Learning Unit	
Subject	**Chemical reactions**
Title	**Acidic, basic and neutral solutions. Acid-base reactions**
Authors	Alexandra Jales
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Description of the unit	● Aqueous solutions and their acidic, basic or neutral nature. ● Acid-base indicators. ● pH scale. ● Reactions between acids and bases.
Contents	● Acids and Bases. ● Acid-base indicators.
Learning Outcomes / Skills	The student should be able to: ● Determine the chemical nature of aqueous solutions, using pH indicators and meters. ● Predict the effect on pH when adding an acidic solution to a basic solution or vice versa. ● Classify the reactions that occur as acid-base reactions, represented by chemical equations. ● Identify laboratory material and laboratory equipment and explain their function/use. ● Select appropriate material for the experimental activity. ● Handle, properly and with respect for safety standards, material and equipment. ● Collect, keep records and organise observational data (qualitative and quantitative) from different sources.
Target students/class	Secondary school (15 – 17 years old)

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Prerequisites	The student should be able to: ● Identify a solution ● Recognize laboratory material to use ● Read the laboratory's measuring instruments ● Recognize the pictograms of solutions
Time expected	2 hours
Interdisciplinary links	--
Methodology	Explanation of contents and carrying out laboratory activities.
Human Resources (internal and/or external)	Physics and Chemistry Teacher
Resources	● Information sheet ● Experimental activity protocol ● Material for writing ● Laboratory supplies
Lesson Plan	**<u>1st lesson</u>** **Summary:** Acids and bases. Acid-base indicators With students organised into groups, present the following motivating questions: **- What is an acidic solution?** **- What does it mean to say that the pH of a solution is 3?** **- When you add an acidic solution to a basic solution, does the basic solution become more or less basic?** After a brief moment of reflection on the motivating questions, the teacher should request answers, moderate the students' interventions and their discussion, systematising the main ideas. Then, ask students to read the information sheet and have a group debate about what they read.

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	After the debate, the spokesperson will present a summary of what they read and debated to the class. The teacher should moderate the students' interventions and their discussion, in plenary, systematising the main ideas. The teacher should then ask the following questions: **- Are acids and bases dangerous? Why?** **- How can we identify whether a material has an acidic, basic or neutral nature?** The teacher should suggest the analysis of examples of acids and bases used in food products, in the chemical industry, in the laboratory. If possible, show and analyse the information on the labels that confirm their presence. Using bottles of acidic and basic solutions from the laboratory, whose labels have pictograms, the teacher should highlight that concentrated solutions of acids and bases can be corrosive and dangerous to health. It is important that students understand that they should only work with diluted acidic and basic solutions in the presence of the teacher and with proper precautions. The teacher should clarify the role of the colorimetric indicators most used in the laboratory and the colour that acid, basic and neutral solutions assume, demonstrate the procedure on material samples, using microscale and highlighting the environmental and economic advantages associated with this technique. When introducing the concept of pH and after students have read the information sheet, the teacher can organise a small debate by showing two bottles of bottled water, with different pH values. The students can "grade" acidic and basic solutions through pH. The teacher should summarise the main ideas and clarify that, through the experimental activity, students will verify the situations analysed during the class. **<u>2nd lesson</u>** **Summary:** Carrying out a laboratory activity. The teacher should make sure that the Practical Activity has been previously prepared by the students. The students work in groups and should be reminded that the use of a gown is recommended.

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	When the activity is finished, all equipment and reagents must be properly stored and electrical devices turned off. In the class debate, and after listening to all groups, the teacher should summarise the main ideas.
21st Century Skills	Critical thinking: students will be able to analyse data during practical experiments and communicate their conclusions. Collaboration: students will be able to collaborate within their groups and with others and help each other understand the content and experimental activities. Communication: Students should be able to share conclusions and doubts with their classmates and teacher. Information research: Students are asked to gather information from various sources. Media and technological proficiency: students will be able to use online sources to clarify doubts.
Assessment	**Class observation:** ● Laboratory work observation grid. ● Quality of oral participation. ● Participation in the activities. ● Interest, commitment, sociality. ● Respect for teachers and peers.
Remarks	Before starting, the teacher should: ● Organise work groups and remind students that the use of a gown is recommended. ● Provide students with the experimental protocol. ● Remind students that the laboratory is a potentially risky place. ● When the tasks are finished, all equipment and reagents must be properly stored and electrical devices turned off.

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Worksheet No. 1

Learning Unit	**Chemistry Reactions - Chemical character of solutions and acid-base reactions**
Authors	Alexandra Jales
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Date	

1. Acidic, basic and neutral solutions

Water is a good solvent for many substances. These substances, once dissolved in water, create acidic solutions, basic or alkaline solutions and neutral solutions. Acidic solutions are solutions that contain dissolved substances that give the solution an acidic characteristic. These substances are called acids.

- Basic or alkaline solutions are solutions that contain dissolved substances that give the solution its basic characteristic. These substances are called bases.
- Neutral solutions are solutions that have neither acidic nor basic characteristics.

Acidic solutions

The sour taste of certain fruit, drinks, vinegar, etc., is due to the acids they contain. For example, in tomato, orange and lemon juice there is citric acid; grape juice contains tartaric acid; apple juice contains malic acid; vinegar, mustard and pickles contain acetic acid; cola contains phosphoric acid and milk contains lactic acid.

Picture 1 – Some acids present in certain foods

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In chemistry laboratories, the most used acidic solutions are:

- Hydrochloric acid, HCl (aq)
- Sulfuric acid, H_2SO_4 (aq)
- Nitric acid, HNO_3 (aq)
- Phosphoric acid, H_3PO_4 (aq)

Some characteristics of acidic solutions:

- react with some metals, corroding them and releasing oxygen;
- react with limestone, releasing carbon dioxide;
- conduct electric current;
- turn litmus red (purplish-blue)

Basic or alkaline solutions

Many products that we use in our daily lives have basic characteristics. For example, soapy water, glass cleaner, bleach, water with baking powder, among others. The basic characteristics of these solutions are due to the dissolved bases.

Picture 2 – Glass cleaner, bleach and baking powder.

Glass cleaner contains ammonium hydroxide, which is a base; bleach contains sodium hypochlorite, which is a base; Baking powder is essentially made up of sodium bicarbonate, which is a base, so when dissolved in water, it gives the solution a basic characteristic.

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In chemistry laboratories, the most commonly used basic solutions are:

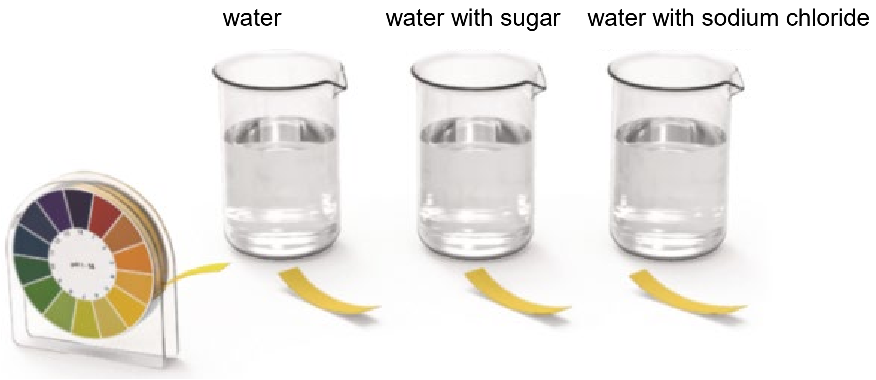
- Sodium hydroxide, NaOH (aq)
- Potassium hydroxide, KHO (aq)
- Calcium hydroxide, $Ca(HO)_2$ (aq)
- Magnesium hydroxide, $Mg(HO)_2$ (aq)

Some characteristics of the basic solutions:

- they are slippery to the touch;
- conduct electric current;
- turn the colourless alcoholic phenolphthalein solution crimson.

Neutral solutions

There are solutions that have neither an acid nor a basic character; they are neutral solutions. For example, water with sugar and water with sodium chloride, among other solutions, are neutral. These solutions, in terms of acidic or basic characteristics, behave like (pure) water, which is neutral.



Picture 3 – Examples of neutral solutions

Acid-base colorimetric indicators

There are substances that have a certain colour in an acidic environment and a different colour in a basic environment. These substances can tell us whether a solution is acidic or basic and are called acid-base colorimetric indicators.

The most used indicators in the laboratory are:

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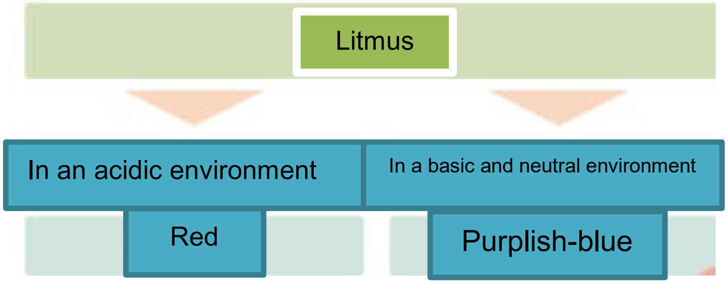
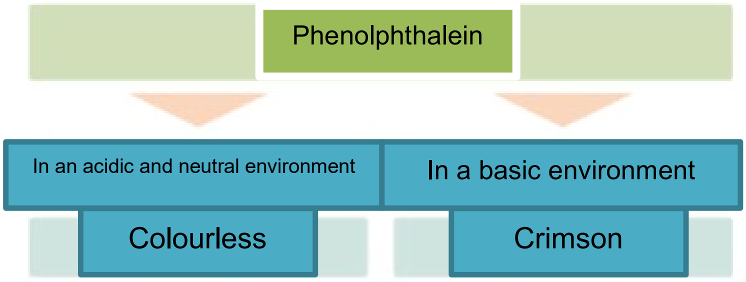
- litmus;
- phenolphthalein;
- the universal indicator.

Litmus is a blue-purplish colour indicator. It can be used in an alcoholic solution, called litmus tincture, or on strips of paper that have been impregnated in litmus solution – litmus paper.

Litmus is a good indicator of acidic solutions, as its colour changes to red in an acidic environment. In basic and neutral solutions, litmus remains purplish-blue.



Phenolphthalein is a colourless indicator that is used in alcoholic solution. It is a good indicator of basic solutions, as its colour, in a basic environment, changes to crimson. In acidic and neutral solutions, phenolphthalein remains colourless.



The universal indicator can be used in solution or on paper tape impregnated with the indicator.

Picture 4 – Solution and universal indicator paper

This allows us to identify not only the acidic or basic nature of a solution, but also to know, with some certainty, whether a given solution is more or less acidic or basic than another. To do so, it is

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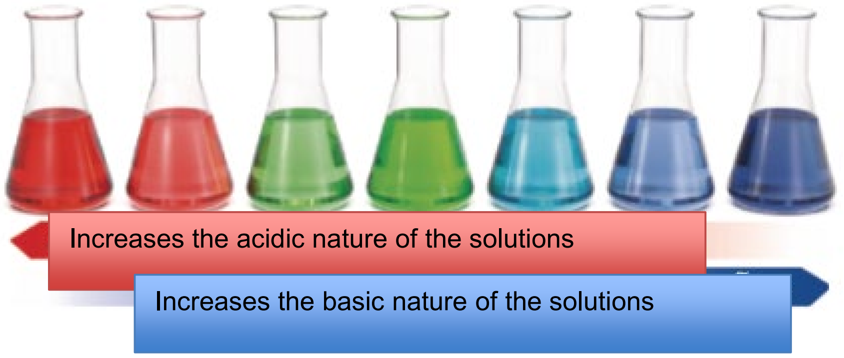
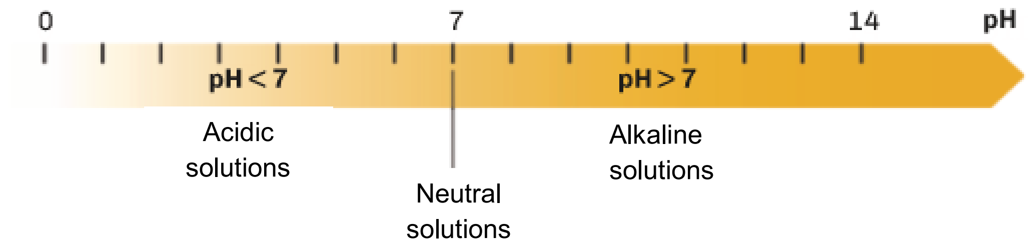
necessary to compare the colour acquired by the universal indicator in the different solutions with the colours in the reference table on the packaging of the universal indicator.

Picture 5 – The universal indicator allows you to know, approximately, the pH value



pH scale

One way to know the degree of acidity or basicity of a solution is through the use of a pH scale, also known as the Sorensen scale. On this pH scale, for low-concentrate solutions at a temperature of 25 ºC, the pH value varies between 0 and 14.



Picture 6 –pH scale

At a temperature of 25 ºC, solutions with:

- pH<7 are acidic;
- pH=7 are neutral;
- pH>7 are basic or alkaline.

So, the lower the pH value, the more acidic the solution and the higher the pH value, the more basic the solution.

In laboratories there are devices called pH meters that allow, through direct reading, to accurately determine the pH value of a solution.

Picture 7 – pH meters

Worksheet No. 2

STEM EDUCATION from school to a tech world

Learning Unit	Chemical Reactions - Acid-base colorimetric indicators
Authors	Alexandra Jales
School	FORAVE – Associação para a Educação Tecnológica do Vale do Ave
Date	

Chemical characteristics of aqueous solutions and acid-base reactions.

There are substances that have a certain colour in an acidic environment and a different one in a basic environment. These substances work as acid-base colorimetric indicators.

The acid-base colorimetric indicators most used in school laboratories are litmus, phenolphthalein and the universal indicator. These are the indicators that will be used in this practical activity.

Many acid-base chemical reactions occur on a daily basis, both in nature and in the laboratory. These chemical reactions occur when a basic solution is added to an acidic solution, or vice versa.

Previous questions

1. Litmus is one of the colorimetric acid-base indicators that will be used in this activity.

1.1. What colour is litmus in an acidic environment? And in a basic one?

1.2. Why is litmus a good indicator of acidic solutions?

2. Phenolphthalein is another colorimetric acid-base indicator that will be used in this activity.

2.1. What is the colour of phenolphthalein in an acidic environment? And in a basic one?

2.2. Why is phenolphthalein a good indicator of basic solutions?

3. The universal indicator is another of the acid-base colorimetric indicators that will be used in this activity.

3.1. If you want to compare the acidity of two solutions, should you use litmus or the universal indicator as an indicator? Justify.

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3.2. What do the numbers next to each colour on the universal indicator packaging indicate?

3.3. If you want to accurately know the pH of an aqueous solution, should you use the universal indicator? Justify.

Laboratory Activity

Part 1: Tests carried out with litmus

a) Place labels numbered from 1 to 6 on the test tubes.

b) Add a little vinegar, bleach, glass cleaner, lemon juice, water with sodium chloride and distilled water to each of the test tubes.

c) Add 2-3 drops of litmus to each of the liquids.

d) Observe and write down the colour of the litmus in each tube in the following table.

Test tubes	1	2	3	4	5	6
Liquid used	Vinegar	Bleach	Glass cleaner	Lemon juice	Water with sodium chloride	Distilled water
Colour acquired by the litmus	…	…	…	…	…	…

Part 2: Tests carried out with phenolphthalein

a) Repeat the procedure in part 1, this time using phenolphthalein.

b) Observe and write down the colour of the phenolphthalein in each tube.

Test tubes	1	2	3	4	5	6

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Liquid used	Vinegar	Bleach	Glass cleaner	Lemon juice	Water with sodium chloride	Distilled water
Colour acquired by the phenolphthalein	...	...	...	...	...	...

Part 3: Tests carried out with universal indicator paper and pH meters

a) Place labels numbered from 1 to 6 on the beakers.

b) Add a little of each of the liquids used in the previous activities to the beakers.

c) Dip a small strip of universal indicator paper in each of the different liquids.

d) Observe the colour of the different strips and compare it with the colours on the reference scale on the universal indicator paper box.

e) Write down the corresponding pH value in the following table.

Test tubes	1	2	3	4	5	6
Liquid used	Vinegar	Bleach	Glass cleaner	Lemon juice	Water with sodium chloride	Distilled water
Approximate pH value	...	...	...	...	...	...

f) Using pH meters, measure the pH value of each liquid and compare this value with the approximate value given by the universal indicator.

Part 4: Acid-base reaction between hydrochloric acid and sodium hydroxide

a) Place approximately 20 ml of aqueous sodium hydroxide solution in a beaker.

b) Then, place the pH meter inside the beaker, measure the pH value of the solution and write it down in a table.

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c) Using a dropper, add a few drops of hydrochloric acid, homogenise the solution with the dipstick and measure the pH.

d) Write down the value of the measured pH in the same table.

e) Add more drops of acid, homogenise the solution and measure the pH again.

f) Repeat this process a few more times.

g) Analyse the values you wrote down in the table.

Final questions

1. Indicate in which liquids litmus turned red.

2. Which of the liquids have acidic characteristics? Justify.

3. In what liquids does phenolphthalein acquire a crimson colour?

4. Considering the pH values estimated with the universal indicator and measured with a pH meter, indicate the liquids tested in ascending order of acidity.

5. How does the pH vary during the addition of acid to sodium hydroxide in aqueous solution?

6. Build a graph of the pH variation of the aqueous sodium hydroxide solution as hydrochloric acid was added to it. To do so, place the pH value on the Y-axis and the number of drops of diluted hydrochloric acid added on the x-axis.

7. Interpret the graph you created in the previous question.

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