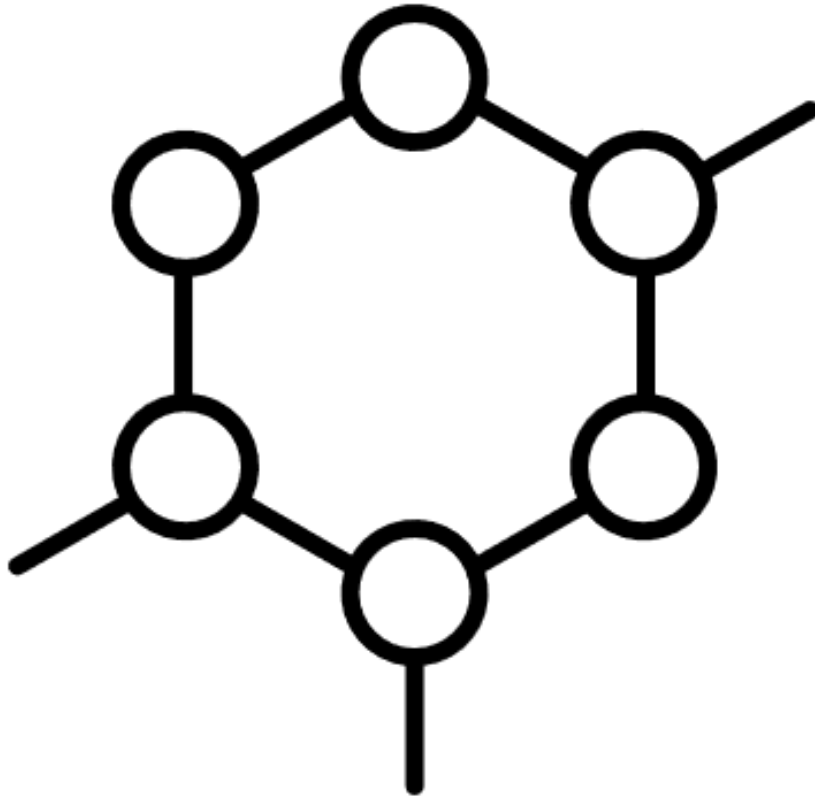


Chemical Analysis



L1 Pure Substances

In chemistry, a pure substance is defined as a material that consists of only one type of element or compound. This means that it is not mixed with any other substances. For example, if you have a piece of gold, and it's made up entirely of gold atoms, then it is a pure substance. Similarly, water (H_2O) is a pure substance if it consists only of water molecules, with no other types of molecules mixed in.

Pure Elements and Compounds

- Elements are substances that contain only one type of atom. Examples include oxygen (O_2), hydrogen (H_2), and iron (Fe). Each element has its own unique properties and cannot be broken down into simpler substances by chemical means.
- Compounds are substances formed when two or more elements chemically combine in fixed proportions. For example, water (H_2O) is a compound made from hydrogen and oxygen in a 2:1 ratio. Carbon dioxide (CO_2) is another compound, consisting of one carbon atom and two oxygen atoms.

Melting and Boiling Points

Pure substances have specific melting and boiling points. The melting point is the temperature at which a solid turns into a liquid, and the boiling point is the temperature at which a liquid turns into a gas. These temperatures are unique to each pure substance. For example, pure water boils at 100°C (at standard atmospheric pressure) and freezes (melts) at 0°C .

In contrast, mixtures (which contain more than one substance) do not have sharp melting and boiling points. Instead, they melt and boil over a range of temperatures. This is because different components in the mixture have different melting and boiling points, causing the temperature to vary as the mixture transitions between phases.

Everyday Use of the Term "Pure"

In everyday language, "pure" can have a slightly different meaning. It often refers to substances that are natural and have had nothing added to them. For instance, when we talk about pure milk, we mean milk that hasn't been mixed with any other ingredients or chemicals. It's in its natural state, just as it came from the cow.

Distinguishing Pure Substances from Mixtures

One practical application of knowing the melting and boiling points of substances is being able to determine if a material is pure or a mixture. Here's how you can do it:

- **Measure the Melting/Boiling Point:** You can measure the melting point of a solid or the boiling point of a liquid in a lab. For instance, if you have a sample of what you think is pure water, you can heat it and see if it boils at exactly 100°C .
- **Compare with Known Data:** Compare the measured melting/boiling point with the known values for the pure substance. If your sample boils at 100°C , it is likely pure water. If it boils at a slightly different temperature, it might contain impurities.
- **Look for Sharp Changes:** Pure substances will show a sharp transition at their melting and boiling points. If the substance melts or boils over a range of temperatures, it is likely a mixture. For example, a saltwater solution will start to boil at a temperature higher than 100°C because the dissolved salt changes the boiling point.

Practical Example

Imagine you have two samples of a white solid substance. One is pure sodium chloride (table salt), and the other is a mixture of sodium chloride and sugar. If you slowly heat both samples, the pure sodium chloride will melt at a specific temperature (about 801°C) without changing state over a range of temperatures. The mixture, however, will start to melt at a lower temperature, and the melting will continue over a range of temperatures because the sugar and sodium chloride melt at different points.

Independent practice

Comprehensive Questions

1. What is a pure substance in chemistry?
2. Give two examples of pure elements and two examples of pure compounds.
3. Define melting point and boiling point.
4. How can melting and boiling points be used to distinguish between pure substances and mixtures?
5. What does "pure" mean in everyday language? Give an example.
6. What happens to the melting point of a mixture compared to a pure substance?

Understanding Questions

1. Why do mixtures not have sharp melting and boiling points?
2. If a sample of water boils at 102°C, is it pure or impure? Explain.
3. How would you determine if a sample of sodium chloride is pure in a laboratory?
4. What is the significance of having specific melting and boiling points for pure substances in industrial applications?
5. Why is it important for food products to be labelled as "pure"?
6. Explain how the concept of pure substances can be applied in environmental science.
7. A white solid melts gradually over a temperature range of 150°C to 180°C. Is this solid likely a pure substance or a mixture? Explain your reasoning.
8. Describe a scenario in which distinguishing between a pure and an impure substance would be crucial in a medical setting.

L2 Formulation

In chemistry, a formulation is a mixture that has been designed to create a useful product. This means that formulations are specifically made by combining various substances in precise amounts to achieve desired properties and functions. Formulations are common in everyday life and are found in a wide range of products, from household items to industrial materials.

What Are Formulations?

Formulations are complex mixtures where each component has a specific purpose. These mixtures are not random; they are carefully crafted to ensure the final product performs as expected. For example, consider a cleaning agent like a multi-purpose spray. This product might contain:

- Water: Acts as a solvent to dissolve other ingredients.
- Detergents: Help remove dirt and grease.
- Fragrances: Provide a pleasant smell.
- Preservatives: Prevent the growth of bacteria and mold.
- Each of these ingredients is included for a specific reason, and the quantities are carefully measured to make sure the product works effectively and safely.

Examples of Formulations

Formulations are everywhere. Here are a few examples to illustrate how diverse and important they are:

- Fuels: Gasoline is a formulation made from various hydrocarbons and additives to improve performance and reduce engine wear.
- Cleaning Agents: Products like laundry detergents contain surfactants, enzymes, and bleaches, all mixed to effectively clean clothes without damaging the fabric.
- Paints: Paints are complex formulations that include pigments for color, binders to hold the pigment to the surface, solvents to make the paint spreadable, and additives to improve properties like drying time and durability.
- Medicines: Tablets and syrups are formulations containing the active drug (to treat the condition), fillers (to bulk out the tablet), and preservatives (to extend shelf life).
- Alloys: Metals like steel are formulations of iron mixed with carbon and other elements to improve strength and resistance to rust.
- Fertilizers: These contain a mix of nutrients like nitrogen, phosphorus, and potassium, carefully balanced to support plant growth.
- Foods: Many food products are formulations. For example, bread is made from flour, water, yeast, and salt, each playing a crucial role in the texture and flavor of the final product.

Identifying Formulations

To identify a formulation, you need to understand the purpose of the product and the role of its components. Given appropriate information about the ingredients and their purposes, you can determine if something is a formulation.

For example, if you know that a certain shampoo contains water, surfactants, conditioners, fragrances, and preservatives, you can identify it as a formulation. Each ingredient has a specific role: water acts as a solvent, surfactants clean the hair, conditioners make the hair smooth, fragrances add scent, and preservatives prevent microbial growth.

Why Formulations Matter

Understanding formulations is crucial because they are integral to many aspects of daily life and industry. Knowing how formulations work helps in various ways:

- Quality Control: Ensuring products are safe, effective, and consistent.
- Innovation: Developing new products with improved properties.
- Problem Solving: Identifying and fixing issues in product performance.

For instance, if a certain sunscreen doesn't protect well against UV rays, chemists can adjust the formulation by adding more effective UV filters.

Summary

Formulations are specifically designed mixtures where each ingredient is included for a particular purpose. These mixtures are essential in creating products that we rely on every day, from fuels and medicines to foods and cleaning agents. By understanding the role of each component and how they work together, we can appreciate the science behind the products we use and the importance of precise measurements and combinations.

Knowing how to identify and understand formulations is a valuable skill, especially in scientific fields and industries where creating and improving products is key. This knowledge not only helps in recognizing the complexity behind everyday items but also underscores the importance of chemistry in practical applications.

Independent practice

Comprehension Questions

1. What is a formulation in chemistry?
2. Why are the components in a formulation carefully measured?
3. List three examples of products that are formulations.
4. What role does water typically play in cleaning agents?
5. What are the four main components of paint, and what is each one's purpose?
6. What makes alloys like steel formulations?
7. Why is it important to understand formulations?

Understanding Questions

1. How would you identify if a product is a formulation given information about its ingredients?
2. Explain why bread can be considered a formulation.
3. If a new cleaning agent doesn't work well, what might chemists do to improve its formulation?
4. Why might a medicine formulation include fillers?
5. What could be the consequence of an improperly measured component in a formulation like fuel?
6. Describe how fertilizers as formulations support plant growth.
7. Given that formulations are essential in creating products, what might be some challenges faced by scientists when developing new formulations?

L3 Chromatography

Chromatography is a scientific technique used to separate mixtures into their individual components. This method is widely used in chemistry, biology, and even in everyday applications such as food testing and forensics. Understanding chromatography can help you see how scientists analyse complex mixtures and identify different substances within them.

What is Chromatography?

Chromatography involves passing a mixture through a medium where different components of the mixture move at different rates. This process allows scientists to separate, identify, and sometimes quantify the individual components. The word "chromatography" comes from the Greek words for "color" (chroma) and "writing" (graphy) because the technique was initially used to separate colored substances in plants.

Key Components of Chromatography

- **Stationary Phase:** This is the medium or material that stays still during the process. It can be a solid or a liquid on a solid support. In paper chromatography, the stationary phase is the paper itself.
- **Mobile Phase:** This is the solvent or liquid that moves through the stationary phase, carrying the components of the mixture with it. In paper chromatography, the mobile phase might be a solvent like water or alcohol.
- **Sample:** The mixture you want to separate. This could be ink, plant extract, or any complex substance.

How Does Chromatography Work?

The basic principle of chromatography is that different substances in a mixture will interact differently with the stationary and mobile phases. These interactions determine how fast each component moves through the stationary phase.

- **Preparation:** First, a small amount of the sample (the mixture you want to analyse) is placed onto the stationary phase. For example, a drop of ink might be placed near the bottom of a strip of chromatography paper.
- **Development:** The paper is then placed in a container with a small amount of the solvent (the mobile phase). The solvent travels up the paper by capillary action, carrying the components of the mixture with it.
- **Separation:** As the solvent moves up the paper, different components of the mixture travel at different speeds. Some substances might stick to the paper more and move slowly, while others travel quickly with the solvent. This causes the components to separate and form distinct spots on the paper.
- **Analysis:** Once the solvent has moved a certain distance up the paper, the paper is removed and dried. The positions of the spots can be analysed to identify the different components. For example, if you were separating inks, you might see different colours at different heights on the paper.

Types of Chromatography

- **Paper Chromatography:** This is the simplest form and is often used in school experiments. It involves using paper as the stationary phase and a liquid solvent as the mobile phase.
- **Thin Layer Chromatography (TLC):** Similar to paper chromatography, but instead of paper, a thin layer of silica gel or alumina is used on a glass or plastic plate. TLC can be more precise and is used for more detailed analysis.
- **Gas Chromatography (GC):** In this method, the mobile phase is a gas, and the stationary phase is a liquid on a solid support. It is used for separating and analysing compounds that can be vaporized without decomposing.
- **Liquid Chromatography (LC):** This technique uses a liquid mobile phase to separate components. High-Performance Liquid Chromatography (HPLC) is a more advanced form of LC that operates under high pressure for faster and more precise separations.

Applications of Chromatography

Chromatography is used in various fields:

- Forensic Science: To analyse substances found at crime scenes, like blood or ink samples.
- Environmental Testing: To detect pollutants in water and soil.
- Food Industry: To ensure quality and safety by analysing additives, contaminants, and nutrients.
- Medicine: To purify compounds, analyse blood samples, and identify drugs.

Summary

Chromatography is a powerful and versatile technique for separating mixtures into their individual components. By understanding the basic principles and types of chromatography, you can appreciate how scientists analyse complex substances in various fields. Whether it's testing the purity of a new drug or identifying pollutants in the environment, chromatography plays a crucial role in modern science and industry.

Independent practice

Comprehension Questions

1. What is chromatography?
2. What are the two main phases in chromatography called?
3. What is the role of the stationary phase in chromatography?
4. What is the role of the mobile phase in chromatography?
5. In paper chromatography, what typically acts as the stationary phase and the mobile phase?
6. What happens to the components of a mixture during the separation stage of chromatography?
7. Name two types of chromatography other than paper chromatography.

Understanding questions

1. Why do different components in a mixture move at different speeds during chromatography?
2. How can chromatography be used in forensic science?
3. Describe a practical example of using chromatography in the food industry.
4. If you were to perform a paper chromatography experiment with black ink, what would you expect to see on the paper after the solvent has moved through it?
5. Why might a scientist choose to use High-Performance Liquid Chromatography (HPLC) instead of Thin Layer Chromatography (TLC)?
6. Explain how gas chromatography (GC) differs from liquid chromatography (LC).
7. How does the principle of capillary action play a role in paper chromatography?

L4 Chromatography Required Practical

Investigating Paper Chromatography: Separating and Identifying Colored Substances

Paper chromatography is a simple yet powerful method used to separate and identify different colored substances in a mixture. This technique is commonly used in schools and laboratories to analyze the components of inks, dyes, and plant pigments. By learning how to use paper chromatography and calculate Rf values, you can gain valuable skills in analyzing and identifying various substances.

What is Paper Chromatography?

Paper chromatography involves using a piece of special paper (the stationary phase) and a solvent (the mobile phase) to separate the different components of a mixture. When the mixture is placed on the paper and the solvent moves through it, the components travel at different speeds and separate into distinct spots on the paper.

Steps in Paper Chromatography

1. Preparation:
 - Cut a strip of chromatography paper.
 - Draw a pencil line near the bottom of the paper (about 2 cm from the edge). This is the baseline where you will place your sample.
 - Place small dots of the colored substances (samples) you want to test on the baseline. Use a capillary tube or a fine-tip pipette to apply the samples.
2. Developing the Chromatogram:
 - Pour a small amount of solvent (like water or alcohol) into a container. The solvent should be shallow, just enough to cover the bottom of the container.
 - Suspend the chromatography paper in the container so that the bottom edge is in the solvent, but the spots are above the solvent level.
 - Cover the container to prevent evaporation and let the solvent travel up the paper by capillary action.
3. Separation:
 - As the solvent moves up the paper, it carries the components of the mixture with it.
 - Different substances in the mixture will travel at different speeds based on their solubility in the solvent and their attraction to the paper.
 - This causes the components to separate into distinct spots at different heights on the paper.
4. Drying and Analyzing:
 - Once the solvent has traveled up the paper and the spots are well separated, remove the paper from the container.
 - Mark the solvent front (the highest point the solvent reached) with a pencil.
 - Allow the paper to dry.

Calculating Rf Values

The Rf value (retention factor) is a numerical way to describe how far a substance has traveled on the chromatography paper relative to the solvent front. It helps to identify substances based on their movement. The Rf value is calculated using the formula:

$$Rf = \frac{\text{Distance traveled by the substance}}{\text{Distance traveled by the solvent front}}$$

Here's how to calculate Rf values step by step:

Measure Distances:

- Measure the distance from the baseline to the centre of each separated spot (this is the distance travelled by the substance).
- Measure the distance from the baseline to the solvent front (this is the distance travelled by the solvent).

Calculate Rf:

Use the formula to calculate the Rf value for each spot.

For example, if a spot travelled 2.5 cm from the baseline and the solvent front travelled 5.0 cm, the Rf value would be:

$$Rf = 2.5\text{cm} / 5.0\text{cm} = 0.5$$

Using Rf Values to Identify Substances

Rf values are unique for different substances under the same experimental conditions. By comparing the Rf values of unknown substances with those of known substances, you can identify the components in a mixture.

For instance, if you have an unknown ink and you separate it using paper chromatography, you can compare the Rf values of the spots with those of known inks. If the Rf values match, you can infer that the unknown ink contains the same substances as the known ink.

Practical Example

Imagine you have a black ink sample and want to determine its components. You place a dot of the ink on the baseline of the chromatography paper and develop the chromatogram using water as the solvent. After the solvent front has travelled 10 cm, you observe three distinct spots at 2 cm, 5 cm, and 8 cm from the baseline. Calculating the Rf values:

1. Rf for the first spot:

$$2/10 = 0.2$$

2. Rf for the second spot:

$$5/10 = 0.5$$

3. Rf for the third spot:

$$8/10 = 0.8$$

By comparing these Rf values with those of known dyes, you can identify the components of the black ink.

Summary

Paper chromatography is a valuable technique for separating and identifying coloured substances. By following the steps to prepare, develop, and analyse a chromatogram, and by calculating Rf values, you can determine the individual components of a mixture. This method is widely used in various scientific fields and is an essential skill in chemistry.

Independent practice

Comprehension Questions

1. What is the main purpose of paper chromatography?
2. What two phases are involved in the chromatography process?
3. Describe the role of the solvent in paper chromatography.
4. What does the R_f value represent in chromatography?
5. How can R_f values be used to identify unknown substances?

Understanding Questions

1. Why is it important to mark the solvent front on the chromatography paper?
2. What might happen if the spots of the sample are placed too close together on the chromatography paper?
3. Explain why different components of a mixture travel at different speeds during chromatography.
4. How would you improve the accuracy of your chromatography results?
5. What is the significance of using a pencil to draw the baseline in paper chromatography?

Calculation Questions

1. A coloured substance travelled 4.0 cm from the baseline, and the solvent front travelled 10.0 cm. Calculate the R_f value for this substance.
2. If the solvent front travelled 12.0 cm and one of the spots was found 9.0 cm from the baseline, what is the R_f value of this spot?
3. A sample's spot travelled 5.5 cm up the chromatography paper, while the solvent front moved 11.0 cm. What is the R_f value of the sample?
4. During an experiment, a spot was observed 3.0 cm from the baseline when the solvent front reached 15.0 cm. Calculate the R_f value for this spot.
5. If a chromatogram shows a spot that moved 7.0 cm when the solvent front moved 14.0 cm, what is the R_f value?

L5 Test for gases

Testing for Gases: Hydrogen, Oxygen, Carbon Dioxide, and Chlorine

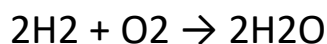
In GCSE Chemistry, understanding how to test for different gases is an essential skill. Different gases have unique properties that can be identified using simple tests. Here, we'll look at how to test for hydrogen, oxygen, carbon dioxide, and chlorine. We'll also provide tips on how to approach these topics in exams.

Test for Hydrogen

Hydrogen is a colorless, odorless gas that is highly flammable. The classic test for hydrogen involves the following steps:

- **Collect the Gas:** Collect the hydrogen gas in a test tube or a container.
- **Ignite:** Bring a lit splint (a small wooden stick used in labs) close to the mouth of the test tube.
- **Observation:** If hydrogen is present, it will react with oxygen in the air to produce water, and you will hear a characteristic 'pop' sound. This is known as the 'pop test.'

The reaction can be written as:



Exam Tip: Remember the sound produced by hydrogen is a 'pop,' not a bang or a fizz.

Test for Oxygen

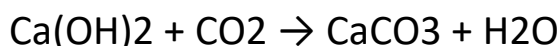
- Oxygen is a colorless, odorless gas that supports combustion. The test for oxygen is straightforward:
- **Collect the Gas:** Collect the oxygen gas in a test tube.
- **Relight a Splint:** Take a glowing splint (a splint that has been lit and blown out so that it is just glowing, not burning) and insert it into the test tube.
- **Observation:** If oxygen is present, the glowing splint will reignite and burst into flame.
- This happens because oxygen is a strong supporter of combustion.

Exam Tip: Emphasize that the splint is glowing, not already burning.

Test for Carbon Dioxide

- Carbon dioxide is a colorless, odorless gas that does not support combustion and can react with limewater. Here's how to test for it:
- **Bubble through Limewater:** Bubble the gas through a solution of limewater (calcium hydroxide solution).
- **Observation:** If carbon dioxide is present, the limewater will turn milky or cloudy. This happens because carbon dioxide reacts with calcium hydroxide to form calcium carbonate, which is insoluble and precipitates out, causing the milky appearance.

The reaction can be written as:



Exam Tip: Make sure to specify that the limewater turns 'milky' or 'cloudy,' not just 'white.'

Test for Chlorine

- Chlorine is a greenish-yellow gas with a pungent smell, and it is highly reactive. The test for chlorine involves using damp litmus paper:
- Damp Litmus Paper: Take a piece of damp blue litmus paper.
- Expose to Gas: Expose the litmus paper to the gas in question.
- Observation: If chlorine is present, the blue litmus paper will first turn red (indicating acidity) and then bleach to white.
- Chlorine is a strong oxidizing agent and reacts with the dye in the litmus paper, causing it to lose its color.

Exam Tip: Note the two-step color change: blue to red, then red to white.

Exam Preparation Tips

- Memorize Key Reactions: Ensure you know the reactions and the expected results for each gas test.
- Use Precise Language: In exams, use specific terms like 'pop,' 'glowing splint,' 'turns milky,' and 'bleaches' to convey clear understanding.
- Practice Describing Procedures: Be able to describe each step of the tests accurately. For example, don't just say "test for oxygen," describe how you use a glowing splint.
- Understand Why: Comprehend why each test works. For example, understand why carbon dioxide turns limewater milky and why chlorine bleaches litmus paper.
- Safety First: Remember that handling gases requires caution. Chlorine, for example, is toxic, so handling it should always be done in a well-ventilated area or under a fume hood.

Independent practice

Comprehension Questions

1. What is the characteristic sound produced when testing for hydrogen?
2. What happens to a glowing splint in the presence of oxygen?
3. What is the observable change when carbon dioxide is bubbled through limewater?
4. How does damp blue litmus paper react to chlorine gas?
5. Write the chemical reaction that occurs when carbon dioxide reacts with limewater.
6. What is the initial color change observed when blue litmus paper is exposed to chlorine gas?
7. Why is it important to specify that a splint is glowing and not already burning when testing for oxygen?

Understanding questions

1. Why does hydrogen produce a 'pop' sound when ignited?
2. Explain why a glowing splint reignites in the presence of oxygen.
3. Describe the chemical reaction that makes limewater turn milky when exposed to carbon dioxide.
4. What does the bleaching effect of chlorine on litmus paper indicate about the gas?
5. Why is it necessary to use damp litmus paper when testing for chlorine gas?
6. In what kind of environment should chlorine gas be handled, and why?
7. How can the presence of oxygen be confirmed using a simple laboratory test?

L6 Title

Insert explanation.

Independent practice

Insert 14 questions including two extended writing questions.