ \text{ml x } 2}{2\ \text{x } 1\ \text{ml}} = 6{,}420\text{x}10^{-3}\ \text{moles}/\text{l}$$

$$6{,}420\text{x}10^{-3}\ \text{moles}/\text{l}\ \text{x } 176{,}13\ \text{g}/\text{mole}\ \text{x}200\ \text{ml x } \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x } \frac{1000\ \text{mg}}{1\text{g}} = 226{,}16\ \text{mg}$$

$$M = \frac{8{,}387\text{x}10^{-4}\ \text{M x } 10{,}4\ \text{ml x } 2}{2\ \text{x } 2\ \text{ml}} = 4{,}36\text{x}10^{-3}\ \text{moles}/\text{l}$$

$$4{,}36\text{x}10^{-3}\ \text{moles}/\text{l}\ \text{x } 176{,}13\ \text{g}/\text{mole}\ \text{x } 200\ \text{ml x } \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x } \frac{1000\ \text{mg}}{1\text{g}} = 153{,}62\ \text{mg}$$

$$M = \frac{8\text{x}10^{-4}\ \text{M x } 16\ \text{ml x } 2}{2\ \text{x } 4\ \text{ml}} = 3{,}2\text{x}10^{-3}\ \text{moles}/\text{l}$$

$$3{,}2\text{x}10^{-3}\ \text{moles}/\text{l}\ \text{x } 176{,}13\ \text{g}/\text{mole}\ \text{x}200\ \text{ml x } \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x } \frac{1000\ \text{mg}}{1\text{g}} = 112{,}72\ \text{mg}$$

$$M = \frac{6{,}68\text{x}10^{-4}\ \text{M x } 12{,}1\ \text{ml x } 2}{2\ \text{x } 6\ \text{ml}} = 1{,}34\text{x}10^{-3}\ \text{moles}/\text{l}$$

$$1{,}34\text{x}10^{-3}\ \text{moles}/\text{l}\ \text{x } 176{,}13\ \text{g}/\text{mole}\ \text{x}200\ \text{ml x } \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x } \frac{1000\ \text{mg}}{1\text{g}} = 47{,}45\ \text{mg}$$

$$M = \frac{8{,}19\text{x}10^{-4}\ \text{M x } 36{,}3\ \text{ml x } 2}{2\ \text{x } 8\ \text{ml}} = 3{,}746\text{x}10^{-3}\ \text{moles}/\text{l}$$

$$3{,}746\text{x}10^{-3}\ \text{moles}/\text{l}\ \text{ml x } 200\ \text{ml x } \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x } \frac{1000\ \text{mg}}{1\text{g}} = 130{,}90\ \text{mg}$$

❖ **SAMPLE JUVER ORANGE JUICE**

$$M = \frac{6{,}77x10^{-4}\ M \times 2{,}1\,ml \times 2}{2 \times 1\,ml} = 1{,}4225x10^{-3}\ moles/l$$

$$1{,}4225x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 50{,}08\,mg$$

$$M = \frac{6{,}153x10^{-4}\ M \times 3{,}2\,ml \times 2}{2 \times 2\,ml} = 9{,}846x10^{-4}\ moles/l$$

$$9{,}846x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 34{,}67\,mg$$

$$M = \frac{6x10^{-4}\ M \times 6\,ml \times 2}{2 \times 4\,ml} = 9x10^{-4}\ moles/l$$

$$9x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 31{,}70\,mg$$

$$M = \frac{5{,}4545x10^{-4}\ M \times 7{,}2\,ml \times 2}{2 \times 6\,ml} = 6{,}5454x10^{-4}\ moles/l$$

$$6{,}5454x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 23{,}05\,mg$$

$$M = \frac{5{,}266x10^{-4}\ M \times 8{,}9\,ml \times 2}{2 \times 8\,ml} = 5{,}858x10^{-4}\ moles/l$$

$$5{,}858x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 20{,}63\,mg$$

❖ **SAMPLE FRESH SQUEEZED ORANGE JUICE**

$$M = \frac{4{,}736x10^{-4}\ M \times 0{,}9\,ml \times 2}{2 \times 1\,ml} = 4{,}261x10^{-4}\ moles/l$$

$$4{,}261x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 7{,}5087\,mg$$

$$M = \frac{4{,}285x10^{-4}\ M \times 1{,}5\,ml \times 2}{2 \times 2\,ml} = 3{,}214x10^{-4}\ moles/l$$

$$3{,}214x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\,ml} \times \frac{1000\,mg}{1g} = 5{,}6613\,mg$$

$$M = \frac{3{,}1034x10^{-4}\ M \times 1{,}8\ ml \times 2}{2 \times 4\ ml} = 1{,}396x10^{-4}\ moles/l$$

$$1{,}396x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 2{,}459\ mg$$

$$M = \frac{2{,}857x10^{-4}\ M \times 2{,}4\ ml \times 2}{2 \times 6\ ml} = 1{,}1428x10^{-4}\ moles/l$$

$$1{,}1428x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 2{,}0129\ mg$$

$$M = \frac{2{,}4528x10^{-4}\ M \times 2{,}6\ ml \times 2}{2 \times 8\ ml} = 7{,}971x10^{-5}\ moles/l$$

$$7{,}971x10^{-5}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 1{,}4040mg$$

- **SAMPLE 1: ECOLOGICAL MANDARINE JUICE**

$$M = \frac{8{,}437x10^{-4}\ M \times 5{,}4\ ml \times 2}{2 \times 1\ ml} = 4{,}556x10^{-3}\ moles/l$$

$$4{,}556x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 160{,}48\ mg$$

$$M = \frac{7{,}8494x10^{-4}\ M \times 7{,}3\ ml \times 2}{2 \times 2\ ml} = 2{,}865x10^{-3}\ moles/l$$

$$2{,}865x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 100{,}91\ mg$$

$$M = \frac{7{,}927x10^{-4}\ M \times 15{,}3\ ml \times 2}{2 \times 4\ ml} = 3{,}032x10^{-3}\ moles/l$$

$$3{,}032x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 106{,}80\ mg$$

$$M = \frac{7{,}529x10^{-4}\ M \times 19{,}2\ ml \times 2}{2 \times 6\ l} = 2{,}409x10^{-3}\ moles/l$$

$$2{,}409x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 84{,}86\ mg$$

$$M = \frac{7{,}278x10^{-4}\ M \times 21{,}4\ ml \times 2}{2 \times 8\ ml} = 1{,}947x10^{-3}\ moles/l$$

$$1{,}947x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 68{,}58\ mg$$

- **SAMPLE 2: ECOLOGIGAL MANDARINE JUICE**

$$M = \frac{8{,}33x10^{-4}\ M \times 5{,}2\ ml \times 2}{2 \times 1\ ml} = 4{,}166x10^{-3}\ moles/l$$

$$4{,}166x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 152{,}58\ mg$$

$$M = \frac{7{,}777x10^{-4}\ M \times 7\ ml \times 2}{2 \times 2\ ml} = 2{,}72x10^{-3}\ moles/l$$

$$2{,}72x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 95{,}88\ mg$$

$$M = \frac{7{,}8021x10^{-4}\ M \times 14{,}2\ ml \times 2}{2 \times 4\ ml} = 2{,}769x10^{-3}\ moles/l$$

$$2{,}769x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 97{,}56\ mg$$

$$M = \frac{7{,}368x10^{-4}\ M \times 16{,}8\ ml \times 2}{2 \times 6\ ml} = 2{,}063x10^{-3}\ moles/l$$

$$2{,}063x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 72{,}67\ mg$$

$$M = \frac{7{,}7142x10^{-4}\ M \times 27\ ml \times 2}{2 \times 8\ ml} = 2{,}60x10^{-3}\ moles/l$$

$$2{,}60x10^{-3}\ moles/l \times 176{,}13\ g/mole \times 200\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 91{,}71\ mg$$

- **SAMPLE FRESH SQUEEZED MANDARINE JUICE**

$$M = \frac{4{,}7368x10^{-4}\ M \times 0{,}9\ ml \times 2}{2 \times 1\ ml} = 4{,}2631x10^{-4}\ moles/l$$

$$4{,}2631x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 7{,}5087\ mg$$

$$M = \frac{3{,}5483x10^{-4}\ M \times 1{,}1\ ml \times 2}{2 \times 2\ ml} = 1{,}9516x10^{-4}\ moles/l$$

$$1{,}9516x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 3{,}4373mg$$

$$M = \frac{3{,}33x10^{-4}\ M \times 2\ ml \times 2}{2 \times 4\ ml} = 1{,}66x10^{-4}\ moles/l$$

$$1{,}66x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 2{,}935\ mg$$

$$M = \frac{3{,}1034x10^{-4}\ M \times 2{,}7\ ml \times 2}{2 \times 6\ ml} = 1{,}396x10^{-4}\ moles/l$$

$$1{,}396x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 2{,}459\ mg$$

$$M = \frac{3{,}9203x10^{-4}\ M \times 3{,}3\ ml \times 2}{2 \times 8\ ml} = 1{,}6171x10^{-4}\ moles/l$$

$$1{,}6171x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 2{,}848mg$$

❖ SAMPLE TWO-HOUR SQUEEZED MANDARINE JUICE

$$M = \frac{3{,}75x10^{-4}\ M \times 0{,}6\ ml \times 2}{2 \times 1\ ml} = 2{,}25x10^{-4}\ moles/l$$

$$2{,}25x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 3{,}96\ mg$$

$$M = \frac{2{,}85x10^{-4}\ M \times 0{,}8\ ml \times 2}{2 \times 2\ ml} = 1{,}1428x10^{-4}\ moles/l$$

$$1{,}1428x10^{-4}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 2{,}0129\ mg$$

$$M = \frac{2{,}1568x10^{-4}\ M \times 1{,}1\ ml \times 2}{2 \times 4\ ml} = 5{,}9313x10^{-5}\ moles/l$$

$$5{,}9313x10^{-5}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 1{,}044\ mg$$

$$M = \frac{2{,}20\text{x}10^{-4}\ \text{M x}\ 1{,}7\ \text{ml x}\ 2}{2\ \text{x}\ 6\ \text{ml}} = 6{,}255\text{x}10^{-5}\ \text{moles}/\text{l}$$

$$6{,}255\text{x}10^{-5}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml}\ \text{x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 1{,}1017\ \text{mg}$$

$$M = \frac{2{,}079\text{x}10^{-4}\ \text{M x}\ 2{,}1\ \text{ml x}\ 2}{2\ \text{x}\ 8\ \text{ml}} = 5{,}457\text{x}10^{-4}\ \text{moles}/\text{l}$$

$$5{,}457\text{x}10^{-4}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml}\ \text{x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 0{,}9613\ \text{mg}$$

- **SAMPLE FRESH SQUEEZED LEMON JUICE**

$$M = \frac{4{,}1176\text{x}10^{-4}\ \text{M x}\ 0{,}7\ \text{ml x}\ 2}{2\ \text{x}\ 1\ \text{ml}} = 2{,}88\text{x}10^{-4}\ \text{mols}/\text{l}$$

$$2{,}88\text{x}10^{-4}\ \text{mols}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mol}\ \text{x}\ 100\ \text{ml}\ \text{x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 5{,}0766\ \text{mg}$$

$$M = \frac{3{,}75\text{x}10^{-4}\ \text{M x}\ 1{,}2\ \text{ml x}\ 2}{2\ \text{x}\ 2\ \text{ml}} = 2{,}25\ \text{x}10^{-4}\ \text{mols}/\text{l}$$

$$2{,}25\ \text{x}10^{-4}\ \text{mols}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mol}\ \text{x}\ 100\ \text{ml}\ \text{x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 3{,}962\ \text{mg}$$

$$M = \frac{3{,}33\text{x}10^{-4}\ \text{M x}\ 2\ \text{ml x}\ 2}{2\ \text{x}\ 4\ \text{ml}} = 1{,}66\text{x}10^{-4}\ \text{mols}/\text{l}$$

$$1{,}66\text{x}10^{-4}\ \text{mols}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mol}\ \text{x}\ 100\ \text{ml}\ \text{x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 2{,}935\ \text{mg}$$

$$M = \frac{2{,}771\text{x}10^{-4}\ \text{M x}\ 2{,}3\ \text{ml x}\ 2}{2\ \text{x}\ 6\ \text{ml}} = 1{,}062\text{x}10^{-4}\ \text{mols}/\text{l}$$

$$1{,}062\text{x}10^{-4}\ \text{mols}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mol}\ \text{x}\ 100\ \text{ml}\ \text{x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 1{,}870\ \text{mg}$$

$$M = \frac{2{,}452\text{x}10^{-4}\ \text{M x}\ 2{,}6\ \text{ml x}\ 2}{2\ \text{x}\ 8\ \text{ml}} = 7{,}97\text{x}10^{-5}\ \text{mols}/\text{l}$$

$$7{,}97\text{x}10^{-5}\ \text{mols}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mol}\ \text{x}\ 100\ \text{ml}\ \text{x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 1{,}404\text{mg}$$

❖ **SAMPLE FRESH SQUEEZED UNRIPED KIWI JUICE**

$$M = \frac{4{,}117\text{x}10^{-4}\ \text{M x } 0{,}7\ \text{ml x } 2}{2\ \text{x}\ 1\ \text{ml}} = 2{,}88\text{x}10^{-4}\ \text{moles}/\text{l}$$

$$2{,}88\text{x}10^{-4}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 5{,}0766\ \text{mg}$$

$$M = \frac{3{,}1034\text{x}10^{-4}\ \text{M x } 0{,}9\ \text{ml x } 2}{2\ \text{x}\ 2\ \text{ml}} = 3{,}103\text{x}10^{-4}\ \text{moles}/\text{l}$$

$$3{,}103\text{x}10^{-4}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 5{,}466\ \text{mg}$$

$$M = \frac{2{,}30\text{x}10^{-4}\ \text{M x } 1{,}2\ \text{ml x } 2}{2\ \text{x}\ 4\ \text{ml}} = 6{,}923\text{x}10^{-5}\ \text{moles}/\text{l}$$

$$6{,}923\text{x}10^{-5}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 1{,}219\ \text{mg}$$

$$M = \frac{2{,}2077\text{x}10^{-4}\ \text{M x } 1{,}7\ \text{ml x } 2}{2\ \text{x}\ 6\ \text{ml}} = 6{,}255\text{x}10^{-5}\ \text{moles}/\text{l}$$

$$6{,}255\text{x}10^{-5}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 1{,}1017\ \text{mg}$$

$$M = \frac{2{,}079\text{x}10^{-4}\ \text{M x } 2{,}1\ \text{ml x } 2}{2\ \text{x}\ 8\ \text{ml}} = 5{,}457\text{x}10^{-5}\ \text{moles}/\text{l}$$

$$5{,}457\text{x}10^{-5}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 0{,}9613\ \text{mg}$$

❖ **SAMPLE FRESH SSQUEEZED RIPE KIWI JUICE**

$$M = \frac{5{,}833\text{x}10^{-4}\ \text{M x } 1{,}4\ \text{ml x } 2}{2\ \text{x}\ 1\ \text{ml}} = 8{,}166\text{x}10^{-4}\ \text{moles}/\text{l}$$

$$8{,}166\text{x}10^{-4}\ \text{moles}/\text{l}\ \text{x}\ 176{,}13\ \text{g}/\text{mole}\ \text{x}\ 100\ \text{ml x}\ \frac{1\text{l}}{10^3\ \text{ml}}\ \text{x}\ \frac{1000\ \text{mg}}{1\text{g}} = 14{,}38\ \text{mg}$$

$$M = \frac{5{,}4545x10^{-4}\ M \times 2{,}4\ ml \times 2}{2 \times 2\ ml} = 6{,}545x10^{-4}\ {}^{moles}/_{l}$$

$$6{,}545x10^{-4}\ {}^{moles}/_{l} \times 176{,}13\ {}^{g}/_{mole} \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 11{,}528\ mg$$

$$M = \frac{4{,}2857x10^{-4}\ M \times 3\ ml \times 2}{2 \times 4\ ml} = 3{,}214x10^{-4}\ {}^{moles}/_{l}$$

$$3{,}214x10^{-4}\ {}^{moles}/_{l} \times 176{,}13\ {}^{g}/_{mole} \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 5{,}661\ mg$$

$$M = \frac{4{,}594x10^{-4}\ M \times 5{,}1\ ml \times 2}{2 \times 6\ ml} = 3{,}9056x10^{-4}\ {}^{moles}/_{l}$$

$$3{,}9056x10^{-4}\ {}^{moles}/_{l} \times 176{,}13\ {}^{g}/_{mole} \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 6{,}879\ mg$$

$$M = \frac{4{,}074x10^{-4}\ M \times 5{,}5\ ml \times 2}{2 \times 8\ ml} = 2{,}8013x10^{-4}\ {}^{moles}/_{l}$$

$$2{,}8013x10^{-4}\ {}^{moles}/_{l} \times 176{,}13\ {}^{g}/_{mole} \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 4{,}934\ mg$$

- **SAMPLE FRESH SQUEEZED OVERRIPED KIWI JUICE**

$$M = \frac{5x10^{-4}\ M \times 1\ ml \times 2}{2 \times 1\ ml} = 5x10^{-4}\ {}^{moles}/_{l}$$

$$5x10^{-4}\ {}^{moles}/_{l} \times 176{,}13\ {}^{g}/_{mole} \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 8{,}80\ mg$$

$$M = \frac{3{,}548x10^{-4}\ M \times 1{,}1\ ml \times 2}{2 \times 2\ ml} = 1{,}9516x10^{-4}\ {}^{moles}/_{l}$$

$$1{,}9516x10^{-4}\ {}^{moles}/_{l} \times 176{,}13\ {}^{g}/_{mole} \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 3{,}4373\ mg$$

$$M = \frac{2{,}857x10^{-4}\ M \times 1{,}6\ ml \times 2}{2 \times 4\ ml} = 1{,}1428x10^{-4}\ {}^{moles}/_{l}$$

$$1{,}1428x10^{-4}\ {}^{moles}/_{l} \times 176{,}13\ {}^{g}/_{mole} \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 2{,}0129\ mg$$

$$M = \frac{2{,}5x10^{-4}\ M \times 2\ ml \times 2}{2 \times 6\ ml} = 8{,}33x10^{-5}\ moles/l$$

$$8{,}33x10^{-5}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 1{,}4677\ mg$$

$$M = \frac{2{,}233x10^{-4}\ M \times 2{,}3\ ml \times 2}{2 \times 8\ ml} = 6{,}4199x10^{-5}\ moles/l$$

$$6{,}4199x10^{-5}\ moles/l \times 176{,}13\ g/mole \times 100\ ml \times \frac{1l}{10^3\ ml} \times \frac{1000\ mg}{1g} = 1{,}1307\ mg$$

CD

We attached a CD which includes:

- One digital copy in pdf format of the project in Catalan.
- One digital copy in pdf format of the project in English.
- The powerpoint project presentation in Catalan.
- The powerpoint project presentation in English.
- To finish we also attach four videos (two in Catalan and two in English) which correspond to the powerpoint presentation.