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# History of Chemistry:

## 1.1 Principles & Methods in Chemistry:

To do science, scientists must follow set principles & techniques, sharing ideas & building knowledge in a systematic way.

### a) Conservation of Mass & Energy:

- Law: Mass & energy can neither be created nor destroyed, but they can change from one form to another. This means the total amount of mass & energy in a closed system always remains constant.
- Example: In a closed system, the total mass of products equals the total mass of reactants.
- Introduced by Antoine Lavoisier in the 18th century.

### b) Using observation & logical thinking:

- Scientists form theories & models from observations.
- Logical thinking helps interpret results.
- Examples: Dimitri Mendeleev predicted elements in the periodic table based on patterns.

### c) Controlled Experiments:

- Only one variable is changed at a time, all others remain constant.

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- Common in pharmaceuticals to set medicine safety.
- Used across sciences (biology, physics) to find cause-effect relationships.

d) **Peer Review:**

- Work is reviewed by other scientists before publications.
- Ensures accuracy, detect mistakes, & confirms findings.
- Example: New catalyst discovery must be independently verified.

e) **Being Objective:**

- Based on facts, not opinions or biases.
- Example: Using spectrometery for identifying molecules depends on measurments, not guesses.

f) **Spetticism & Proof:**

- Scientists are skeptical & recheck findings.
- Others must replicate experiments before acceptance.
- Helps ensure trustworthy & verified information becomes part of science.

## 1.2 Evolution of scientific ideas:

: What is a scientific paradigm?

- A set of ideas, methods & rules guiding scientific research.
- Helps provide structures to explain discoveries.

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- Paradigm can change when new evidence appears.

### 1- Phlogiston Theory:

- 1700 ideas: Substances burn by releasing a material called phlogiston.
- Disproved by Lavoisier, who introduced oxidation & reduction instead.

### 2- Historical models of the atom:

- Plum Pudding Model (1904) - J.J Thomson: Electrons in a positively charged "pudding".
- Rutherford Model (1911) - Small dense nucleus, electrons orbit around it.
- Bohr's & Quantum Model: Added energy levels & quantum mechanics.

### 3- The Periodic Table:

- Created by Dmitri Mendleev in 1869.
- Organized by atomic masses & properties.
- Predicted undiscovered elements.

## 1-3 Scientific paradigms in Chemistry:

- Paradigm helps scientists understand substances & how they interact.
- Aid in experimentation, testing & interpreting results.
- Help in developing new materials & technologies.

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- Essential in fields like medicine, materials science & environmental protection.

## 1.4 Confidence & un-certainty in Chemistry:

Scientists use tools to measure how precise or reliable data is.

### 1. Confidence Intervals:

- Shows how precise measurement is.
- Example: 0.50 molar ± 0.02 with 95% confidence = result is within 0.48-0.52.

### 2. P-values:

- Check if results are statistically meaningfull.
- Lower p-values (e.g. 0.01) = more confidence in the results.

### 3. Standard error & standard derivation:

- Measure how data varies.
- Example: Average = 120°C, Standard derivation = 0.5°C ⇒ results are consistent.
- Standard error (e.g. 0.1°C) = more accurate average.

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4. **Bayesian Probability:**
- Updates confidence based on new evidence.
- Example: Initial belief = 60%, new evidence ⇒ 80%.

5. **Quantifying uncertainity:**
- Tells how reliable a measurement is.
- Example: 0.250 molar ± 0.005 molar = actual values lies near 0.250.

1.5

# Repeatability & Reproducibility:

- **Definition & Importance:**

In chemistry, repeatability & reproducibility are essential to ensure that experimental results are reliable. They help verify that findings are trustworthy, accurate & accepted by the scientific community.

1. **Repeatability:**

Definition:
- Getting the same result when repeating an experiment under the same conditions.
- Involves using the same tools, same procedures, & same setting.

Example:
- A chemist measure the melting point of substance several times in the same lab,

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& gets the same result each time → the experiment is repeatable.

## 2- Reproducibility:

Definition:

- Getting the same results even when the experiment is conducted in different labs, by different scientists, using different tools & methods.

Example:

Scientists in different labs measure the same substances melting point & get similar results → The experiment is reproducible.

Q. Why are these important?

- **Repeatability:**
  Shows the experiment is well-controlled & consistent in one setting.
- **Reproducibility:**
  Proves that the findings are reliable across multiple labs & different methods.

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# History of Chemistry

Topic:

## Short Questions Answers

1. Explain the principle of conservation of mass in chemical reaction?

Ans: The law of conservation of mass states that mass can neither be created nor destroyed in a chemical reaction. The total mass of the reactants equals the total mass of the products. For examples if 10g of Hydrogen reacts with 80g of Oxygen, the total mass of water produced will be 90g.

2. What is the role of empirical evidence in scientific research?

Ans: Empirical evidence refers to data collected through observation & experimentation. It helps scientists validate or reject hypotheses. Without empirical evidence, scientific claims would be unstable & unreliable.

3. Describe the peer review process & its importance

in science -

A. Peer review is the evaluation of scientific work by independent experts in the same field - It ensures that the research is credible, accurate, & free from bias befor publication - This process maintains the quality & integrity of scientific knowledge -

4- How did the phlogiston theory explain combustion?

A2 The phlogiston theory proposed that a substance called phlogiston was released during burning - According to this theory, combustible materials contain phlogiston, which escaped during combustion, leaving behind a residue - However, this theory was later disproved by the oxygen theory of combustion -

5. What is the significance of Rutherford's model of the atom?

A1 Rutherford's model proposed that atoms consist of a dense, positively charged nucleus, surrounded by electrons - This revolutionized atomic theory by introducing the concept of the nucleus, replacing the earlier plum-pudding model -

6. How does the periodic table organize elements?

A1 The periodic table arranges elements in

increasing order of atomic number. Elements with similar chemical properties are grouped into columns (groups), & periods (rows) represent element with increasing energy levels. This structure helps predict chemical behavior.

7. Define scientific paradigm with an example?

A: A scientific paradigm is a widely accepted scientific theory or framework that guides research & understanding.

Example: The atomic model is a paradigm in chemistry that explains the structure & behavior of matter.

8. What does a confidence level in scientific research indicate?

A: A confidence level expresses how certain scientists are that the results of their searches are not due to chance. A 95% confidence level means there is a 95% probability the results are correct & only 5% chance they occured randomly.

9. Differentiate between repeatability & reproducibility in experiments?

| Aspect | Repeatability | Reproducibility |
|---|---|---|
| • Definition | Ability to get the same result under same conditions. | Ability to get the same result under different conditions. |
| • Who performs it? | Same person. | Different people. |
| • Conditions. | Same equipment, same lab, same method. | Different equipment, diff lab, possibly different method. |
| • Purpose | Checks consistency of one persons method. | Check reliability accross scientists & environments. |

10. Why is skepticism important in scientific community?

Ans (Speak)$^{x}$ Skepticism promote critical thinking & questioning of ideas. It prevents blind acceptance & encourages scintists to test, verify, & challange claim before accepting them. This ensures scientific accuracy & integrity.

# Long Question Answers

1- Discuss the transition from the phlogiston theory to oxygen theory of combustion & its impact on Chemistry?

Ans: **Introduction:**

The phlogiston theory was a historical explanation for combustion. It stated that all flammable substances contained a substance called phlogiston, which was released during burning.

- **The Phlogiston Theory:**

According to this theory, when a material burned, it gave off phlogiston into the air, & the leftover material (ash or residue) was "dephlogisticated". This theory couldn't explain why metal gain mass after burning (forming oxides).

- **Lavoisier's Oxygen Theory:**

Antoine Lavoisier, a French chemist, disproved the phlogiston theory in the 1770s. Through careful experimentation, he showed that oxygen is required for combustion. He proved that combustion is a chemical reaction between a substance & oxygen, not the release of phlogiston.

- **Impact on chemistry:**
- Introduced the law of conservation of mass.
- Marked the end of alchemy & beginning of modern chemistry.
- Improved understanding of oxidation, respiration & chemical reactions.
- Emphasize the use of quantative experiments in science.

2- Explain the development of atomic models from plum-pudding to quantum mechanical model?

A:- **Plum - Pudding model:**

In 1904, J.J. Thomson proposed that atoms are spheres of positive charges with negatively charged electrons embedded in them like raisins in a pudding.

- **Rutherford's nuclear model:**

In 1911, Ernest Rutherford conducted the gold foil experiment & discovered that atoms have a tiny, dense, positively charged nucleus. Electrons orbit the nucleus, like planets orbit the sun.

- **Bohr's model:**

In 1913, Niels Bohr refined Rutherford's model by suggesting that electrons orbit the nucleus

in fixed energy levels (shells). Electrons can jump between level by absorbing or emitting energy.

- **Quantum mechanical model:**
Modern atomic theory developed by Schrodinger, Heisenberg, & others, describes electrons as cloud of probability within orbitals. It no longer views electrons as moving in fixed paths.

2- **Summary:**
Each model improved our understanding of atomic structure. The quantum model is the most accurate & widely accept today.

3- Analyze how the periodic table serve as paradigm in chemistry, guiding research & discovery of new elements?

A: **Introduction:**
The periodic table is not just a list of elements — it is a scientific paradigm that organizes & predicts chemical behavior.

- **Organization:**
Elements are arranged by increasing atomic number. Vertical columns (groups) contains elements with similar

chemical properties - Horizontal row (periods) show trends like atomic size & reactivity.

- **Predictive power:**

Mendeleev left gaps for undiscovered elements & currently predicted properties of Gallium & Germanium.

Trends such as electronegativity, ionization energy & metallic character help in predicting chemical behavior.

- **Role in research:**
  - Helps in discovering new elements.
  - Assits in studying Chemical bonding.
  - Guides material science & modern chemical industries.

: **Conclusion:**

The periodic table is a powerful tool that guides research, discovery & understanding in all branches of chemistry.

4- Evaluate the importance repeatability & reproducibility in maintaining scientific integrity & process?

A: **Introduction:**

Scientific knowledge must be reliable. This reliability depends on two key principles: repeatability

& reproducibility.

- **Repeatability:**
Means that the same person, under the same condition, can get the same results multiple times.

- **Reproducibility:**
Means that different scientists, under different conditions, can repeat an experiment & obtain the same results.

- **Why they're important:**
- Build trust in scientific data.
- Helps detect errors or fraud.
- Ensures results are not accidental.
- Form the basis of scientific progress & new discoveries.

- **Example in chemistry:**
If Two chemists titrate the same acid & base & get the same concentration, it shows reproducibity & confirms the method is reliable.

5. Describe the levels of confidence & uncertainty

are expressed & interpreted in -----?

Ans: **Introduction:**

In science, especially in chemistry, every measurement include some level of uncertainty - To understant how much we can trust a result, scientist use confidence levels-

- **Confidence Level:**

It shows how sure scientists are about their results - For example, a 95% confidence level means there's a 95% chance the result is correct.

- **Uncertainty:**

It refers to the range of errors in measurements - For example, a volume may be recorded as $25.0 \pm 0.2$ mL, meaning the true value could lie between 24.8 mL & 25.2 mL.

- **Importance in Chemistry:**
  - Helps evaluate the accuracy of experimental results.
  - Allows scientists to compare results.
  - Makes research more transparent.
  - Prevents false conclusions.

**Conclusion:**

Confidence & uncertainty help scientists report results clearly, ensuring the quality & reliability of their work.