



Class: 9th

Subject: Chemistry

Chapter 12: Empirical Data Collection and Analysis

Exercise MCQs:

(i) Which of the following pairs of quantities may be measured in the same unit?

- (a) Heat and temperature
- (b) Temperature and area
- (c) Heat and work
- (d) Length and work

(ii) In which unit do we usually measure the energy present in the food?

- (a) Kilojoules
- (b) Calorie



(c) Megajoules

(d) Joule

(iii) What prefix is used for 10^{12} ?

(a) Mega

(b) Pico

(c) Giga

(d) Tera

(iv) In SI units, pressure is expressed in:

(a) Newton per metre

(b) Newton per metre square

(c) Joule

(d) Pascal

(v) Which symbol is used for kilogram in SI units?

(a) K

(b) K

(c) Kgm

(d) kg

(vi) What does a mole represent?






(a) Number

(b) Mass

(c) Volume

(d) Length



(vii) Which unit of volume should usually be used in Chemistry?

(a) Millilitre

(b) Litre

(c) Cubic centimetre

(d) Cubic metre

(viii) Express 0.000840 in scientific notation:

(a) 8.40×10^3

(b) 840×10

(c) 8.40×10^{-4}

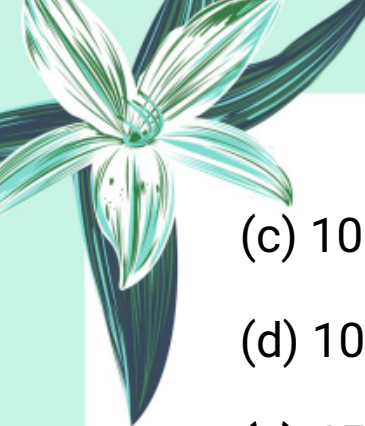
(d) 84.0×10^5

(ix) In SI units, prefix nano means:

(a) 10^{-8}

(b) 10^{-9}





(c) 10^{-11}

(d) 10^{-12}

(x) 65°C is equivalent to:

(a) 208 K

(b) 338 K

(c) 403 K

(d) 300 K



Important MCQs:

1. How many base units are there in the SI system?

(a) 5

(b) 6

(c) 7

(d) 8

2. Which of the following is not an SI base unit?

(a) mole

(b) litre





(c) kilogram

(d) kelvin

3. What is the SI unit of length used in Chemistry?

(a) kilometre

(b) centimetre

(c) metre

(d) millimetre

4. One metre is defined as the distance travelled by light in vacuum in approximately:

(a) one second

(b) 300 millionth of a second

(c) one minute

(d) one hour

5. What is the SI unit of mass?

(a) gram

(b) tonne

(c) kilogram

(d) pound





6. One kilogram is defined as the mass of:

- (a) 100 g of water
- (b) 1000 cm³ of water
- (c) 1 g of water
- (d) 10 cm³ of water

7. What is the SI unit of time?

- (a) hour
- (b) minute
- (c) second
- (d) millisecond

8. One second is defined based on:

- (a) Water freezing point
- (b) Earth's rotation
- (c) 9,192,631,770 cycles of cesium-133 radiation
- (d) Pendulum oscillation

9. What is the SI unit of temperature?

- (a) Celsius



(b) Fahrenheit

(c) Kelvin

(d) Degree

10. At the triple point of water, which states of matter coexist?



(a) Solid only

(b) Liquid only

(c) Gas only

(d) Solid, liquid, and gas

11. One mole is defined as containing exactly:

(a) 1000 atoms

(b) 6.022×10^{23} particles

(c) 1 gram of substance


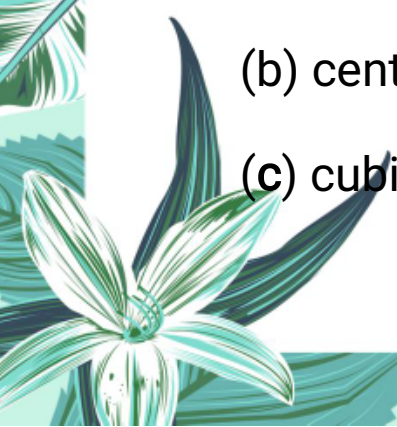
(d) 100 molecules

12. What is the derived SI unit for volume?

(a) metre

(b) centimetre³

(c) cubic metre





(d) litre

13. What is the SI unit of force?

(a) Joule

(b) Newton

(c) Pascal

(d) Watt

14. What is the SI unit of pressure?

(a) Newton

(b) Joule

(c) Pascal

(d) Kelvin

15. What is the prefix for 10^6 in the SI system?

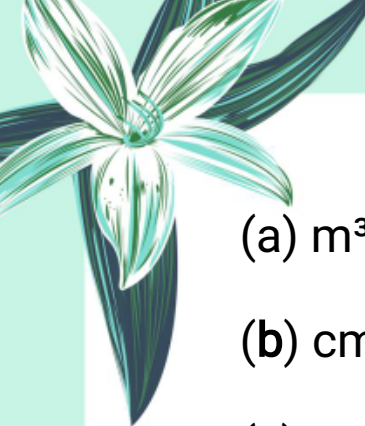
(a) kilo

(b) micro

(c) deca

(d) Mega

16. Which unit is commonly used to measure volume in chemistry laboratories?



(a) m^3

(b) cm^3

(c) L

(d) mm^3



17. What is an error in measurement?



(a) Correct result

(b) Tool calibration

(c) Difference between actual and measured value



(d) Skill of the student

18. Which of the following is a source of systematic error?

(a) Temperature

(b) Slight changes in readings

(c) Limitation of measuring instruments

(d) Human eyesight

19. Systematic error affects the:

(a) Accuracy





(b) Precision

(c) Volume

(d) Weight

20. Which of these tools may contribute to systematic errors?



(a) Test tube

(b) Measuring tape

(c) Burette

(d) Beaker cover

21. Random error is mainly caused by:

(a) Permanent defects

(b) Faulty instruments

(c) Environmental factors and slight variation in procedure

(d) Exact tool precision

22. What does random error affect?

(a) Accuracy

(b) Precision





(c) Units

(d) Conversion

23. If a student measures the same mass five times and gets 3.2 kg each time, the measurement is:



(a) Accurate

(b) Not precise

(c) Precise

(d) Incorrect

24. A student measures mass of 20g object as 17.3, 17.4 and 17.2. This student is:

(a) Accurate

(b) Both accurate and precise

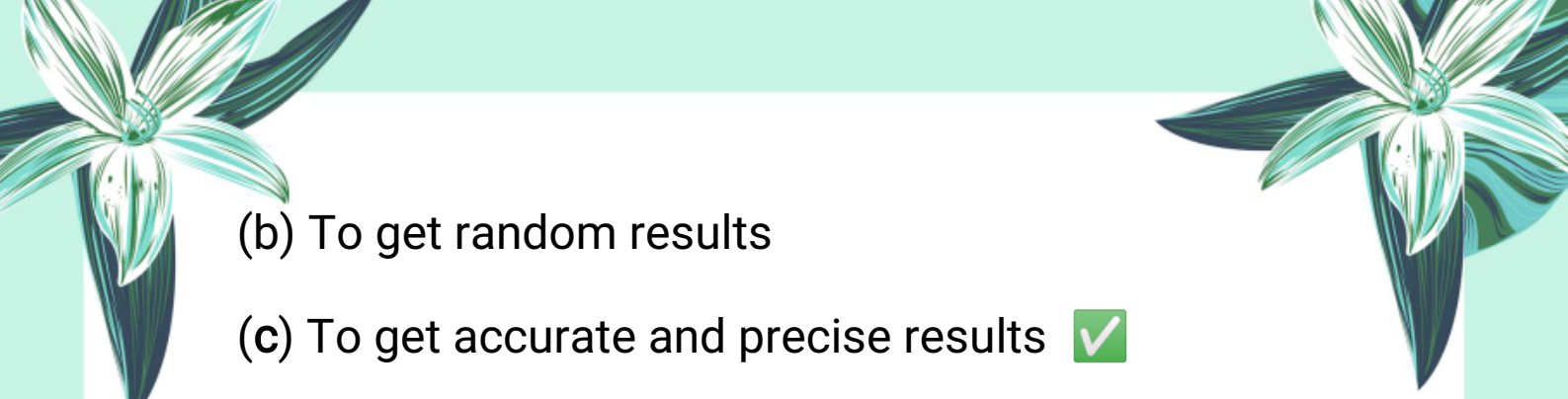
(c) Precise but not accurate

(d) Neither accurate nor precise

25. What is the goal of any scientific experiment regarding results?

(a) To save time



- 
- (b) To get random results
- (c) To get accurate and precise results
- (d) To use expensive tools



Exercise Short Questions:

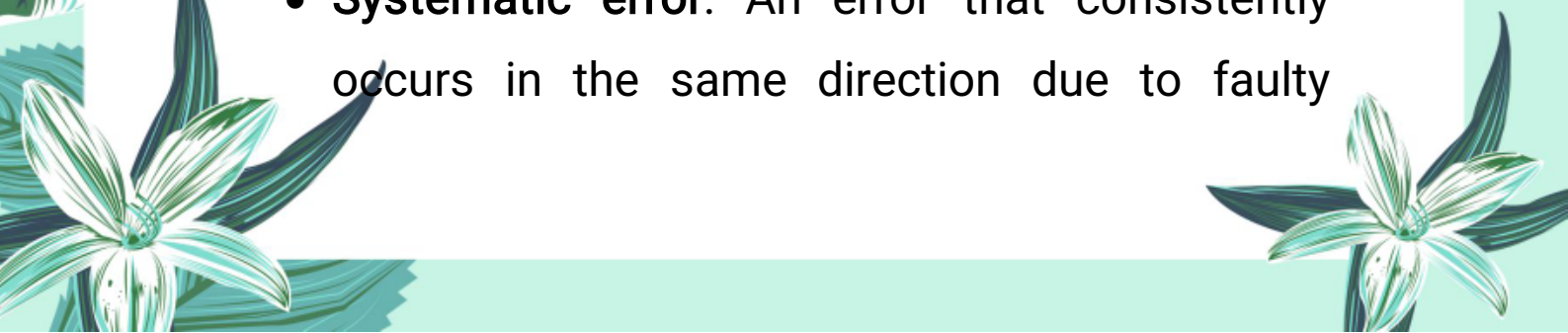
1. What is consistency of results?

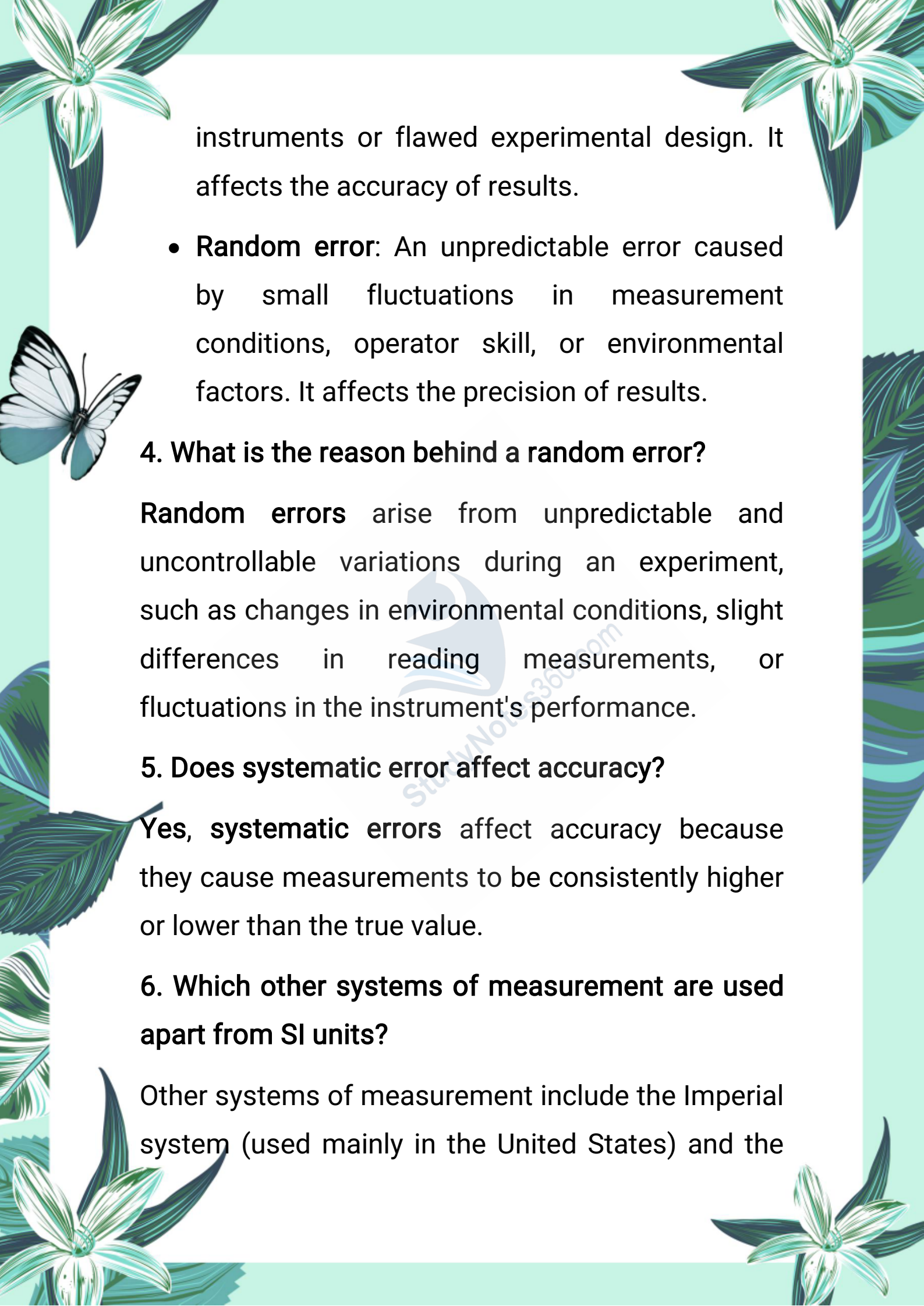
Consistency of results means obtaining similar or nearly the same values when a **measurement** is repeated under the same conditions. It indicates the precision of the measurements.

2. Why are SI units user-friendly?

SI units are user-friendly because they are based on the decimal system (multiples of 10), making calculations simpler and conversion between units easier. This **standardization** helps scientists **worldwide** communicate measurements clearly.

3. Define systematic error and random error.

- **Systematic error:** An error that consistently occurs in the same direction due to faulty
- 



instruments or flawed experimental design. It affects the accuracy of results.

- **Random error:** An unpredictable error caused by small fluctuations in measurement conditions, operator skill, or environmental factors. It affects the precision of results.

4. What is the reason behind a random error?

Random errors arise from unpredictable and uncontrollable variations during an experiment, such as changes in environmental conditions, slight differences in reading measurements, or fluctuations in the instrument's performance.

5. Does systematic error affect accuracy?

Yes, systematic errors affect accuracy because they cause measurements to be consistently higher or lower than the true value.

6. Which other systems of measurement are used apart from SI units?

Other systems of measurement include the Imperial system (used mainly in the United States) and the



CGS system (centimeter-gram-second).

7. Define metre.

Metre is the SI unit of length. It is defined as the distance traveled by light in a vacuum in $1/299,792,458$ seconds.

8. Mention two benefits scientists get by using SI units.

SI units provide a universal standard, allowing scientists from different countries to communicate results clearly and consistently.

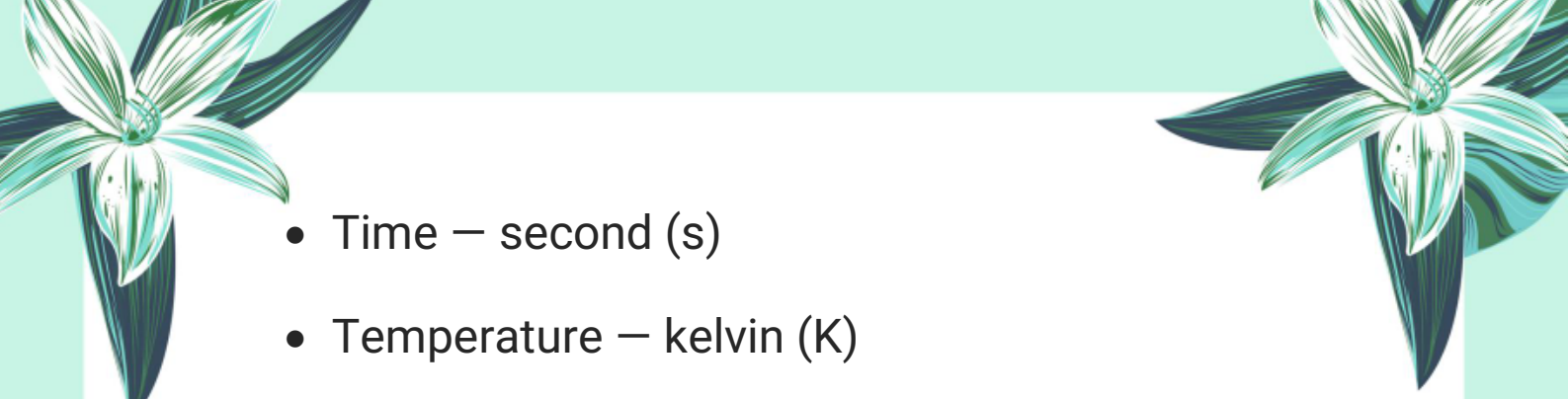
They simplify calculations and conversions due to their decimal-based structure.

Important Short Questions:


1. What are the five base SI units commonly used in Chemistry?

The five base SI units used in Chemistry are:

- Length – metre (m)
- Mass – kilogram (kg)

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- Time – second (s)
 - Temperature – kelvin (K)
 - Amount of substance – mole (mol)

2. Define the metre as an SI unit of length.



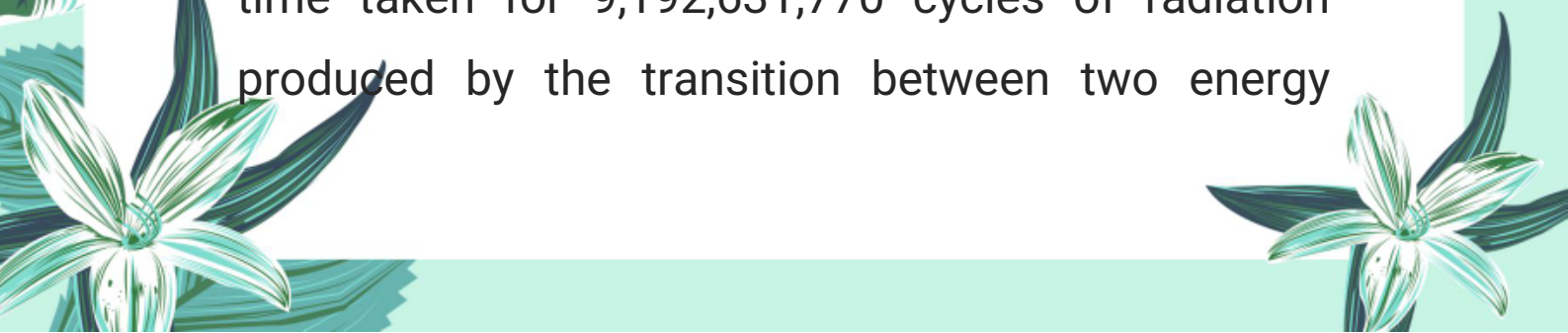
Metre (m) is the standard unit of length in the SI system. It is defined as the distance traveled by light in vacuum in approximately $1/300,000,000$ of a second.

3. How is the kilogram defined as an SI unit of mass?

Kilogram (kg) is the SI unit of mass. It is defined as the mass of a platinum-iridium alloy cylinder kept in France, which serves as the standard reference. It is also approximately equal to the mass of 1000 cubic centimetres of water.

4. What is the definition of a second in the SI system?


Second (s) is the SI unit of time. It is defined as the time taken for 9,192,631,770 cycles of radiation produced by the transition between two energy





levels of a cesium-133 atom.

5. Explain the meaning of Kelvin and how it relates to the triple point of water.

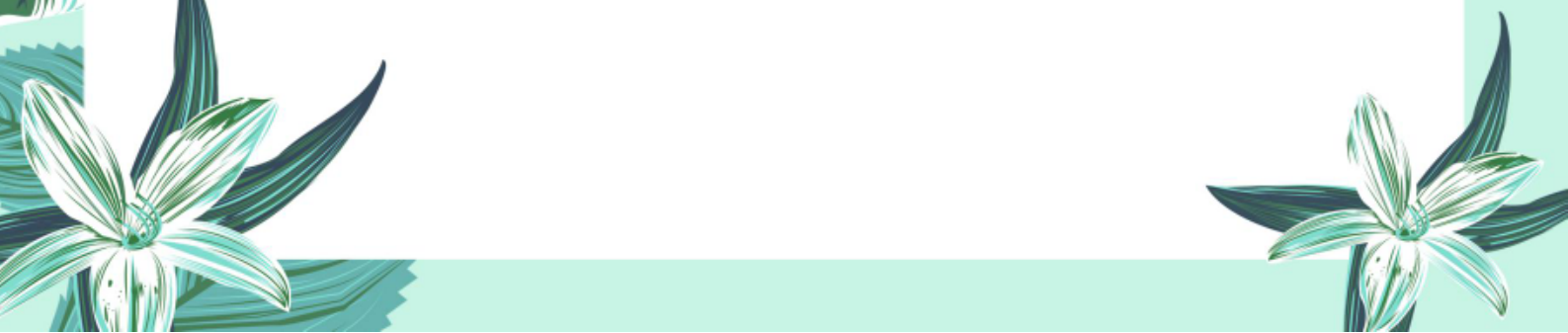


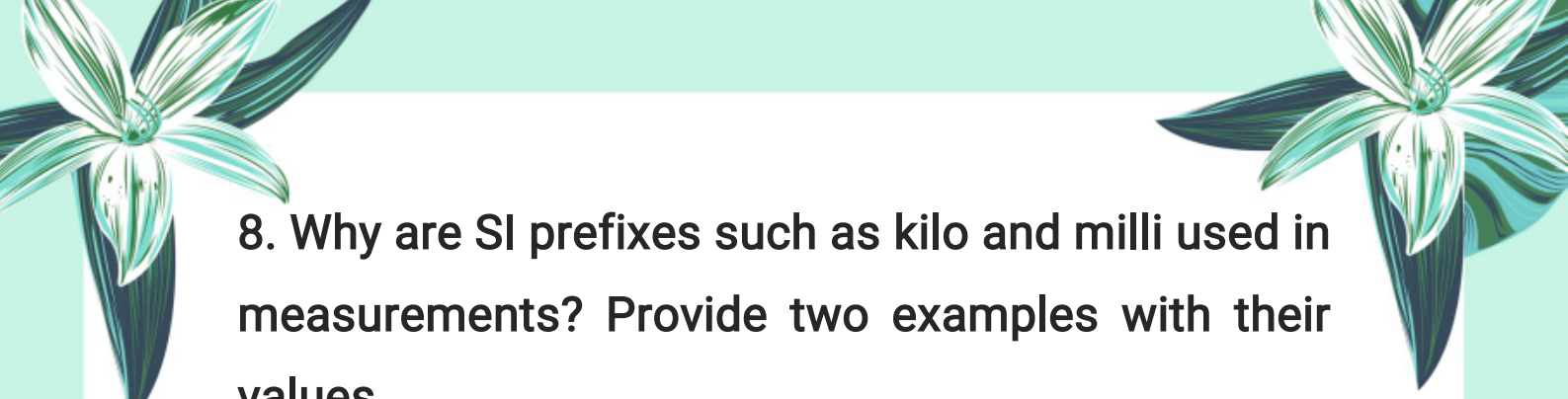
Kelvin (K) is the SI unit of temperature. It is defined as $1/273.16$ of the thermodynamic temperature of the triple point of water, where water coexists in solid, liquid, and gaseous states.

6. What is a mole, and why is it important in Chemistry?

A mole (mol) is the amount of substance that contains exactly 6.022×10^{23} particles (atoms, molecules, or ions). It is important because it allows chemists to count particles by weighing substances.

7. Name three derived SI units used in Chemistry and their symbols.

- Volume – cubic metre (m^3)
 - Density – kilogram per cubic metre (kg/m^3)
 - Pressure – pascal (Pa), where $1 \text{ Pa} = 1 \text{ N}/\text{m}^2$
- 



8. Why are SI prefixes such as kilo and milli used in measurements? Provide two examples with their values.

SI prefixes express multiples or fractions of units to simplify large or small numbers.



Examples:

- Kilo (k) = 10^3 (1 kilogram = 1000 grams)
- Milli (m) = 10^{-3} (1 millilitre = 0.001 litre)


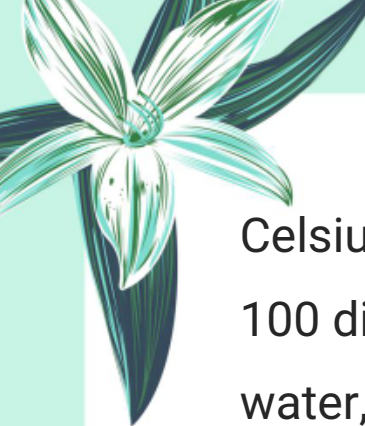
9. Why is gram preferred over kilogram for measuring mass in Chemistry laboratories?

Gram is preferred because laboratory masses are usually small and grams provide manageable numbers, making calculations easier without dealing with very large or small values.


10. How do you convert temperature from Celsius to Kelvin? Write the formula and explain why Celsius is more convenient in Chemistry.

Formula:

$$K = ^\circ C + 273$$

Celsius scale is more convenient because it has 100 divisions between freezing and boiling points of water, making it easier to use and compatible with the base-10 SI system.



11. What is meant by systematic error? Give an example.



Systematic error is a consistent, repeatable error caused by faulty equipment or flawed experimental design. It affects the accuracy of measurements.

Example: A pipette delivering slightly less volume than indicated due to incorrect calibration.

12. Explain random error and its causes.

Random error is the variation in measurements caused by unpredictable changes during an experiment. It leads to different results each time the measurement is taken.

Causes: Limitations of instruments, environmental factors, or small variations in measurement procedures.





13. How do systematic errors affect the accuracy of measurements?

Systematic errors cause measurements to be consistently off from the true value, thus decreasing the accuracy of the results.



14. Define accuracy with an example.

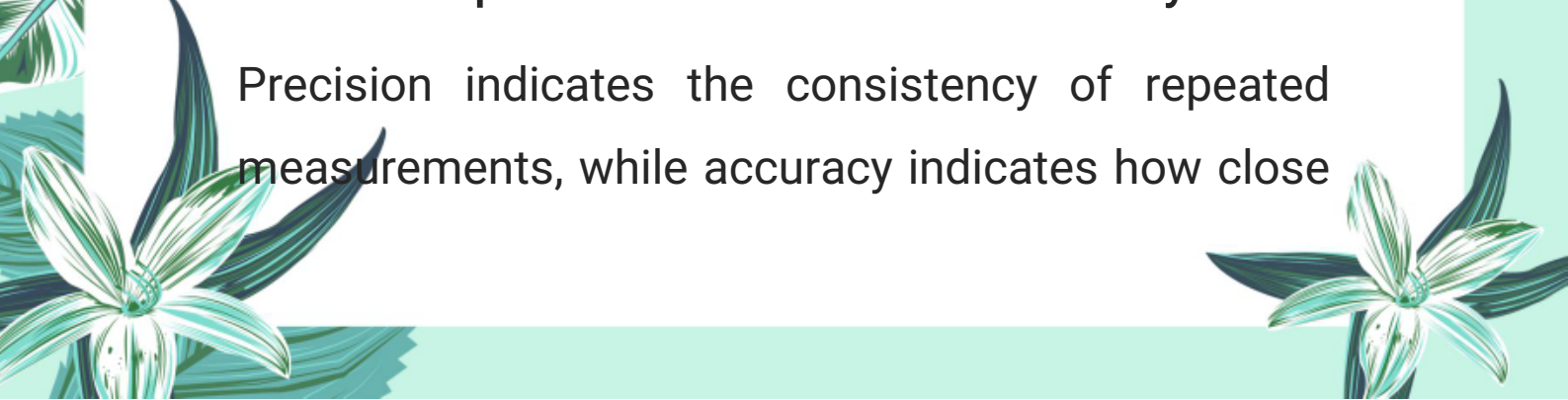
- Accuracy refers to how close a measured value is to the true or accepted value.
- **Example:** If the true volume is 26 cm^3 and the measured volume is 26.1 cm^3 , the measurement is accurate.

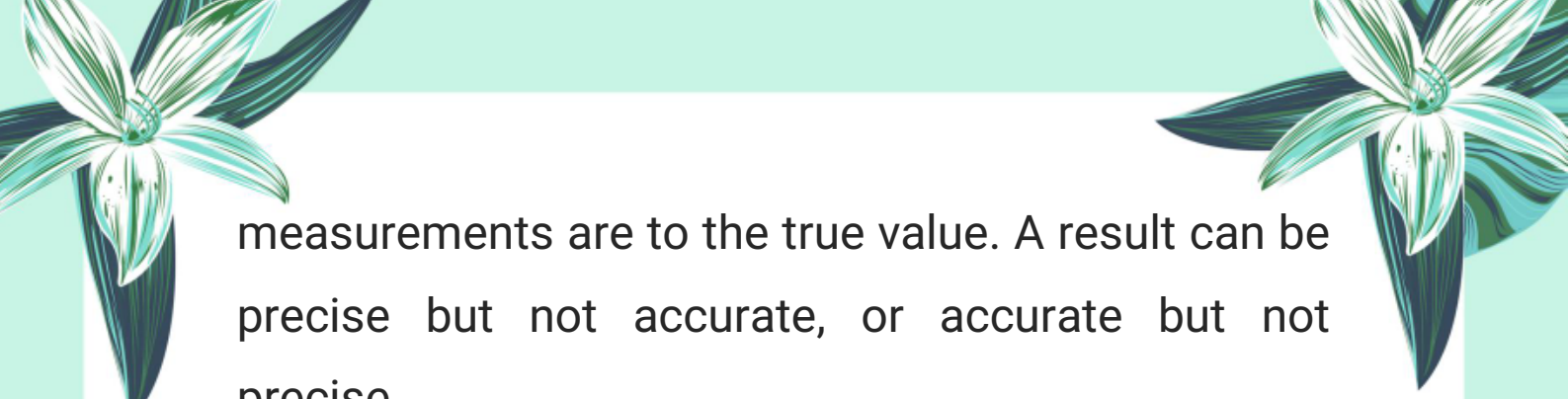
15. Define precision with an example.

- Precision refers to how close repeated measurements are to each other, regardless of whether they are close to the true value.
- **Example:** Measuring a mass five times and getting 3.2 kg every time shows high precision.

16. How is precision different from accuracy?

Precision indicates the consistency of repeated measurements, while accuracy indicates how close






measurements are to the true value. A result can be precise but not accurate, or accurate but not precise.

17. What factors cause random errors during an experiment?

Random errors are caused by:

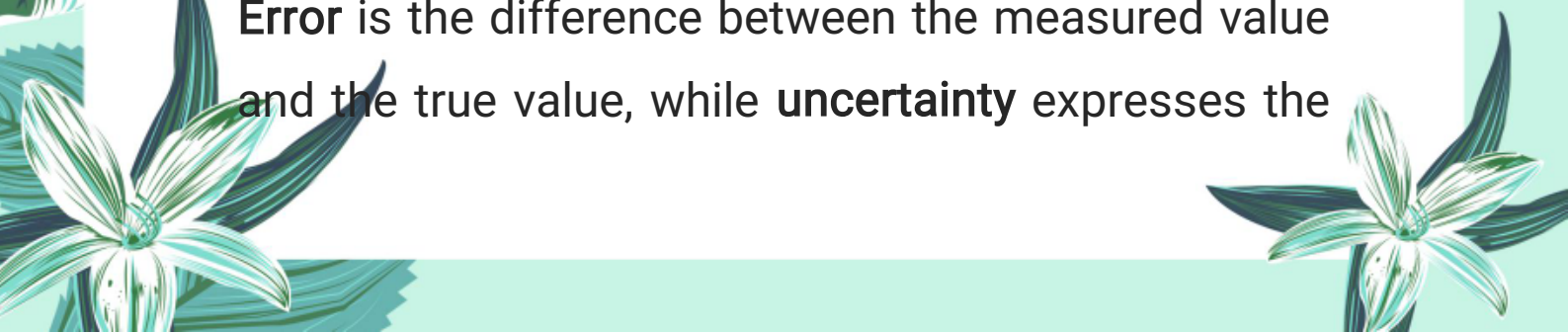
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- Limitations of measuring instruments
 - Environmental changes (temperature, air currents)
 - Slight differences in measurement procedure or observation angle

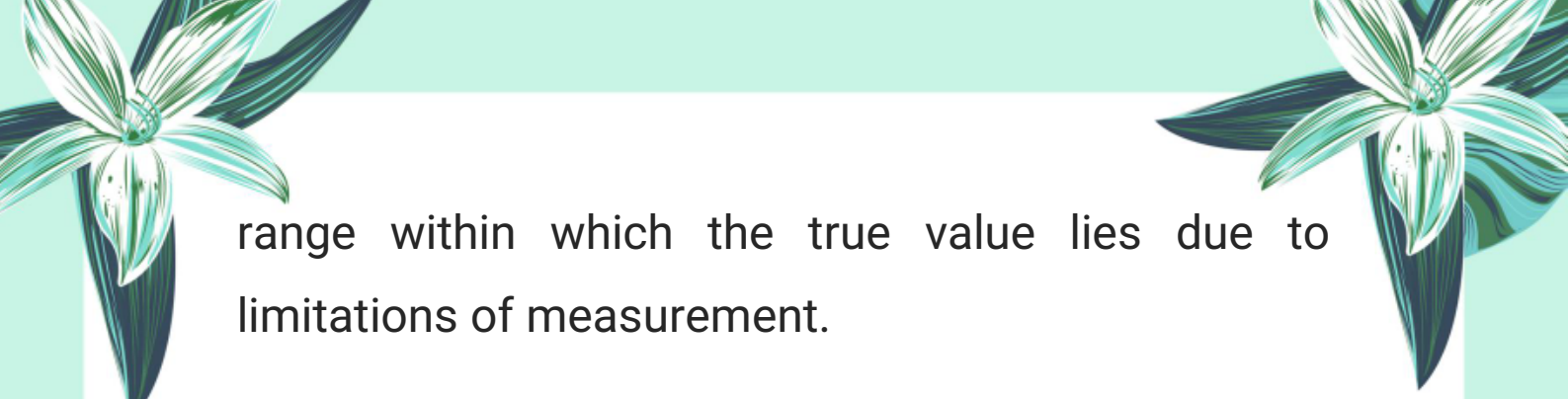
18. How can systematic errors be minimized or corrected?

Systematic errors can be reduced by calibrating instruments properly and applying constant adjustments or corrections to measurements.

19. What is the difference between error and uncertainty in measurements?


Error is the difference between the measured value and the true value, while **uncertainty** expresses the





range within which the true value lies due to limitations of measurement.

Important Long Questions :



Q1: Explain the SI system of units and describe the five base units commonly used in Chemistry.

SI System of Units:


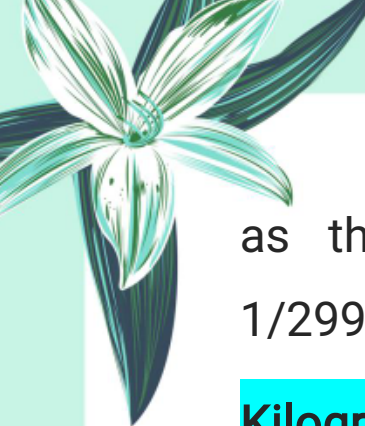
The SI system, or the International System of Units, is the globally accepted standard system for measuring physical quantities. It provides a uniform and consistent way to express measurements in science, enabling clear communication and comparison of data worldwide. The SI system is based on seven fundamental base units, each corresponding to a fundamental physical quantity.

Five base units commonly used in Chemistry:


Out of the seven SI base units, five are frequently used in Chemistry:

Metre (m): The SI base unit of length. It is defined





as the distance light travels in a vacuum in $1/299,792,458$ of a second.




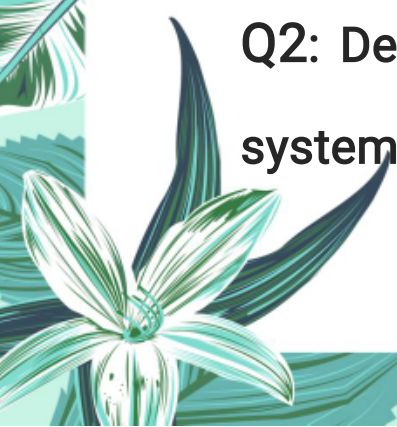
Kilogram (kg): The SI base unit of mass. Originally defined by a platinum-iridium standard kept in France, it is the mass unit used to measure how much matter an object contains.

Second (s): The SI base unit of time. It is defined based on the radiation frequency of the cesium-133 atom, specifically the time taken for 9,192,631,770 oscillations of this radiation.

Kelvin (K): The SI base unit of thermodynamic temperature. It is defined as $1/273.16$ of the thermodynamic temperature at the triple point of water, where all three phases of water coexist.

Mole (mol): The SI base unit of the amount of substance. One mole contains exactly 6.022×10^{23} elementary entities (Avogadro's number), such as atoms, molecules, or ions.

Q2: Describe the standard unit of mass in the SI system.



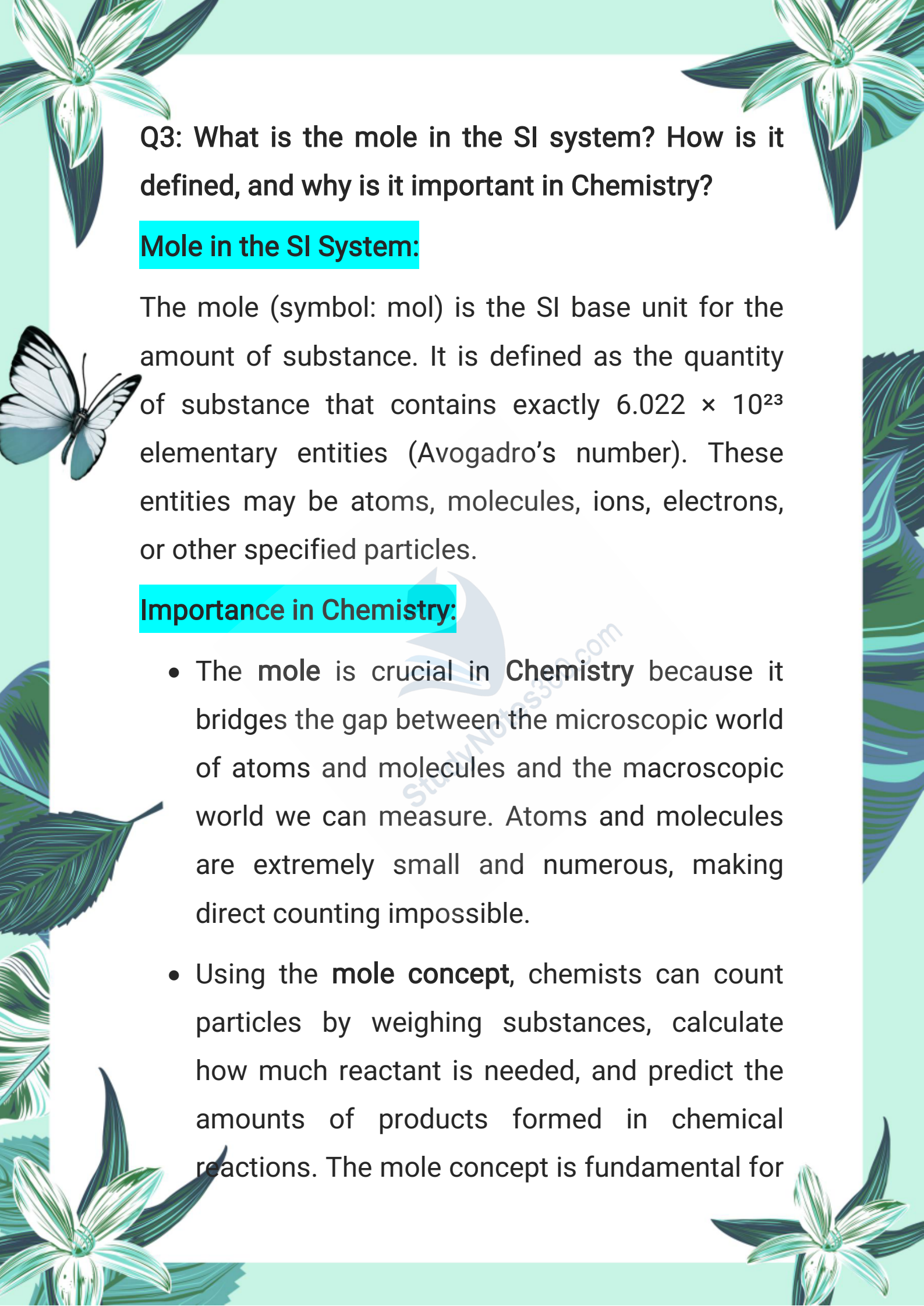
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Standard Unit of Mass – Kilogram (kg):

The **kilogram** is the SI base unit of mass. It represents the **amount of matter** contained in an object. **Historically**, it was defined by a **physical object**—a **platinum-iridium alloy cylinder** stored in the **International Bureau of Weights and Measures in France**.

Currently, the **kilogram** is defined by a fixed numerical value of the Planck constant, linking mass to fundamental physical constants, but practically, it remains the standard unit for mass measurement worldwide.

In **Chemistry**, although the **kilogram** is the **official unit**, **grams** ($1 \text{ kg} = 1000 \text{ grams}$) are commonly used because chemical quantities are often small, making grams more convenient. The kilogram provides a universal standard ensuring that mass measurements are accurate and comparable everywhere.

The page is decorated with various illustrations: a white butterfly with black markings on its wings is on the left side. There are several green and white flowers with long, narrow leaves, some in the top corners and some at the bottom. The background is a light green color with a subtle pattern of leaves and flowers.

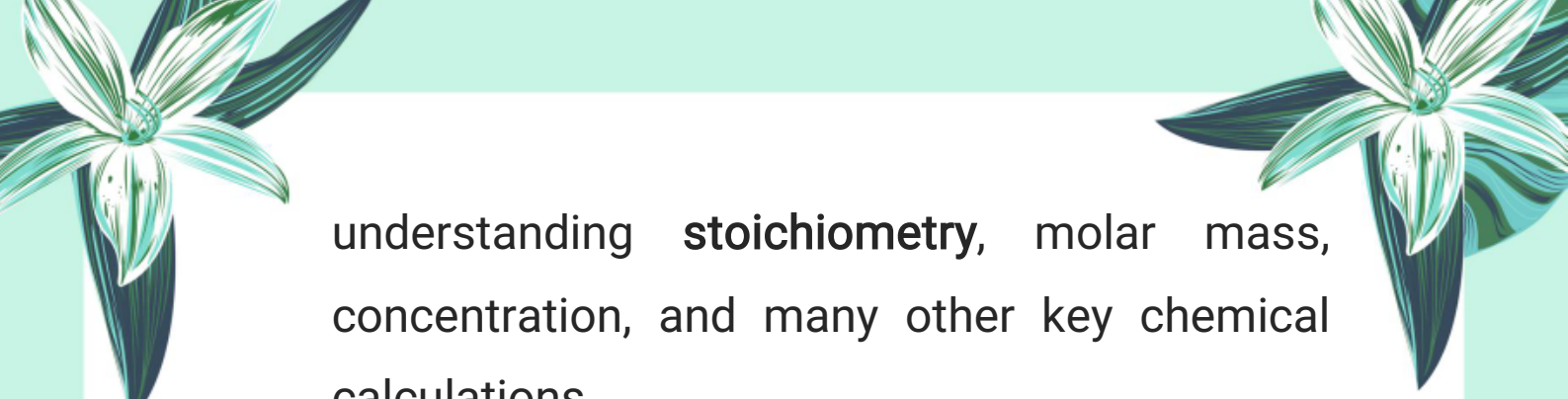
Q3: What is the mole in the SI system? How is it defined, and why is it important in Chemistry?

Mole in the SI System:

The mole (symbol: mol) is the SI base unit for the amount of substance. It is defined as the quantity of substance that contains exactly 6.022×10^{23} elementary entities (Avogadro's number). These entities may be atoms, molecules, ions, electrons, or other specified particles.

Importance in Chemistry:


- The mole is crucial in Chemistry because it bridges the gap between the microscopic world of atoms and molecules and the macroscopic world we can measure. Atoms and molecules are extremely small and numerous, making direct counting impossible.
- Using the mole concept, chemists can count particles by weighing substances, calculate how much reactant is needed, and predict the amounts of products formed in chemical reactions. The mole concept is fundamental for



understanding **stoichiometry**, molar mass, concentration, and many other key chemical calculations.

Q4: What is meant by error in measurement?


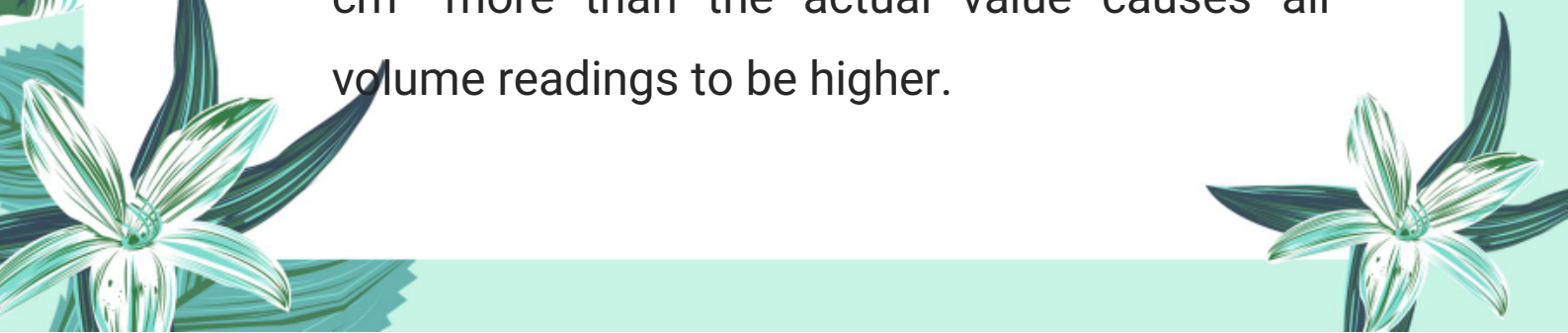
Explain the types of errors with examples.



Definition of Error: An error is the difference between the measured value and the actual (true) value of a quantity. No measurement is completely free of error.

Types of Errors:

A. Systematic Error:

- 
- These errors occur consistently and are predictable.
 - They are caused by faulty instruments or flaws in measurement techniques.
 - **Impact:** Affects accuracy of measurements.
 - **Example:** A burette that always delivers 0.5 cm³ more than the actual value causes all volume readings to be higher.
- 

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Causes:

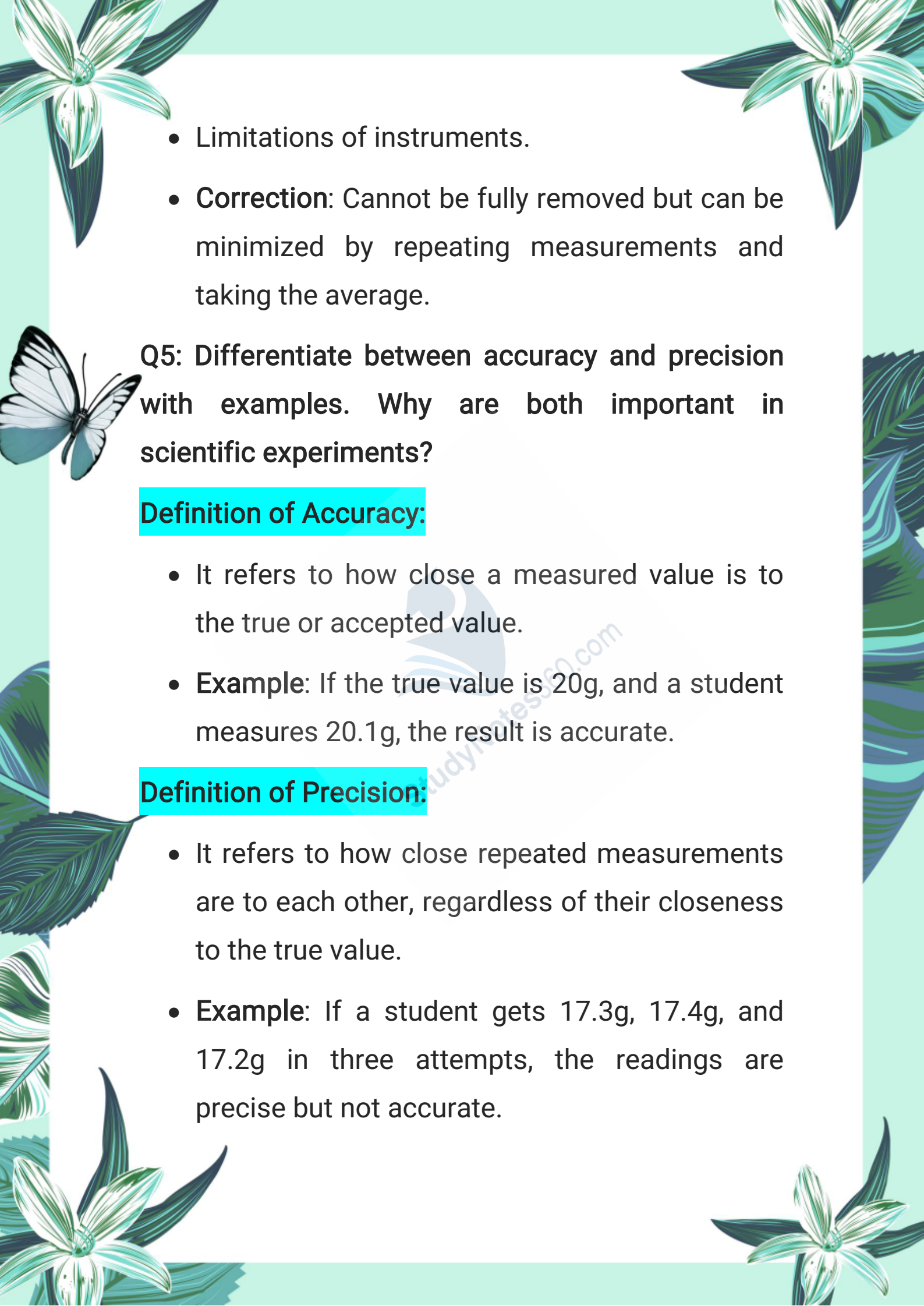
- Imperfect calibration of instruments.
- Consistent parallax error.
- Temperature effects on instruments.
- **Correction:** Can be reduced or corrected by adjusting the measurement (adding/subtracting a constant value).

B. Random Error:

- These are unpredictable variations in measurements.
- They differ from one reading to another.
- **Impact:** Affects precision of measurements.
- **Example:** Reading a balance gives slightly different mass each time due to airflow or vibration.

Causes:

- Environmental changes (temperature, pressure).
- Human errors like reading angles differently.

- 
- The page is decorated with stylized illustrations of white flowers with green leaves in the corners and a white butterfly with black markings on its wings on the left side. The background is a light green color.
- Limitations of instruments.
 - **Correction:** Cannot be fully removed but can be minimized by repeating measurements and taking the average.

Q5: Differentiate between accuracy and precision with examples. Why are both important in scientific experiments?

Definition of Accuracy:

- It refers to how close a measured value is to the true or accepted value.
- **Example:** If the true value is 20g, and a student measures 20.1g, the result is accurate.

Definition of Precision:

- It refers to how close repeated measurements are to each other, regardless of their closeness to the true value.
- **Example:** If a student gets 17.3g, 17.4g, and 17.2g in three attempts, the readings are precise but not accurate.

Key Differences:

Key Differences Between Accuracy and Precision

Feature	Accuracy	Precision
Meaning	Closeness to actual value	Closeness among repeated values
Focus	Correctness of result	Consistency of result
Affected by	Systematic error	Random error
Example	20.1g when true value is 20g	17.3g, 17.4g, 17.2g
Importance	Ensures correctness	Ensures repeatability

Examples:

- **Accurate but not Precise:**
- **Readings:** 19.8g, 20.5g, 19.6g (average close to true value but not consistent)

Precise but not Accurate:

- **Readings:** 17.3g, 17.4g, 17.2g (very consistent but far from the true value)

Accurate and Precise:

- **Readings:** 20.0g, 20.1g, 20.0g

Importance in Science:

- Both accuracy and precision are essential for



valid and reliable experimental results.

- High accuracy ensures the correctness of results.
- High precision ensures repeatability and consistency, which builds trust in data.

3. Constructed Response Questions:

i. Compare the units in SI system with those in MKS system:

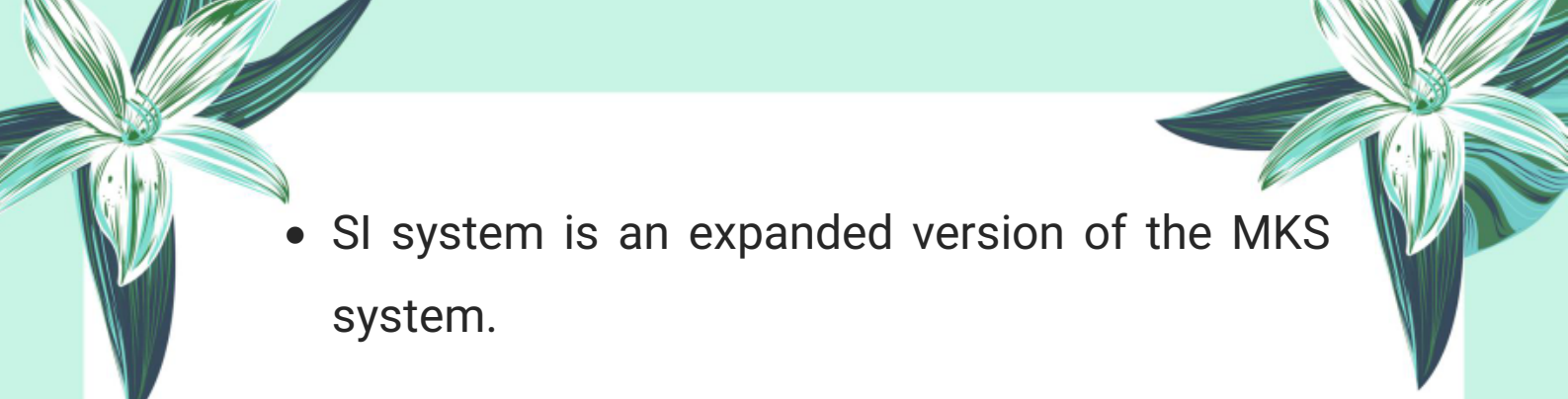
SI System (International System of Units):


It is the modern and most widely used system of measurement. It includes seven base units, among which metre (m) for length, kilogram (kg) for mass, and second (s) for time are common in Chemistry.

MKS System (Metre-Kilogram-Second System):

It is an older system based on three fundamental units: metre for length, kilogram for mass, and second for time.

Comparison:

- 
- SI system is an expanded version of the MKS system.
 - MKS system uses only 3 units, while SI includes 7 base units and multiple derived units.
 - SI system is internationally standardized, while MKS was limited in usage.



ii. What are five basic SI units which are used in Chemistry?

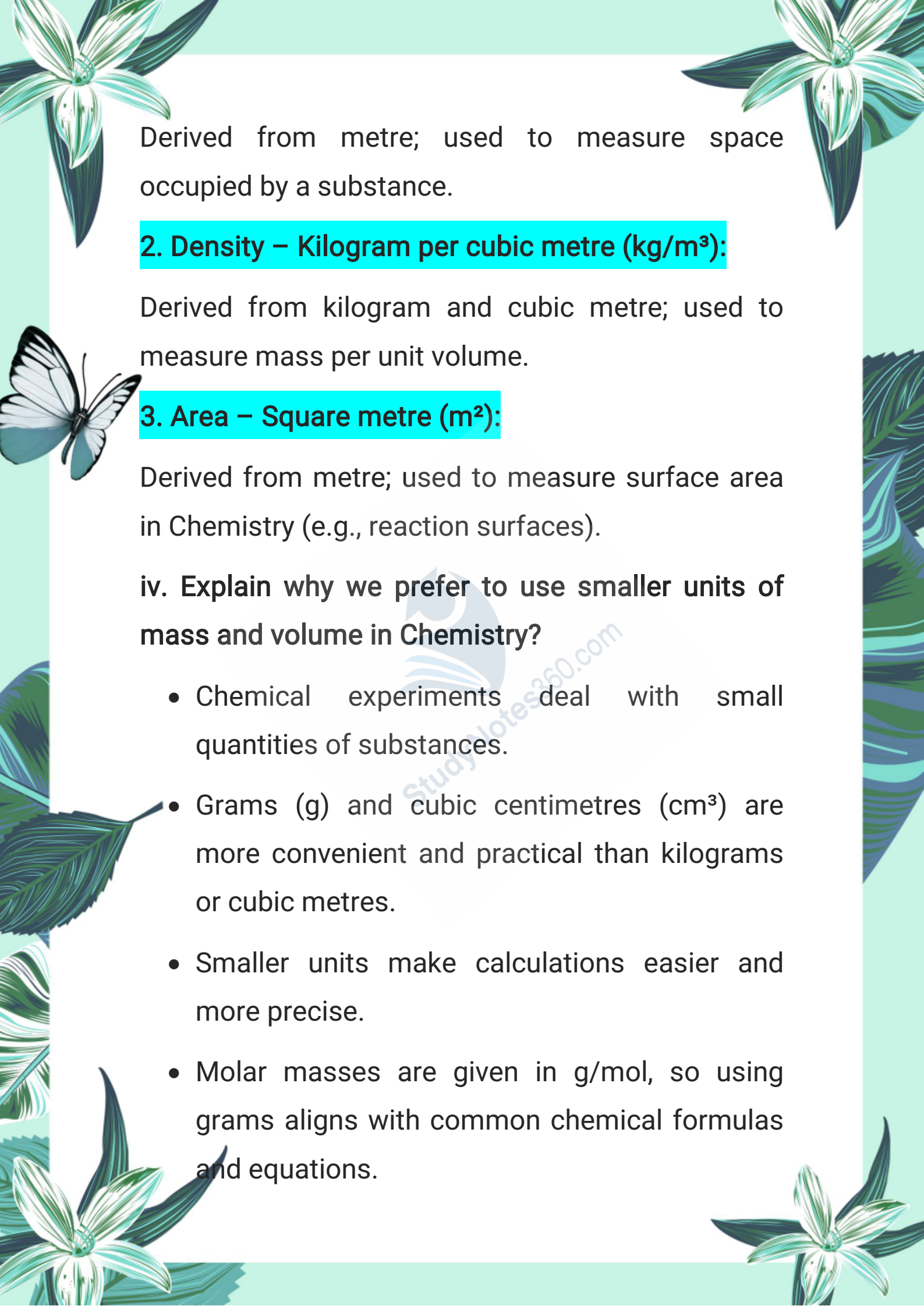
1. **Metre (m)** – Unit of length.
2. **Kilogram (kg)** – Unit of mass.
3. **Second (s)** – Unit of time.
4. **Kelvin (K)** – Unit of temperature.
5. **Mole (mol)** – Unit of amount of substance.

These units help in accurate and standardized measurement in chemical reactions and experiments.

iii. Explain the three units derived from the basic SI units:

1. Volume – Cubic metre (m³):





Derived from metre; used to measure space occupied by a substance.

2. Density – Kilogram per cubic metre (kg/m³):

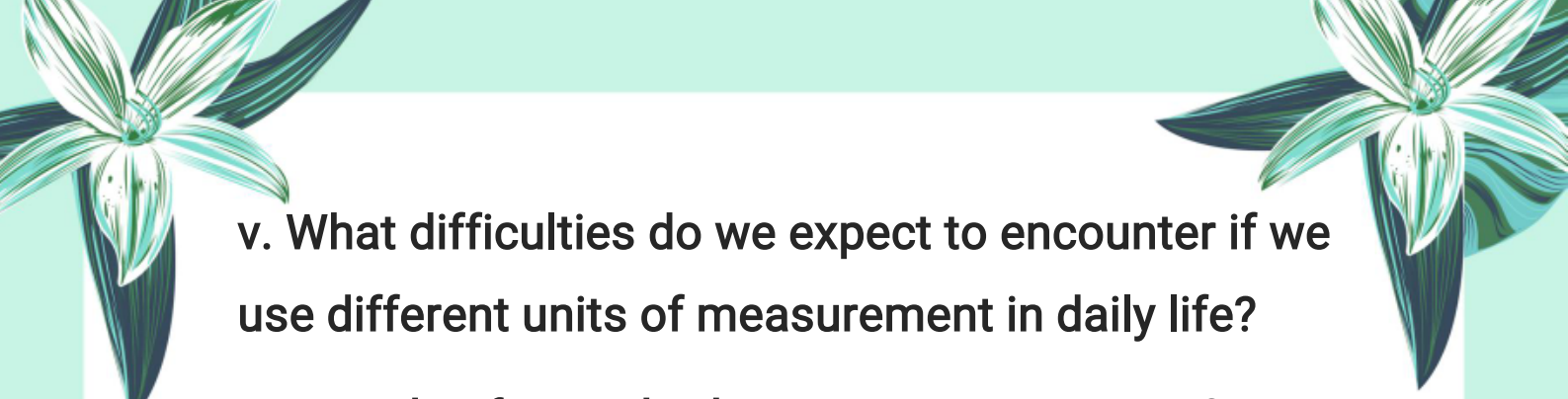
Derived from kilogram and cubic metre; used to measure mass per unit volume.

3. Area – Square metre (m²):

Derived from metre; used to measure surface area in Chemistry (e.g., reaction surfaces).

iv. Explain why we prefer to use smaller units of mass and volume in Chemistry?

- Chemical experiments deal with small quantities of substances.
- Grams (g) and cubic centimetres (cm³) are more convenient and practical than kilograms or cubic metres.
- Smaller units make calculations easier and more precise.
- Molar masses are given in g/mol, so using grams aligns with common chemical formulas and equations.






v. What difficulties do we expect to encounter if we use different units of measurement in daily life?

- **Lack of Standardization:** Leads to confusion and errors in communication and calculations.
- **Conversion Problems:** Constant need to convert units increases chances of mistakes.
- **Inefficiency:** Using different units can slow down processes in science, engineering, and commerce.
- **Global Incompatibility:** Difficult to share and understand data internationally if units vary.
- **Safety Hazards:** In medicine and chemistry, incorrect units may lead to dangerous outcomes (e.g., overdose or wrong chemical quantity).

4. Descriptive Questions


i. What are our indigenous units of measurement of mass, volume, and length?






In the past, before the adoption of standard international units, people used indigenous (local) units for measurement:


Mass:

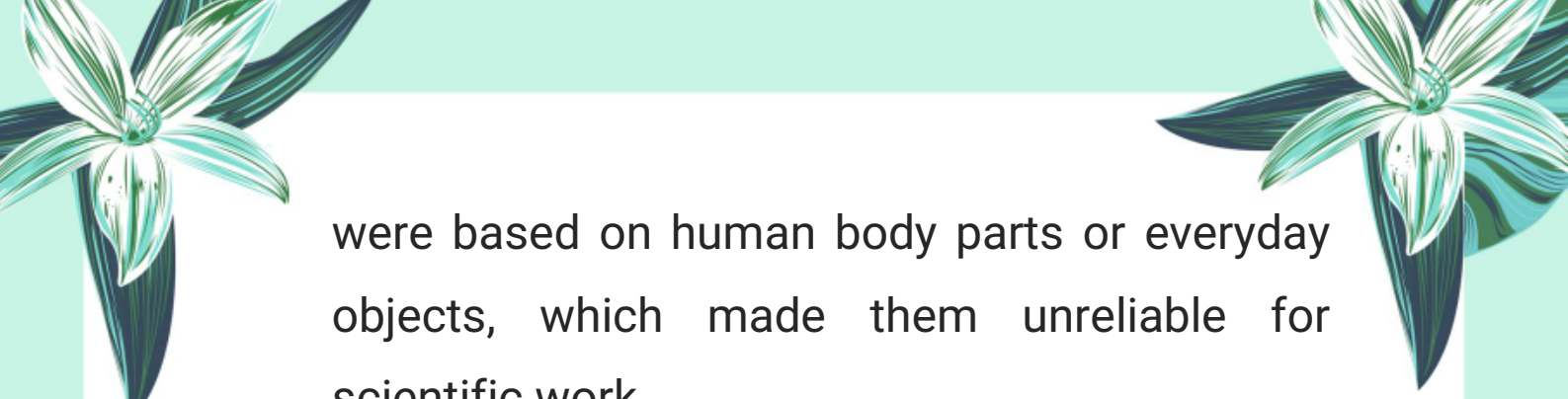
- 
- Tola, seer, maund
 - 1 tola \approx 11.66 grams
 - 1 seer \approx 0.933 kg
 - 1 maund \approx 37.32 kg

Volume:


- 
- Lota, gilaas, paili
 - These were based on the size of containers and were not standardized.

Length:

- 
- Gaz, hatth, angul
 - 1 gaz \approx 0.91 metres
 - 1 hatth (hand-span) \approx 45 cm
 - 1 angul (finger-width) \approx 2 cm
 - These units varied from place to place and
- 



were based on human body parts or everyday objects, which made them unreliable for scientific work.



ii. Elaborate the difference between precision and accuracy.

- Precision refers to how close repeated measurements are to each other.
- Accuracy refers to how close a measurement is to the actual or true value.

Example:

- If a student measures the mass of a sample three times and gets: 3.2 g, 3.2 g, and 3.3 g – it is precise (close to each other).
- If the true mass is 3.2 g, and the student records: 3.1 g, 3.2 g, and 3.3 g – the measurements are accurate.

iii. How can you avoid systematic errors in your measurements?


To avoid systematic errors, follow these







steps:

1. Calibrate instruments before use.
2. Use well-maintained and accurate instruments.
3. Read scales at eye level to avoid parallax error.
4. Follow standard procedures every time.
5. Adjust for zero error, if present.
6. Use proper techniques and avoid assumptions.



By minimizing systematic errors, measurements become more reliable and accurate.


iv. How do taking measurements in SI units ensure safety and reliability?

1. **SI units are universal** – understood worldwide, avoiding confusion.
 2. **Standardized system** – ensures consistency in all experiments.
 3. **Precise measurements** – reduce risks in sensitive fields like chemistry and medicine.
 4. **Easier conversions** – simplifies scientific
- 
- 



calculations and reduces human errors.

5. International collaboration – scientists and industries across the globe can communicate without misinterpretation.



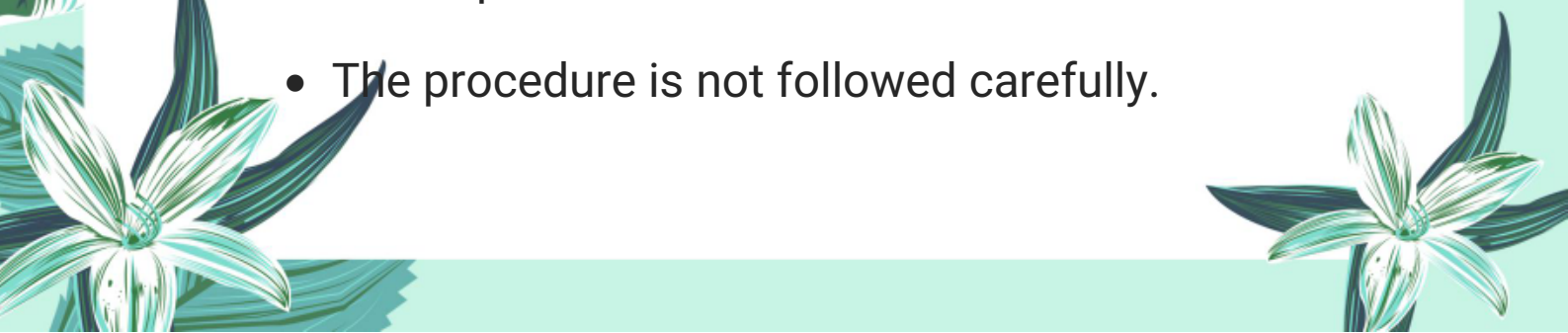
v. Can a student be both inaccurate and imprecise in his measurements?

- **Yes**, a student can be both inaccurate and imprecise.
- If the **student measures the mass** of an object (true mass = 20 g) and gets readings:
- 16.8 g, 18.2 g, 21.5 g

These results:

- Are not close to the true value \Rightarrow inaccurate
- Are not close to each other \Rightarrow imprecise

This usually happens when:

- The instrument is faulty or not calibrated.
 - The student lacks proper skill or uses a wrong technique.
 - The procedure is not followed carefully.
- 



Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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